TABLE OF CONTENTS

CHAPTER 11 RADIOACTIVE WASTE MANAGEMENT

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

* These Figures are Proprietary.

CHAPTER 11.0 RADIOACTIVE WASTE MANAGEMENT

11.1 SOURCE TERMS

This information is evaluated in PUSAR Section 2.9.1

General Electric has evaluated radioactive material sources (activation products and fission products releases from fuel) in operating boiling water reactors (BWRs) over the past decade. These source terms are reviewed and periodically revised to incorporate up-to-date information. Release of radioactive material from operating BWRs has generally resulted in doses to offsite persons which have been only a small fraction of permissible doses, or of the natural background dose.

The information provided in this section defines the design basis radioactive material levels in the reactor water, steam, and offgas. The various radioisotopes listed have been grouped as coolant activation products, noncoolant activation products, and fission products. The fission product levels are based on measurements of BWR reactor water and offgas at several stations through mid-1971. Emphasis was placed on observations made at KRB and Dresden 2. The design basis radioactive material levels do not necessarily include all the radioisotopes observed or predicted theoretically to be present. The radioisotopes included are considered significant to one or more of the following criteria:

a. Plant equipment design

b. Shielding design

c. Understanding system operation and performance

d. Measurement practicability

e. Evaluating radioactive material releases to the environment

For halogens, radioisotopes with half-lives less than 3 minutes were omitted. For other fission product radioisotopes in reactor water, radioisotopes with half-lives less than 10 minutes were not considered.

The EPU source term analysis (Ref.9) calculated the radioisotopes concentrations expected at the EPU power levels. The EPU analysis concluded that the sum of activated corrosion products activity and the fission product activity remains a fraction (14%) of the total design basis activity in reactor water. The analysis also noted that the

margin of GGNS plant design basis for reactor coolant activation concentrations significantly exceeded potential increases due to EPU increased thermal power levels. Therefore the activated corrosion product and fission product activities, and reactor coolant activation concentrations design bases for GGNS are unchanged. Tables 11.1-1 through 11.1-5 source term concentrations were updated to reflect the current license basis contained in the EPU source term analysis (Ref.9).

11.1.1 Fission Products

11.1.1.1 Noble Radiogas Fission Products

The noble radiogas fission product source terms observed in operating BWRs are generally complex mixtures whose sources vary from minuscule defects in cladding to "tramp" uranium on external cladding surfaces. The relative concentrations or amounts of noble radiogas isotopes can be described as follows:

$$\text{Equilibrium: } R_g \sim k_1 y \qquad (11.1\text{-}1)$$

$$\text{Recoil: } R_g \sim k_2 y \qquad (11.1\text{-}2)$$

The nomenclature in subsection 11.1.1.4 defines the terms in these and succeeding equations. The constants k_1 and k_2 describe the fractions of the total fissions that are involved in each of the releases. The equilibrium and recoil mixtures are the two extremes of the mixture spectrum that are physically possible. When a sufficient time delay occurs between the fission event and the time of release of the radiogases from the fuel to the coolant, the radiogases approach equilibrium levels in the fuel and the equilibrium mixture results. When there is no delay or impedance between the fission event and the release of the radiogases, the recoil mixture is observed.

Prior to Vallecitos boiling water reactor (VBWR) and Dresden 1 experience, it was assumed that noble radiogas leakage from the fuel would be the equilibrium mixture of the noble radiogases present in the fuel.

VBWR and early Dresden 1 experience indicated that the actual mixture most often observed approached a distribution which was intermediate in character to the two extremes (Ref. 1). This intermediate decay mixture was termed the "diffusion" mixture. It must be emphasized that this "diffusion" mixture is merely one possible point on the mixture spectrum ranging from the equilibrium to the recoil mixture and does not have the absolute mathematical and mechanistic basis for the calculational methods possible for equilibrium and recoil mixtures. However, the "diffusion" distribution pattern which has been described is as follows:

$$\text{Diffusion: } R_g \sim k_3 y \lambda^{0.5} \qquad (11.1\text{-}3)$$

The constant k_3 describes the fraction of total fissions that are involved in the release. The value of the exponent of the decay constant, λ, is midway between the values for equilibrium, 0, and recoil, 1. The "diffusion" pattern value of 0.5 was originally derived from diffusion theory.

Although the previously described "diffusion" mixture was used by GE as a basis for design since 1963, the design basis release magnitude used has varied from 0.5 Ci/sec to 0.1 Ci/sec as measured after 30-min decay (t = 30 min).* Since about 1967, the design basis release magnitude used (including the 1971 source terms) was established at an annual average of 0.1 Ci/sec (t = 30 min). This design basis is considered as an annual average with some time above and some time below this value. This design value was selected on the basis of operating experience rather than predictive assumptions. Several judgment factors, including the significance of environmental release, reactor water radioisotope concentrations, liquid waste handling and effluent disposal criteria, building air contamination, shielding design, and turbine and other component contamination affecting maintenance, have been considered in establishing this level.

Noble radiogas source terms from fuel above 0.1 Ci/sec (t = 30 min) can be tolerated for reasonable periods of time. Continual assessment of these values is made on the basis of actual operating experience in BWRs (Ref. 2 and 3).

While the noble radiogas source-term magnitude was established at 0.1 Ci/sec (t = 30 min), it was recognized that there may be a more statistically applicable distribution for the noble radiogas mixture. Sufficient data were available from KRB operations from 1967 to mid-1971 along with Dresden 2 data from operation in 1970 and several months in 1971 to characterize more accurately the noble radiogas mixture pattern for an operating BWR.

The basic equation for each radioisotope used to analyze the collected data is:

$$R_g = k_g y \lambda^m \; (1 - e^{-\lambda T}) \; (e^{-\lambda t}) \qquad (11.1\text{-}4)$$

* The noble radiogas source-term rate after 3D-minute decay has been used as a conventional measure of the design basis fuel leakage rate since it is conveniently measurable and was consistent with the nominal design basis 30-minute offgas holdup system used on a number of plants.

With the exception of Kr-85 with a half-life of 10.74 years, the noble radiogas fission products in the fuel are essentially at an equilibrium condition after an irradiation period of several months (rate of formation is equal to the rate of decay). So for practical purposes the term $(1 - e^{-\lambda T})$ approaches 1 and can be neglected when the reactor has been operating at steady-state for long periods of time. The term $(e^{-\lambda T})$ is used to adjust the releases from the fuel (t = 0) to the decay time for which values are needed. Historically, t = 30 min has been used. When discussing long steady-state operation and leakage from the fuel (t = 0), the following simplified form of Equation 11.1-4 can be used to describe the leakage of each noble radiogas:

$$R_g = K_g y \lambda^m \qquad (11.1\text{-}5)$$

The constant, K_g, describes the magnitude of leakage. The relative rates of leakage of the different noble radiogas isotopes is accounted for by the variable, m, the exponent of the decay constant, λ.

Dividing both sides of Equation 11.1-5 by y, the fission yield, and taking the logarithm of both sides results in the following equation:

$$\log (R_g/y) = m \log (\lambda) + \log (K_g) \qquad (11.1\text{-}6)$$

Equation 11.1-6 represents a straight line when log R_g/y is plotted versus log (λ); m is the slope of the line. This straight line is obtained by plotting (R_g/y) versus (λ) on logarithmic graph paper. By fitting actual data from KRB and Dresden 2 (using least squares techniques) to the equation the slope, m, can be obtained. This can be estimated on the plotted graph. With radiogas leakage at KRB over the nearly 5-year period varying from 0.001 to 0.056 Ci/sec (t = 30 min) and with radiogas leakage at Dresden 2 varying from 0.001 to 0.169 Ci/sec (t = 30 min), the average value of m was determined. The value for m- is 0.4 with a standard deviation of ±0.07. This is illustrated in Figure 11.1-1 as a frequency histogram. As can be seen from this figure, variations in m were observed in the range m = 0.1 to m = 0.6. After establishing the value of m = 0.4, the value of Kg can be calculated by selecting a value for R_g, or as has been done historically, the design basis is set by the total design basis

source-term magnitude at t = 30 min. With ΣR_g at 30 min = 100,000 µCi/sec, Kg can be calculated as being 2.6×10^7 and Equation 11.1-4 becomes:

$$R_g = 2.6 \times 10^7 \, y\lambda^{0.4}(1 - e^{-\lambda T})\,(e^{-\lambda t}) \qquad (11.1\text{-}7)$$

This updated noble radiogas source-term mixture has been termed the "1971 Mixture" to differentiate it from the "diffusion mixture." The noble gas source term for each radioisotope can be calculated from Equation 11.1-7. The resultant source terms are presented in Table 11.1-1 as leakage from fuel (t = 0) and after 30-min decay. While Kr-85 can be calculated using Equation 11.1-7, the number of confirming experimental observations was limited by the difficulty of measuring very low release rates of this isotope. Therefore, the table provides an estimated range for Kr-85 based on a few actual measurements. Table 11.1-1 was updated to reflect the EPU source term analysis (Ref.9) and the expected source terms as leakage from fuel after 30-min decay. The "t=0" values results were not included in the EPU analysis and the t=0 values remain as the original design basis values as discussed.

11.1.1.2 Radiohalogen Fission Products

Historically, the radiohalogen design basis source term was established by the same equation as that used for noble radiogases. In a fashion similar to that used with gases, a simplified equation can be shown to describe the release of each halogen radioisotope:

$$R_h = K_h y \, \lambda^n \qquad (11.1\text{-}8)$$

The constant, K_h, describes the magnitude of leakage from fuel. The relative rates of halogen radioisotope leakage is expressed in terms of n, the exponent of the decay constant, λ. As was done with the noble radiogases, the average value was determined for n. The value for n is 0.5 with a standard deviation of ±0.19. This is illustrated in Figure 11.1-2 as a frequency histogram. As can be seen from this figure, variations in n were observed in the range of n = 0.1 to n = 0.9.

It appeared that the use of the previous method of calculating radiohalogen leakage from fuel was overly conservative. Figure 11.1-3 relates KRB and Dresden 2 noble radiogas versus I-131 leakage. While it can be seen from Dresden 2 data during the period August 1970 to January 1971 that there is a relationship between noble radiogas and I-131 leakage under one fuel

condition, there was no simple relationship for all fuel conditions experienced. Also, it can be seen that during this period, high radiogas leakages were not accompanied by high radioiodine leakage from the fuel. Except for one KRB datum point, all steady-state I-131 leakages observed at KRB or Dresden 2 were equal to or less than 505 µCi/sec. Even at Dresden 1 in March 1965, when severe defects were experienced in stainless-steel- clad fuel, I-131 leakages greater than 500 µCi/sec were not experienced. Figure 11.1-3 shows that these higher radioiodine leakages from the fuel were related to noble radiogas source terms of less than the design basis value of 0.1 Ci/sec (t = 30 min). This may be partially explained by inherent limitations due to internal plant operational problems that caused plant derating.

In general, it would not be anticipated that operation at full power would continue for any significant time period with fuel cladding defects which would be indicated by I-131 leakage from the fuel in excess of 700 µCi/sec. When high radiohalogen leakages are observed, other fission products will be present in greater amounts. This may increase potential radiation exposure to operating and maintenance personnel during plant outages following such operation.

Using these judgment factors and experience to date, the design basis radiohalogen source terms from fuel were established based on I-131 leakage of 700 µCi/sec. This value, as seen in

Figure 11.1-3, accommodates the experience data and the design basis noble radiogas source term of 0.1 Ci/sec (t = 30 min). With the I-131 design basis source term established, K_h can be calculated as being 2.4×10^7 and halogen radioisotope release can be expressed by the following equation:

$$R_h = 2.4 \times 10^7 \, y\lambda^{0.5} \, (1 - e^{-\lambda T}) \, (e^{-t}) \qquad (11.1\text{-}9)$$

Concentrations of radiohalogens in reactor water can be calculated using the following equation:

$$C_h = \frac{R_h}{(\lambda + \beta + \gamma)M} \qquad (11.1\text{-}10)$$

Although carryover of most soluble radioisotopes from reactor water to steam is observed to be <0.1 percent (<0.001 fraction), the observed "carryover" for radiohalogens has varied from 0.1 percent to about 2 percent on newer plants. The average of observed radiohalogen carryover measurements has been 1.2 percent by weight of reactor water in steam with a standard deviation of ±0.9. In the present source-term definition, a radiohalogen carryover of 2 percent (0.02 fraction) was used.

The halogen release rate from the fuel can be calculated from Equation 11.1-9. Concentrations in reactor water can be calculated from Equation 11.1-10. The resultant concentrations calculated at EPU power levels (Ref. 9) are presented in Table 11.1-2.

11.1.1.3 Other Fission Products

The observations of other fission products (and transuranic nuclides, including Np-239) in operating BWRs are not adequately correlated by simple equations. For these radioisotopes, design basis concentrations in reactor water have been estimated conservatively from experience data and updated based on the EPU source term analysis (Ref.9). These results are presented in Table 11.1-3. Carryover of these radioisotopes from the reactor water to the steam is estimated to be <0.1 percent (<0.001 fraction). In addition to carryover, however, decay of noble radiogases in the steam leaving the reactor will result in production of noble gas daughter radioisotopes in the steam and condensate systems.

Some daughter radioisotopes (e.g., yttrium and lanthanum), were not listed as being in reactor water. Their independent leakage to the coolant is negligible; however, these radioisotopes may be observed in some samples in equilibrium or approaching equilibrium with the parent radioisotope.

Except for Np-239, trace concentrations of transuranic isotopes have been observed in only a few samples where extensive and complex analyses were carried out. The predominant alpha emitter present in reactor water is Cm-242 at an estimated concentration of 10^{-6} μCi/g or less, which is below the maximum permissible concentration in drinking water applicable to continuous use by the general public. The concentration of alpha-emitting plutonium radioisotopes is more than one order of magnitude lower than that of Cm-242.

Plutonium-241 (a beta emitter) may also be present in concentrations comparable to the Cm-242 level.

11.1.1.4 Nomenclature

The following list of nomenclature defines the terms used in equations for source-term calculations:

R_g	Leakage rate of a noble gas radioisotope (µCi/sec)
R_h	Leakage rate of a halogen radioisotope (µCi/sec)
y	Fission yield of a radioisotope (atoms/fission)
λ	Decay constant of a radioisotope (sec^{-1})
T	Fuel irradiation time (sec)
t	Decay time following leakage from fuel (sec)
m	Noble radiogas decay constant exponent (dimensionless)
n	Radiohalogen decay constant exponent (dimensionless)
K_g	A constant establishing the level of noble radiogas leakage from fuel
K_h	A constant establishing the level of radiohalogen leakage from fuel
C_h	Concentration of a halogen radioisotope in reactor water (µCi/g)
M	Mass of water in the operating reactor (g)
β	Cleanup system removal (sec)
g	Grams mass

$$\beta = \frac{\text{cleanup system flowrate (g/sec)}}{M}$$

γ = halogen steam carryover removal constant (sec^{-1})

γ = concentration of halogen radioisotope in steam (μCi/g) steam flow (g/sec)

$$\frac{C_h}{M}$$

11.1.2 Activation Products

This information is evaluated in PUSAR Section 2.9.1

11.1.2.1 Coolant Activation Products

The coolant activation products are not adequately correlated by simple equations. Design basis concentrations in reactor water and steam have been estimated conservatively from experience data. The resultant concentrations calculated at EPU power levels (Ref.9) are presented in Table 11.1-4.

11.1.2.2 Noncoolant Activation Products

The activation products formed by activation of impurities in the coolant or by corrosion of irradiated system materials are not adequately correlated by simple equations. The design basis source terms of noncoolant activation products have been estimated conservatively from experience data. The resultant concentrations calculated at EPU power levels (Ref.9) are presented in Table 11.1-5. Carryover of these isotopes from the reactor water to the steam is estimated to be <0.1 percent (<0.001 fraction).

11.1.2.3 Steam and Power Conversion System N-16 Inventory

N-16 sources in the steam and power conversion system are described in Section 12.2.

11.1.3 Tritium

In a BWR, tritium is produced by three principal methods:

a. Activation of naturally occurring deuterium in the primary coolant

b. Nuclear fission of UO_2 fuel

c. Neutron reactions with boron used in reactivity control rods

The tritium, formed in control rods, which may be released from a BWR in liquid or gaseous effluents, is believed to be negligible. A prime source of tritium available for release from a BWR is that produced from activation of deuterium in the primary coolant. Some fission product tritium may also transfer from fuel to primary coolant. This discussion is limited to the uncertainties associated with estimating the amounts of tritium generated in a BWR which are available for release.

All of the tritium produced by activation of deuterium in the primary coolant is available for release in liquid or gaseous effluents. The tritium formed in a BWR from this source can be calculated using the equation:

$$R_{act} = \frac{\Sigma\Phi V\lambda}{3.7\times 10^{4}P} \qquad (11.1\text{-}11)$$

where,

R_{act} = tritium formation rate by deuterium activation (µCi/sec/MWt)

Σ = macroscopic thermal neutron cross section (cm^{-1})

Φ = thermal neutron flux (neutrons/ (cm^2-sec))

V = coolant volume in core (cm^3)

λ = tritium radioactive decay constant (1.78×10^{-9} sec^{-1})

P = reactor power level (MWt)

For recent BWR designs, R_{act} is calculated to be $1.3 \pm 0.4 \times 10^{-4}$ µCi/sec/MWt. The uncertainty indicated is derived from the estimated errors in selecting values for the coolant volume in the core, coolant density in the core, abundance of deuterium in light water (some additional deuterium will be present because of the H(n,γ) D reaction, thermal neutron flux, and microscopic cross section for deuterium).

The fraction of tritium produced by fission which may transfer from fuel to the coolant (which will then be available for release in liquid and gaseous effluents) is much more difficult to estimate. However, since zircaloy-clad fuel rods are used in BWRs, essentially all fission product tritium will remain in the fuel rods unless defects are present in the cladding material (Ref. 4).

The study made at Dresden 1 in 1968 by the U.S. Public Health Service suggests that essentially all of the tritium released from the plant could be accounted for by the deuterium activation source (Ref. 3). For purposes of estimating the leakage of tritium from defective fuel, it can be assumed that it leaks in a manner similar to the leakage of noble radiogases. Thus, use can be made of the empirical relationship described as the “diffusion mixture” used for predicting the source term of individual noble gas radioisotopes as a function of the total noble gas source term. The equation which describes this relationship is:

$$R_{dif} = Ky\lambda \qquad (11.1\text{-}12)$$

where,

R_{dif} = leakage rate of tritium from fuel (µCi/sec)

y = fission yield fraction (atoms/fission)

λ = radioactive decay constant (sec^{-1})

K = a constant related to total tritium leakage rate

If the total noble radiogas source term is 10^5 µCi/sec after 30-minute decay, leakage from fuel can be calculated to be about 0.24 µCi/sec of tritium. To place this value in perspective in the USPHS study, the observed rate of Kr-85 (which has a half-life similar to that of tritium) was 0.06 to 0.4 times that calculated using the "diffusion mixture" relationship. This would suggest that the actual tritium leakage rate might range from 0.015 to 0.10 µCi/sec. Since the annual average noble radiogas leakage from a BWR is expected to be less than 0.1 Ci/sec (t = 30 min), the annual average tritium release rate from the fission source can be conservatively estimated at 0.12 ± 0.12 µCi/sec, or 0.0 to 0.24 µCi/sec.

For this reactor, the estimated total tritium appearance rate in reactor coolant and release rate in the effluent is about 19 µCi/year.

Tritium formed in the reactor is generally present as tritiated oxide (HTO) and to a lesser degree as tritiated gas (HT). Tritium concentration in the steam formed in the reactor will be the same as in the reactor water at any given time. This tritium concentration will also be present in condensate and feedwater. Since radioactive effluents generally originate from the reactor and power cycle equipment, radioactive effluents will also have this tritium concentration. Condensate storage receives treated

water from the liquid radwaste system and supplies water to the condensate system. Thus, all plant process water will have a common tritium concentration.

Offgases released from the plant will contain tritium, which is present as tritiated gas (HT) resulting from reactor water radiolysis as well as tritiated water vapor (HTO). In addition, water vapor from the turbine gland seal steam packing exhauster and a lesser amount present in ventilation air due to process steam leaks or evaporation from sumps, tanks, and spills on floors will also contain tritium. The remainder of the tritium will leave the plant in liquid effluents or with solid wastes.

Recombination of radiolysis gases in the offgas system (from the air ejector discharge) will form water, which is condensed and returned to the main condenser. This tends to reduce the amount of tritium leaving in gaseous effluents. Reducing the gaseous tritium release will result in a slightly higher tritium concentration in the plant process water. Reducing the amount of liquid effluent discharged will also result in a higher process coolant equilibrium tritium concentration.

Essentially, all tritium entering the primary coolant will eventually be released to the environs, either as water vapor and gas to the atmosphere, or as liquid effluent to the plant discharge or as solid waste. Reduction due to radioactive decay is negligible due to the 12-year half-life of tritium.

The USPHS study at Dresden 1 estimated that approximately 90 percent of the tritium release was observed in liquid effluent, with the remaining 10 percent leaving as gaseous effluent (Ref. 5). Efforts to reduce the volume of liquid effluent discharges may change this distribution so that a greater amount of tritium will leave as gaseous effluent. From a practical standpoint, the fraction of tritium leaving as liquid effluent may vary between 60 and 90 percent with the remainder leaving in gaseous effluent.

11.1.4 Fuel Fission Product Inventory and Fuel Experience

11.1.4.1 Fuel Fission Product Inventory

Fuel fission product inventory information is used in establishing fission product source terms for accident analysis and is discussed in Chapter 15.

11.1.4.2 Fuel Experience

A discussion of fuel experience gained for BWR fuel including failure experience, burnup experience, and thermal conditions under which the experience was gained is available in three GE topical reports (Ref. 2, 3 and 6) and one ENC topical report (Ref. 8).

11.1.5 Process Leakage Sources

Process leakage results in potential release paths for noble gases and other volatile fission products via ventilation systems. Liquids from process leaks are all collected and routed to the liquid-solid radwaste system. Radionuclide releases via ventilation paths are at extremely low levels and have been insignificant compared to process offgas from operating BWR plants. However, because the implementation of improved process offgas treatment systems makes the ventilation release relatively significant, General Electric has conducted measurements to identify and qualify these low-level release paths. General Electric has maintained an awareness of other measurements by the Electric Power Research Institute and other organizations and routine measurements by utilities with operating BWRs. Leakage of fluids from the process system results in the release of radionuclides into plant buildings. In general, the noble radiogases remain airborne and are released to the atmosphere with little delay via the building ventilation exhaust ducts. The radionuclides partition between air and water, and airborne radioiodines may “plateout” on metal surfaces, concrete, and paint. A significant amount of radioiodine remains in the air or is desorbed from surfaces. Radioiodines are found in ventilation air as methyl and inorganic iodines which are here defined as particulate, elemental, and hypoiodous acid forms of iodine. Particulates will also be present in the ventilation exhaust air.

The airborne radiological releases from BWR building heating, ventilating, and air conditioning and the main condenser mechanical vacuum pump have been compiled and evaluated in NEDO-21159, Airborne Releases from BWRs for Environmental Impact Evaluations, March 1976, Licensing Topical Report (Ref. 7). This report is periodically updated to incorporate the most recent data on airborne emissions. The results of these evaluations are based on data obtained by utility personnel and special in-plant

studies of operating BWR plants by independent organizations and the General Electric Company. The results are summarized in Section 11.3.

11.1.6 Radioactive Sources in the Liquid Radwaste System

The source terms for the liquid radwaste system are described in Section 11.2.

11.1.7 Radioactive Sources in the Offgas System

The radioactive sources for the offgas system are described in Section 11.3. The calculated offgas rates for EPU (Ref.9) after thirty minutes decay are 0.064 Curies/sec, within the original design basis of 0.1 Curies/sec. Therefore, no change was required in the design basis for offgas activity as a result of the increased EPU power levels.

11.1.8 Source Terms for Component Failures

The source terms for evaluation of the radiological consequences of component failures are described in Section 15.7.

11.1.9 References

1. Brutschy, F. J., "A Comparison of Fission Product Release Studies in Loops and VBWR," Paper presented at the Tripartite Conference on Transport of Materials in Water Systems, Chalk River, Canada (February 1961).

2. Williamson, H. E., Ditmore, D. C., "Experience with BWR Fuel Through September 1971," NEDO-10505, May 1972 (Update).

3. Elkins, R. B., "Experience with BWR Fuel Through September 1974," NEDO-20922, June 1975.

4. Ray, J. W., "Tritium in Power Reactors," Reactor and Fuel-Processing Technology, 12 (1), pp. 19-26, Winter 1968-1969.

5. Kahn, B., et al, "Radiological Surveillance Studies at a Boiling Water Nuclear Power Reactor," BRH/DER 70-1, March 1970.

6. Williamson, H. E., Ditmore, D. C., "Current State of Knowledge of High Performance BWR Zircaloy Clad UO Fuel," NEDO-10173, May 1970.

7. Marrero, T. R., "Airborne Releases From BWRs for Environmental Impact Evaluations," NEDO-21159, March 1976.

8. XN-NF-86-74(P), Revision 1, "Summary of Exxon Nuclear Company Fuel Performance for 1985," September 1987.

9. GE Hitachi Nuclear Energy Report, "Safety Analysis Report for Grand Gulf Nuclear Station Constant Pressure Power Uprate," NEDC-33477P, August 2010 (Tables 2.9-2 through 2.9-6).

TABLE 11.1-1: NOBLE RADIOGAS SOURCE TERMS

Isotope	Half-Life	Source Term @ t = 0 Note 1 (µCi/sec)	Source Term @ t = 30 min (µCi/sec)
Kr-83m	1.86 hr	3.4×10^3	1.8×10^3
Kr-85m	4.4 hr	6.1×10^3	3.5×10^3
Kr-85	10.74 yr	10 to 20 *	10 to 20 * 12
Kr-87	76 min	2.0×10^4	1.0×10^4
Kr-88	2.79 hr	2.0×10^4	$1\ 2 \times 10^4$
Kr-89	3.18 min	1.3×10^5	1.1×10^2
Kr-90	32.3 sec	2.8×10^5	
Kr-91	8.6 sec	3.3×10^5	
Kr-92	1.84 sec	3.3×10^5	
Kr-93	1.29 sec	9.9×10^4	
Kr-94	1.0 sec	2.3×10^4	
Kr-95	0.5 sec	2.1×10^3	
Kr-97	1.0 sec	1.4×10^1	
Xe-131m	11.96 day	1.5×10^1	9.3×10^0
Xe-133m	2.26 day	2.9×10^2	1.8×10^2
Xe-133	5.27 day	8.2×10^3	5.0×10^3
Xe-135m	15.7 min	2.6×10^4	4.3×10^3
Xe-135	9.16 hr	2.2×10^4	1.4×10^4
Xe-137	3.82 min	1.5×10^5	4.1×10^2
Xe-138	14.2 min	8.9×10^4	1.3×10^4
Xe-139	40 sec	2.8×10^5	
Xe-140	13.6 sec	3.0×10^5	
Xe-141	1.72 sec	2.4×10^5	
Xe-142	1.22 sec	7.3×10^4	
Xe-143	0.96 sec	1.2×10^4	
Xe-144	9.0 sec	5.6×10^2	
	TOTALS	$\sim 2.5 \times 10^6$	6.4×10^4

*Estimated from experimental observations.
Note 1: Source Term @ t=0 was not included in the EPU source term analysis and the associated t=0 values contained in Table 11.1-1 reflect the original design basis values.

TABLE 11.1-2: HALOGEN RADIOISOTOPES IN REACTOR WATER

Isotope	Half-Life	Concentration(μCi/g)
Br-83 Note 1	2.40 hr	1.5×10^{-2}
Br-84 Note 1	31.8 min	2.8×10^{-2}
Br-85 Note 1	3.0 min	1.7×10^{-2}
I-131	8.065 day	3.5×10^{-3}
I-132	2.284 hr	5.3×10^{-2}
I-133	20.8 hr	4.7×10^{-2}
I-134	52.3 min	8.6×10^{-2}
I-135	6.7 hr	4.6×10^{-2}

Note 1: Isotopes Br-83, Br-84, and Br-85 were not included in the EPU source term analysis results and the values contained in Table 11.1-2 reflects the original design basis source term analysis values.

TABLE 11.1-3: OTHER FISSION PRODUCT RADIOISOTOPES IN REACTOR WATER

Isotope	Half-Life	Concentration (μCi/g)
Sr-89	50.8 day	9.4×10^{-5}
Sr-90	28.9 yr	6.6×10^{-6}
Sr-91	9.67 hr	3.7×10^{-3}
Sr-92	2.69 hr	8.8×10^{-3}
Zr-95	65.5 day	7.5×10^{-6}
Zr-97	16.8 hr	5.5×10^{-6}
Nb-95	15.1 day	7.5×10^{-6}
Mo-99	66.6 hr	1.9×10^{-3}
TC-99m	6.007 hr	1.9×10^{-2}
TC-101 Note 1	14.2 min	1.6×10^{-1}
Ru-103	39.8 day	1.9×10^{-5}
Ru-106	368 day	2.8×10^{-6}
Te-129m	34.1 day	3.7×10^{-5}
Te-132	78.0 hr	9.3×10^{-6}
Cs-134	2.06 yr	2.8×10^{-5}
Cs-136	13.0 day	1.8×10^{-5}
Cs-137	30.2 yr	7.4×10^{-5}
Cs-138	32.3 min	8.3×10^{-3}
Ba-139	83.2 min	8.6×10^{-3}
Ba-140	12.8 day	3.7×10^{-4}
Ba-141	18.3 min	8.4×10^{-3}
Ba-142	10.7 min	5.0×10^{-3}
Ce-141	32.53 day	2.8×10^{-5}
Ce-143	33.0 hr	2.8×10^{-5}
Ce-144	284.4 day	2.8×10^{-6}
Pr-143	13.58 day	3.7×10^{-5}
Nd-147	11.06 day	2.8×10^{-6}
Np-239	2.35 day	7.5×10^{-3}

Note 1: Isotope Tc-101 was not included in the EPU souce term analysis results and the value in Table 11.1-3 reflects the original design basis source term value.

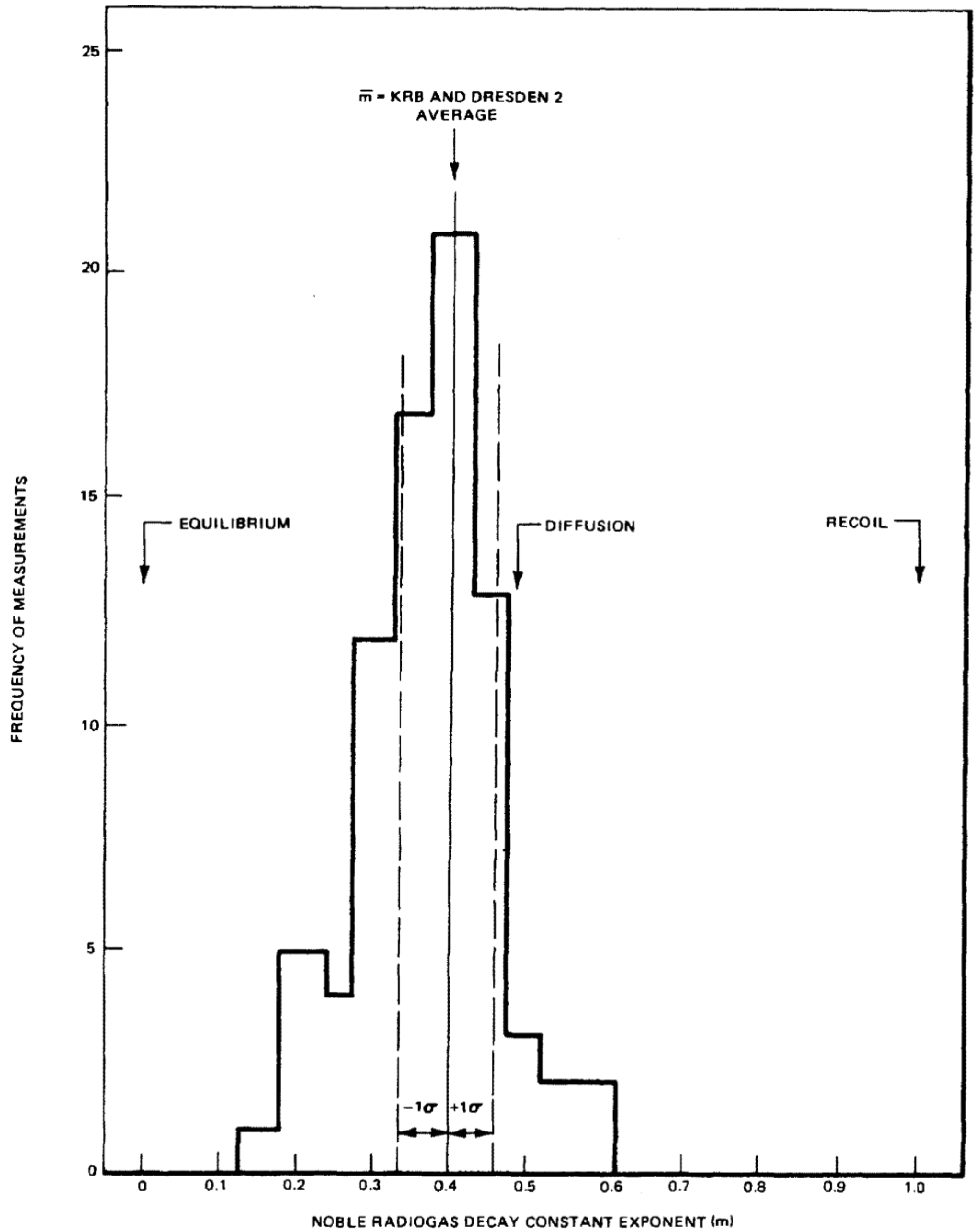
TABLE 11.1-4: COOLANT ACTIVATION PRODUCTS IN REACTOR WATER AND STEAM

Isotope	EPU Analysis Values (µCi/g)	Design Basis Values (µCi/g)	EPU Analysis Values (µCi/g)	Design Basis Values (µCi/g)
	Reactor Water		Steam	
N-13	4.0E-02	7.1E-01	3.5E-02	1.5E-03
N-16	4.8E+01	4.8E+01	2.5E+02	2.5E+02
N-17	7.2E-03	1.3E-02	1.0E-01	3.5E-02
O-19	5.6E-01	1.2E+00	1.0E+00	5.9E-01
F-18	3.2E-03	4.8E-02	2.0E+02	4.4E-04
Total	**4.9E+01**	**5.0E+01**	**2.5E+02**	**2.5E+02**

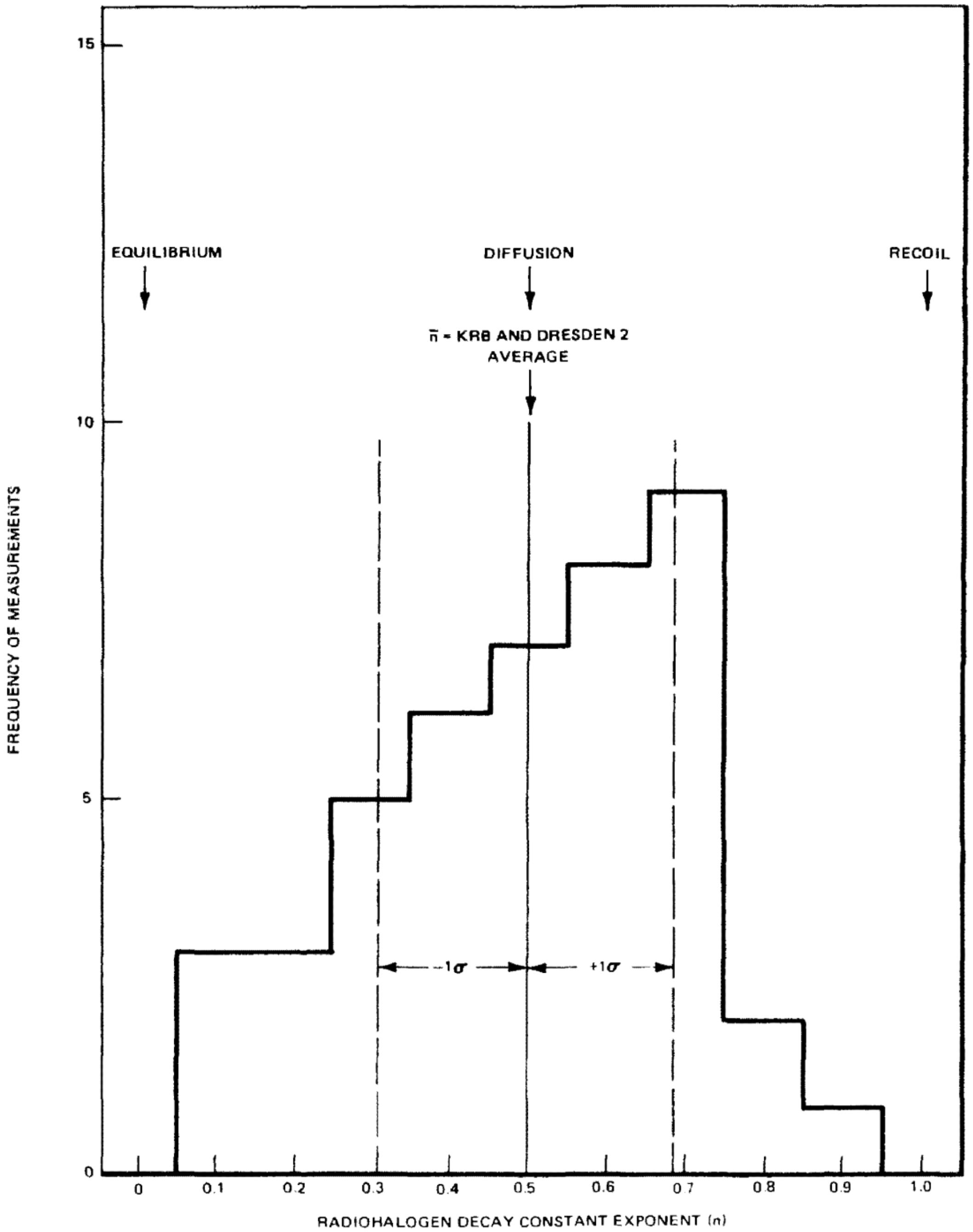
TABLE 11.1-5: NONCOOLANT ACTIVATION PRODUCTS IN REACTOR WATER

Isotope	Half-Life	Concentration(µCi/g)
Na-24	15.0 hr	9.2×10^{-3}
P-32	14.31 day	1.9×10^{-4}
Cr-51	27.8 day	5.6×10^{-3}
Mn-54	313.0 day	6.6×10^{-5}
Mn-56	2.582 hr	4.4×10^{-2}
Co-58	71.4 day	1.9×10^{-4}
Co-60	5.258 yr	3.7×10^{-4}
Fe-59	45.0 day	2.8×10^{-5}
Ni-65	2.55 hr	2.6×10^{-4}
Zn-65	243.7 day	1.9×10^{-3}
Zn-69m Note 1	13.7 hr	3.0×10^{-5}
Ag-110m	253.0 day	9.4×10^{-7}
W-187	23.9 hr	2.8×10^{-4}

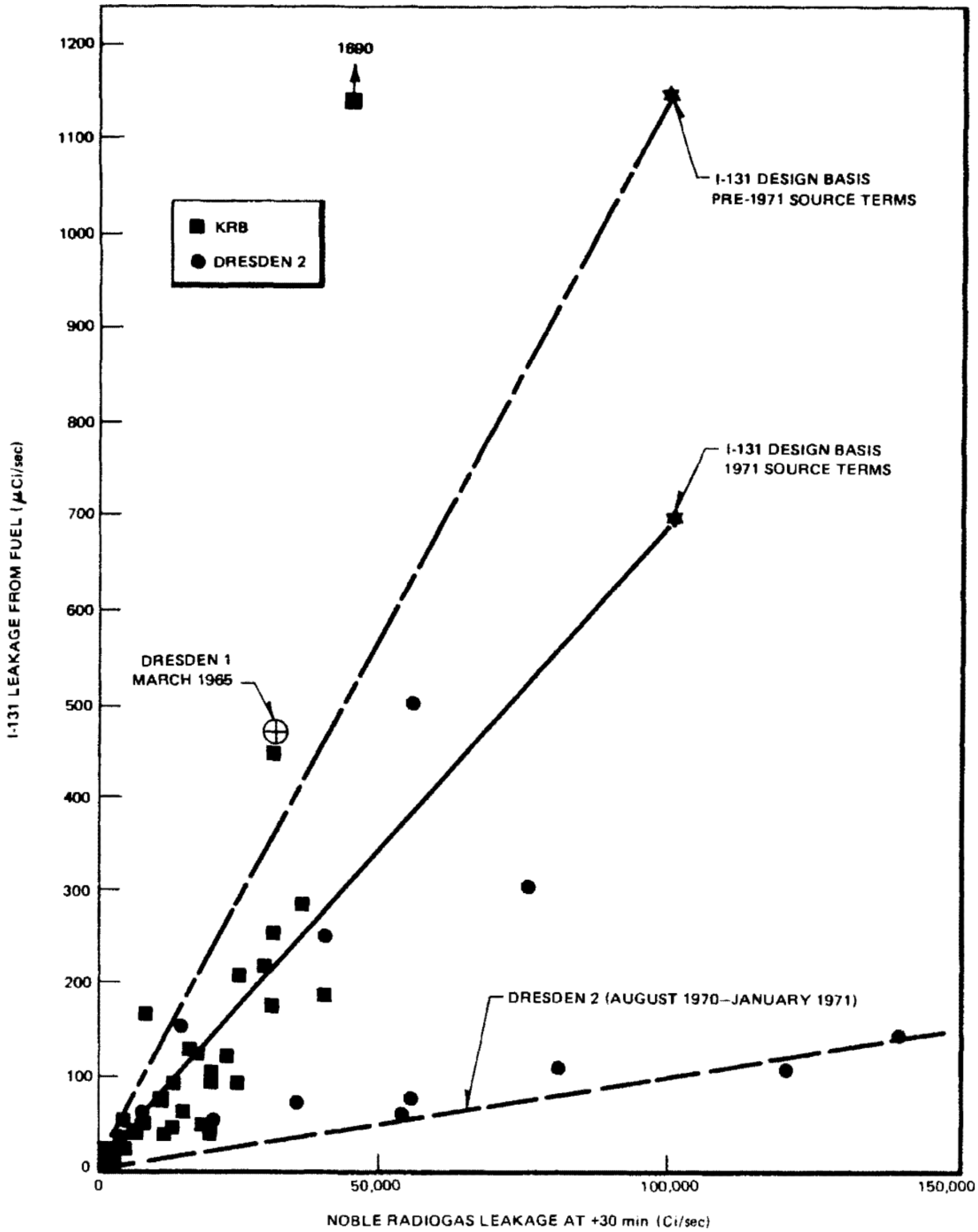
Note 1: Isotope Zn-69m was not included in the EPU source term analysis results and the value contained on Table 11.1-5 reflects the original design basis value.



MISSISSIPPI POWER & LIGHT COMPANY GRAND GULF NUCLEAR STATION UNITS 1 & 2 UPDATED FINAL SAFETY ANALYSIS REPORT	NOBLE RADIOGAS DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM FIGURE 11.1-1



MISSISSIPPI POWER & LIGHT COMPANY GRAND GULF NUCLEAR STATION UNITS 1 & 2 UPDATED FINAL SAFETY ANALYSIS REPORT	RADIOHALOGEN DECAY CONSTANT EXPONENT FREQUENCY HISTOGRAM FIGURE 11.1-2



MISSISSIPPI POWER & LIGHT COMPANY GRAND GULF NUCLEAR STATION UNITS 1 & 2 UPDATED FINAL SAFETY ANALYSIS REPORT	NOBLE RADIOGAS LEAKAGE VERSUS 1-131 LEAKAGE FIGURE 11.1-3

11.2 LIQUID RADWASTE SYSTEM

11.2.1 Design Objectives

The design objective of the liquid radwaste system is to collect, process, monitor and recycle or dispose radioactive liquid wastes. Liquid waste is processed on a batch basis to permit optimum control and disposal of radioactive waste. Prior to being released, samples will be analyzed to determine the types and amounts of radioactivity present. Based on the results of this analysis as well as other parameters, the waste may be recycled for eventual reuse in the plant, retained for further processing, or released under controlled conditions to the environment. Discharge to the environs from the Liquid Radwaste System, shall be via the discharge basin. Recycle of liquid waste will result in a radwaste material release which conforms with 10 CFR 50, which requires such releases to be “as low as reasonably achievable.”

11.2.1.1 Power Generation Design Bases

The power generation design objective of the liquid radwaste system is to collect, process, recycle or dispose of potentially radioactive wastes produced during the operation of the plant. Therefore, waste concentrations which result from effluent releases during normal plant operation will be below the regulatory limits of 10 CFR 20 and will result in doses below the “as low as reasonably achievable” guidelines set forth in 10 CFR 50, Appendix I. These wastes are grouped as floor drains, equipment drains, and chemical waste.

Liquid waste collected in the equipment drain processing system is normally transferred to the condensate storage tank after processing. Chemical wastes are sent to the floor drain collector tank for further processing or returned to the condensate storage tank. Liquid waste collected in the floor drain processing system is normally treated and released to the environment but may be recycled to the condensate storage tank. Any of these treated wastes may be discharged to the environment, providing proper dilution at the discharge basin is maintained; however, normally only processed waste from the floor drain and chemical waste subsystems will be discharged to the environment. The discharge basin is the only area designed for release of liquid effluent from the liquid radwaste system to the environment.

The liquid effluents from the liquid radwaste system are continuously monitored, and the discharges are terminated if the effluents exceed preset radioactivity levels. These levels are specified in the Offsite Dose Calculation Manual (ODCM).

Figures 11.2-13 through 11.2-18 show the liquid radwaste system components and their design parameters (e.g., flow, temperature, and pressure). Materials of construction for major components are listed in Table 11.2-14.

The liquid radwaste system is designed so that failure or maintenance of any frequently used component will not impair system or plant operation. Redundancy of frequently used components is provided to achieve this design basis. Equipment which is not redundant is cross-tied, where feasible, with similar components for backup service. The location of backup and redundant equipment allows access to nonfunctioning components for maintenance and repair. Areas of the radwaste building for which access is required under all operating conditions are shielded from radioactive and potentially radioactive components. Condensate flushing connections are provided on all process pump suction lines for decontamination of system lines and components.

Permanent contaminated laundry services will not be provided on site; normally contaminated laundry will be contracted to a commercial laundry licensed to handle contaminated material from nuclear facilities. Temporary services for contaminated laundry may be provided during outages or times of high laundry demand.

11.2.1.2 Codes and Standards

Codes and standards applicable to the liquid waste management system are listed in Table 3.2-1. The liquid waste management system and the Radwaste Building are designed and constructed in accordance with quality group D and the additional requirements of Branch Technical Position ETSB 11-1 (Revision 1, 4/75), “Design Guidance for Radioactive Waste Management Systems Installed In Light-Water-Cooled Nuclear Power Reactor Plants.”

The Spent Resin Tank (G17A007) was exposed to an overpressure condition which resulted in this tank exceeding its maximum allowable design pressure and stresses. The tank was subsequently examined, evaluated, and tested to verify it is adequate for its intended Radwaste System function. Although this tank was originally designed, constructed and tested in accordance with ASME Code Section VIII, due to the overpressure event, the tank no

longer meets requirements of ASME Code Section VIII, API-620, API-650, AWWA-D100, ANSI B96.1, or Branch Technical Position ETSB 11-1 (Revision 1).

11.2.2 System Description

The liquid radwaste system is composed of a group of subsystems designed to collect and treat different types of liquid waste. These subsystems are designated as the equipment drain processing subsystem (clean radwaste), floor drain processing subsystem (dirty radwaste), chemical waste subsystem, and miscellaneous supporting subsystems. The piping and instrumentation diagrams of these subsystems are shown in Figures 11.2-1 through 11.2-12. The system flow diagrams are shown in Figures 11.2-13 through 11.2-18. Activity concentrations for selected points on the system flow diagram also are indicated.

Design isotopic concentration or inventories for major components are given in Tables 11.2-1 through 11.2-3. These are based on parameters given in Table 11.2-7.

Isotopic decontamination factors for each piece of equipment in each subsystem are given in Tables 11.2-7 and 11.2-8.

11.2.2.1 Equipment Drains (Clean Radwaste)

High quality, generally low conductivity (less than 100 µmho/cm) wastes collected in the various equipment drain sumps (floor and equipment drains system) located throughout the plant are pumped to one of the two equipment drain collector tanks located in the radwaste building.

Figures 11.2-1 through 11.2-3 show the various flow paths that are available and the instrumentation and sample lines which provide operational performance data of the equipment.

The estimated specific activity in the equipment drain collector tank is 5.50×10^{-1} µCi/ml, assuming an average flow rate of 12 gpm. This subsystem will normally be operated on a batch basis 24-hours-per-day.

The waste, which is collected in one of the two 40,000-gallon equipment drain collector tanks, is pumped at a maximum process flow rate of 300 gpm through a precoat-type filter.

After being filtered, the waste is processed through a mixed deep bed non-regenerative demineralizer and discharged into one of two 40,000-gallon sample tanks. If the demineralizer is not operating, the waste can be bypassed directly to the sample tank or processed in the floor drain demineralizer, depending on the water quality. Provisions are also available for interfacing with mobile filtration equipment or alternative waste processing equipment.

Conductivity elements are located upstream and downstream of the equipment drain demineralizer to signal improper equipment operation. Prior to pumping the recycled water back to the condensate storage tank samples are taken from the sample tank to assure that the water quality meets the requirements for reuse. If the water in a sample tank does not meet the specified requirements, it can be pumped back to the corresponding collector tank or the waste surge tank. (See subsection 11.2.2.7.)

In addition to the tanks which are considered part of the equipment drain processing subsystem, there are two waste surge tanks (interconnected) with a total capacity of 100,000 gallons. These tanks are normally used to collect surge volumes of liquid wastes for processing and can accommodate very large transient waste generation (e.g., discharge from the suppression pool and RHR systems). The waste collected in the waste surge tanks can be processed as equipment drain waste, except that the condensate precoat filter backwash wastes, produced during startup, which are normally collected by the condensate phase separator tanks, can also be collected in the waste surge tanks and transferred directly to the solid radwaste system for disposal. In the event neither the equipment drain nor floor drain processing equipment is available, there is adequate storage in the collector tanks for approximately three days accumulation of waste (assuming an average daily total input of 32,052 gallons). Both subsystem flow rates are adequate to process the anticipated waste volumes from both equipment drains and floor drains.

11.2.2.2 Floor Drains (Dirty Radwaste)

Lower quality, intermediate-conductivity (between 100 and 1000 µmho/cm) wastes collected in the various floor drain sumps (floor and equipment drains system) located in the drywell, containment, auxiliary building, and radwaste building and chemical drain

subsystem wastes are pumped directly to the floor drain collector tank (capacity 30,000 gallons) in the radwaste building. Turbine building floor drains and drains from the control building are first routed through the liquid radwaste system floor drain oil separator; oil-free effluent from the oil separator is then allowed to overflow to the floor drain collector tank. These wastes will contain a lesser percentage of reactor coolant water than the waste treated as equipment drain waste.

Figures 11.2-4 through 11.2-7, 11.2-9 and 11.2-12 show the various flow paths that are available and the instrumentation and sample lines which provide the operational and performance data of the equipment.

The floor drain waste is filtered and demineralized with the same type of equipment as the equipment drain waste. This subsystem will normally be operated on a batch basis 24 hours per day. As with the equipment drain subsystem, provisions are available for interfacing with mobile filtration equipment or alternative waste processing equipment.

If it is impractical to clean up the floor drain subsystem inventory to meet condensate water quality standards, the water can either be sent back to the floor drain collector tank or waste surge tank, or discharged to the environment. Prior to discharge of water to the environs, it may be processed through mobile filtration equipment or alternative waste processing equipment. Up to 100 percent of this waste may be discharged. All discharges will be monitored for concentration of radioactive material and evaluated for doses to unrestricted areas in accordance with the Offsite Dose Calculation Manual (ODCM).

There is sufficient storage capacity in the floor drain collector tank to accommodate the average flow from the floor drain subsystem for approximately 2.5 days (assuming an average daily input of 11,775 gallons).

This subsystem is so sized that, in the event the equipment drain processing subsystem is unavailable, the floor drain subsystem can accommodate the entire equipment drain flow without detrimental effect on plant operation.

11.2.2.3 Chemical Waste Subsystem

Chemical wastes from laboratory drains, equipment decontamination, and drains from systems that have chemical additives are transferred from the chemical waste sumps (floor and equipment drains system) located in various areas of the plant to the miscellaneous chemical waste receiver tank (capacity 10,000 gallons) located in the radwaste building.

The chemical waste subsystem is shown in Figures 11.2-8, 11.2-9, and 11.2-11. Indicated are the various flow paths that are available and the instrumentation and sample lines which provide the operational performance data of the equipment.

The Advanced Resin Cleaning Subsystem is located in the area where the resin regeneration equipment had previously been located on Elevation 93'-0" of the Turbine Building. The drains in the immediate vicinity are chemical waste drains. Even though the ARCS does not produce chemical wastes, the drains for the ARCS are routed to the chemical waste drains in the immediate vicinity. These ARCS drains will be mixed and processed along with dirty radwaste. Also, mobile filtration equipment or alternative waste processing equipment may be used to process this waste.

11.2.2.4 Miscellaneous Support Subsystems

The following support items are included as part of the liquid radwaste system to serve the noted functions:

a. Oil Separation

   The floor drain oil separator is used to prevent oil from entering the liquid radwaste processing stream, and thus avoiding potential problems in attaining high-quality effluent for return to condensate storage or for plant discharge. Oil is separated from the water on the basis of the difference in their specific gravities. Oil which is collected on the surface of the water is removed by a skimming process. The oilfree effluent from the oil separator overflows, by gravity, to the floor drain collector tank. This item and associated flows are shown in Figure 11.2-14.

b. RWCU Phase Separation and Decay

Wastes resulting from the backwash of the reactor water cleanup (RWCU) system filter/demineralizers and fuel pool cooling and cleanup (FPC&CU) system filter/ demineralizers are transferred from the containment and auxiliary building, respectively, to one of the two RWCU phase separator decay tanks located in the radwaste building. The RWCU decant pump draws off excess water and transfers it to the equipment drain collector tank for further processing. When sufficient decay of the RWCU and FPC&CU precoat material waste has been achieved, the contents of the tank are slurried with condensate and pumped to the solid radwaste system for disposal.

Figure 11.2-10 shows the various flow paths that are available and the instrumentation associated with this equipment.

c. Spent Resin

The spent resin tank collects exhausted resins from the equipment drain and floor drain demineralizers and condensate demineralizers. The spent resin pump is used to provide motive force to the spent resin tank sparger to slurry the resins and to transfer the resin slurry to the solid radwaste system for disposal.

These items and associated flows are shown in Figure 11.2-16. Isotopic activities of the exhausted resin mixture entering the spent resin tank are given in Table 11.2-2.

d. Condensate Phase Separation

Wastes resulting from the backwash of the condensate cleanup system precoat filters are transferred from the turbine building to one of two condensate phase separator tanks located in the radwaste building. Excess water is gravity drained to the waste surge tanks or RWCU phase separator decay tanks for further processing. When processing of the spent filter precoat material is desired, the contents of the tank are slurried with condensate and pumped to solid radwaste system for disposal.

Figure 11.2-12a shows the various flow paths that are available and the instrumentation associated with this equipment.

e. Removal of Resin Fines, Particles and Other Impurities

Liquid radwaste flow from the Equipment Drain Demineralizer is filtered via the Liquid Radwaste cartridge filter before going into the Equipment Drain Sample Tanks and subsequently to the Condensate Storage Tank.

Figure 11.2-3 shows the filter and various flow paths available and instrumentation associated with this equipment.

f. Alternative Liquid Radioactive Waste Processing Equipment

The radwaste system includes provisions for use of alternate liquid radioactive processing equipment. This equipment may include strainers, carbon bed filters, cartridge filters, a reverse osmosis unit or other components which process liquid radioactive wastes. Alternative liquid waste processing equipment will be used in conjunction with existing radwaste system equipment such as collection tanks, transfer piping and demineralizers. This processing equipment will be designed and constructed in accordance with applicable codes and standards. The flow rate of the alternative liquid waste processing system will be commensurate with the design of the liquid radwaste system. Radioactive wastes generated by the alternative liquids waste processing equipment will be collected and processed through the use of approved methods.

g. Condensate Full Flow Filter (CFFF) backwash suspended solids that are removed from the condensate system by the CFFF system are backwashed into the Condensate Clean Waste Tank (CCWT). From there the fluid is pumped to the Radwaste system for processing. The CCWT acts as a surge tank allowing for a controlled flow to be forwarded into the Radwaste system.

11.2.2.5 Instrumentation Application

The equipment drain collector tanks, waste surge tanks, equipment drain sample tanks, floor drain collector tank, floor drain sample tanks, condensate demineralizer regeneration solution receiving tanks, and miscellaneous chemical waste receiver tank are each provided with the following instrumentation:

a. Continuous level recording in the water inventory control station and continuous level monitoring by the plant computer

b. Alarm points and computer logging for each excessively high or low tank level

c. Low-level pump shutoff for pump protection

In addition to the above, the recirculation conductivity is continuously monitored on the equipment drain collector tanks, the waste surge tanks, and the floor drain collector tank.

The equipment drain collector pump, waste surge pump, equipment drain sample pump, floor drain collector pump, and miscellaneous chemical waste receiver pump are each provided with the following instrumentation:

a. Continuous local pressure indication on the pump discharge

b. Alarm points, computer logging, and pump shutoff for excessively high discharge pressure

The spent resin pump and condensate phase separator pumps have continuous local pressure indication on the pump discharge only. The RWCU phase separator discharge pump and the RWCU phase separator decant pump have continuous local pressure indication on the pump discharge as well as pump shutoff for excessively low pressure.

The equipment drain and floor drain filters are package systems. The following instrumentation is provided as part of the package:

a. Inlet pressure indication

b. Differential pressure indication between filter vessel and the outlet

c. An excessive cake-thickness switch

d. Turbidity monitoring of the filter effluent

e. Miscellaneous switches and indicators for proper control and performance monitoring of the system

The flow through each filter shall be recorded and controlled in the water inventory control station and monitored by the plant computer. An excessively low flow will be alarmed and logged by the plant computer.

The radwaste demineralizers have their differential pressure indicated locally. An excessively high differential pressure will be alarmed and logged by the plant computer.

The influent and effluent conductivity of each demineralizer is continuously recorded and monitored by the plant computer. An excessively high effluent conductivity will be alarmed, and logged by the plant computer, and isolation of the sample tanks will be initiated.

The RWCU phase separator tanks, condensate phase separator tanks, and the spent resin tank have ultrasonic level instrumentation. This instrumentation will indicate discrete resin levels and discrete liquid levels for control and alarming functions. The spent resin tank and the condensate phase separator tanks also have a bubbler system for gross liquid level indication and control functions.

All radwaste discharge to the plant discharge basin is continuously monitored, recorded, and controlled for flow, and continuously monitored for radioactivity. High radioactivity will be alarmed, and the discharge isolated.

11.2.2.6 System Design

The radwaste building equipment arrangement is presented in Figures 12.3-5 through 12.3-9. Seismic analysis of the building is in accordance with Branch Technical Position ETSB 11-1 (Revision 1, 4/75). The seismic classification of the radwaste building foundation is also in accordance with the requirements of ETSB 11-1. The radwaste building layout provides design features consistent with Regulatory Guide 8.8 (as discussed in Appendix 3A) to minimize operator exposure. Components of high activity are segregated and shielded in separate compartments. Those of intermediate and low activity are grouped so that doses are minimized during operator entry for inspection or maintenance.

System piping and components were hydrostatically tested prior to initial startup.

A 6-inch curb is provided at the entrance to each liquid radwaste system tank room to contain the release of radioactive wastes caused by a pipe break or equipment failure inside the room. Overflow from these tanks will be collected in one of the floor and equipment drains system sumps.

The primary operating station for the liquid radwaste system is the water inventory control station located at El. 118-0 in the radwaste building, with some less critical functions being performed locally. The philosophy of the liquid radwaste control system is manual start and automatic stop, with all functions interlocked to provide a fail-safe mode of operation. Each process path is set up manually and interlocked by means of the solid-state interlock system (radwaste control) to prevent incorrect operation. Only when a “legitimate” path is established by the operator can processing through the selected path commence.

Samples needed frequently are drawn in a centrally located sample sink adjacent to the sample lab. Throughout the building, process support equipment, such as pumps and valves, are located outside process component cells in their own shielded areas. Piping runs are located in shielded piping chases.

Special equipment design provisions also have been incorporated to reduce maintenance, equipment downtime, and liquid leakage and to reduce operator exposure, consistent with Regulatory Guide 8.8. Where practicable, welded connections are used in lieu of flanged ones. Butt welds without backing rings are used through most of the liquid waste systems to reduce crud trap formation. Redundant or backup pumps and process lines allow for draining and flushing of individual pumps and piping.

Tanks are provided with mixing eductors and sloped bottoms to control sediment buildup. Reduced maintenance of equipment is provided by utilizing plug valves and corrosion-resistant materials wherever feasible.

Control and monitoring of radioactive releases consistent with Design Criteria 60 and 64 of Appendix A to 10 CFR 50 are discussed in subsection 11.2.3 and Section 11.4, respectively.

A list of tanks located outside the containment which contain potentially radioactive fluid is provided in Table 11.2-15.

11.2.2.7 Operating Procedures

Operation of the liquid radwaste system consists of a series of automatic and operator-controlled operations. Collection is generally accomplished automatically while processing paths are selected by the operator. Plant operating procedures will be written covering Radioactive Waste Management.

Filters are used until the pressure drop across them or the cake thickness on the plates reaches a predetermined limit. In the modified filtration mode the flow through the filters can be continued at reduced flow rate while maintaining a constant pressure drop across the filter until a preset minimum is reached. At this time the flow can be stopped or diverted until backwash and precoating are completed. Demineralizers (ion exchangers) are operated until either the conductivity of the effluent or the differential pressure across the vessels reaches a preset level indicating resin bed depletion. At this time the demineralizer is isolated from the system. The exhausted resin bed is sluiced to the spent resin tank and a new resin bed is established using either new resin or used resin transferred from the condensate clean-up (N22) system demineralizers.

Two evaporators were available for removing solids from the liquid radwaste system. Though originally intended for normal use in processing liquid radwaste, the evaporators at GGNS have never been used.

The distillate sample tanks and pumps will be used to dispose of flush water resulting from standby liquid control system testing.

When two tanks are used for collection of wastes, one tank is used to receive influent liquid until processing begins or until the tank's liquid volume reaches the predetermined level. Tank level switches, with appropriate gauges and alarms, are used to alert operators to high level and low level conditions. Overflow lines are connected to the radwaste building sumps.

The following constitutes a set of operational methods which minimizes operator error and provides proper integrated system operation.

11.2.2.7.1 Equipment Drain

Equipment drains are collected in one of two equipment drain collector tanks. The contents of one tank will be processed while the other tank is being filled. Two interconnected waste surge tanks can also be used to collect quantities of waste. Wastes from both sets of tanks can be processed in a similar manner.

A cross-connection with the suction of the floor drain collector pump is located upstream of the isolation valves on the equipment drain collector pump and the waste surge pump. The cross-connection allows the processing of the contents of any of the above tanks, including the floor drain collector tank, using any of the three pumps. Similar cross-connections exist between the pump discharges for each of the three pumps, downstream of the equipment and floor drain filters and downstream of the equipment and floor drain demineralizers. Additional flexibility is provided in the form of cross-ties which permit interfacing with mobile filtration equipment or alternative waste processing equipment.

Waste water is processed through the equipment drain filter and equipment drain demineralizer. A flow element downstream of the filter will automatically cause an alarm in the water inventory control station should the system flow rate drop below 25 percent of rated flow. Both the floor and equipment drain filters have the capability to remove suspended “crud” and heavy metal oxides, such as iron oxides. Conductivity cells are located both upstream and downstream of the equipment drain demineralizer. A high reading in either conductivity cell will automatically alarm in the water inventory control station. If low flow is detected downstream of the filter, the equipment drain collector pump will be stopped.

If high conductivity is detected, the process feed isolation valve will be closed and the pump will be returned to its recirculation mode of operation. A conductivity cell is also provided on the equipment drain collector tank and waste surge tank recirculation lines. This feature enables the operator to determine the conductivity of the wastes prior to processing, without sampling, thereby permitting best selection of a processing mode (i.e., filtration and/or demineralization).

Cross-connections have been provided between each demineralizer inlet and outlet line; this feature permits operation of the equipment drain demineralizer and floor drain demineralizer in either a series or a parallel mode.

A siphon-breaker loop seal is provided on the line between the demineralizer and the sample tank. The purpose of this device is to prevent the loss of water from the filter and demineralizer, because of the difference in elevation between the equipment and the sample tank, when process flow is stopped.

The processed water is collected in one of two equipment drain sample tanks. The water is sampled and, if suitable for condensate makeup, is pumped, using the equipment drain sample pump, to the condensate storage tank. If additional processing is required, the water may be transferred to either of the equipment drain collector tanks or the floor drain subsystem. At no time will discharge from either equipment drain sample tank be allowed while it is being filled. It is anticipated that most of the water treated as equipment drains will be reused in the plant.

11.2.2.7.2 Floor Drains

Floor drains are collected in the floor drain collector tank. Two interconnected waste surge tanks can collect quantities of waste in the event the floor drain collector tank is unavailable or in use for other purposes.

A cross-connection with the suction piping of the equipment drain collector pump and the waste surge pump from the suction piping of the floor drain collector pump is located upstream of the pump suction isolation valves. Similar cross-connections exist between the pump discharges, filter discharges, and demineralizer discharges. As with the equipment drain subsystem, cross-ties are available which permit interfacing with mobile filtration equipment or alternative waste processing equipment.

When the floor drain collector tank is filled, its contents are processed through the floor drain filter and the floor drain demineralizer. A flow element downstream of the filter will automatically cause an alarm in the water inventory control station should the system flow rate drop below 25 percent of the rated flow. Conductivity cells are located both upstream and downstream of the floor drain demineralizer. A high reading in either conductivity cell will automatically alarm in the water inventory control station. If low flow is detected downstream of

the filter, the floor drain collector pump will be stopped. If high conductivity is detected, the process feed isolation valve will be closed and the pump will be returned to its recirculation mode of operation. A conductivity cell is also provided on the floor drain collector pump recirculation line to provide the operator with an immediate reading on the conductivity of tank contents. If the conductivity is relatively high, the waste may be processed with or without filtration and processed through alternative available equipment. If the conductivity is relatively low, the waste may be processed, normally, by filtration and demineralization.

Cross-connections on the inlet and outlet lines of the floor drain demineralizer permit operation of the equipment and floor drain demineralizers in series or parallel, in lieu of the single stream processing mode.

A siphon-breaker loop seal is provided on the line between the demineralizer and the sample tank. The purpose of this device is to prevent the loss of water from the filter and demineralizer, because of the difference in elevation between this equipment and the sample tank, when process flow is stopped.

If the conductivity of the floor drain waste is low enough to be treated (i.e., by filtration and demineralization) the processed water is collected in one of two floor drain sample tanks. The water is sampled, and, if suitable for condensate makeup, is pumped, using the floor drain sample pump, to the condensate storage tank. A cross-connection exists between the suction side of the equipment drain and floor drain sample pumps. Should either pump be out of service, the contents of any of the aforementioned four sample tanks can be transferred using the remaining sample pump. If, after sampling, additional processing is required, the water may be recycled to the floor drain collector tank. At no time will discharge from either floor drain sample tank be allowed while it is being filled. Waste which is not recycled will be discharged to the environs through the discharge basin.

11.2.2.7.3 Chemical Wastes

Chemical wastes collected in the miscellaneous chemical waste receiver tank or regeneration solution receiving tanks may be mixed with floor drain wastes, processed, and released to the discharge basin.

Since the radwaste system evaporators are not used to process radioactive wastes, the evaporator concentrate line heat trace circuits have been electrically disconnected and have been abandoned in place. All concentrate lines were electrically heat traced to prevent crystallization (or solidification) of evaporator concentrate in the process lines. Although these heat trace circuits are electrically disconnected, and are not in use, the heat trace material remains installed on the affected radwaste system piping.

11.2.2.7.4 Miscellaneous Support Systems

a. Oil Separation

Radioactive drains from the turbine building floors and control building hot machine shop area and nonradioactive, potentially oily drains from the lube oil conditioner, reactor feed pump turbine lube oil coolers and tank, and the main turbine lube oil reservoir area are collected in selected floor drain sumps (floor and equipment drains systems) and are pumped to the radwaste building for processing. Because of deleterious and undesirable effects on the liquid radwaste system processing components, it is necessary to remove all oil from the liquid waste influent streams. The floor drain oil separator is used to remove this oil contaminant. The oil is separated from the water on the basis of the difference in their specific gravities. As the waste stream enters the unit the oil is allowed to separate and rise to the top, while the clarified water is directed out the discharge and allowed to overflow to the floor drain collector tank. The oil which is collected on the surface of the water is controlled, and finally removed, by a pivoted float assembly and skimmer.

b. RWCU Phase Separation and Decay

Backwash from the RWCU filter/demineralizers and FPC&CU filter/demineralizer is transferred to one of the two RWCU phase separator decay tanks. After the filter media settles, the RWCU decant pump is used to draw off the excess backwash water. This water is routed to the equipment drain collector tank for processing. A sparger system in each tank is used to prevent excessive settling of the media. After decanting, water is added to the tank

through the sparger system. The solids in the tank are mixed with the water until a homogeneous slurry (approximately 15 percent by weight) is produced. The slurry is then pumped, using the RWCU discharge pump, into liners for dewatering or solidification.

c. Spent Resin

A high conductivity reading in the conductivity cell located downstream of either the equipment or floor drain demineralizer, without a high reading in the corresponding conductivity cell upstream of the demineralizer, would indicate resin exhaustion. A high differential pressure across the demineralizer can also indicate exhaustion of the resin bed, but in this case, exhaustion will be due to a high crud loading and not ionic depletion of the resin. In either case, flow through the demineralizer is stopped (see subsections 11.2.2.7.1 and 11.2.2.7.2), and the spent resins are flushed from the vessel. The spent resin is collected in the spent resin tank and held for decay. The spent resin tank may also be used to collect wastes resulting from depleted condensate demineralizer resins and high particulate wastes resulting from cleaning of the condensate demineralizer beds. After sufficient time for radioactive decay of the short-lived isotopes, the resin is transferred to the solid radwaste system. The spent resin pump is used to mix the settled resins with water (using the spent resin tank sparger) until a homogeneous slurry is produced, and to transfer the slurry to the solid radwaste system for disposal.

d. Condensate Phase Separation

Backwash from the condensate cleanup system precoat filter is transferred to one of the two condensate phase separator tanks. After the filter media settles, the excess water is gravity drained to the waste surge tanks, where it is processed as described in Subsection 11.2.2.7.1, or the RWCU phase separator decay tanks (where further settling can be performed) where it is processed as described in Subsection 11.2.2.7.4.b. Either condensate phase separator tank can be used to collect the condensate precoat filter backwashes. When processing of the filter media is desired water can be added to the tank(s) from the condensate and refueling water storage and transfer

system. The solids in the tank are mixed with a sparger until a homogeneous slurry is produced. The slurry is then pumped, using the condensate phase separator pump, to the solid radwaste system for disposal.

e. Removal of Resin Fines, Particles and Other Impurities

Before going to the EDSTs, Liquid Radwaste, from the Equipment Drain Demineralizers is filtered via the Radwaste Cartridge Filter. Resin fines, filter media particles, iron particles and other impurities are removed from water passing through the filter before being transferred into the EDSTs for makeup to the Condensate Storage Tank (CST). Filtering the water before it reaches the CST is needed to prevent the transfer of resin and particulates which could cause reactor conductivity spikes.

11.2.2.8 Performance Testing and Inspection

Actual system performance tests (without radioactive materials) for each component are performed prior to plant operation to ensure that the equipment performs as specified. Shop tests are performed on most equipment to ensure it meets the performance requirements prior to its shipment. Field tests also are performed after the component has been installed.

In addition to performance testing, the process components of the radwaste system (liquid and solid) are inspected for conformance to design specifications and particular installation requirements set forth in Table 3.2-1.

Tests involving radioactive materials cannot be performed until the plant is operational and waste is being produced.

Samples are taken at strategic locations to assure that the equipment decontamination factors are equal to or better than those used in estimating plant effluents. In the event the factors are significantly higher or lower than those specified, the Safety Analysis Report and Environmental Report will be amended to reflect the new factors. During the startup test phase, the operation and surveillance of the liquid radwaste system processing will be in accordance with technical specifications and approved plant operating procedures.

The frequency of these tests is based on actual operating experience in the plant and data from other plants with similar systems.

11.2.2.9 Quality Control

The quality control program for the liquid radwaste system is the same as described in section 11.3.2.2.1.3. This program is in accordance with BTP-ETSB 11-1 (Rev. 1).

11.2.3 Radioactive Releases

As discussed in subsection 11.2.1.1, the subsystem that normally discharges to the environment is the floor drain processing subsystem which includes the chemical waste subsystem as discussed in subsection 11.2.2.7.3. However, the processed equipment drains may be discharged via the discharge canal to the environment if necessary. The rate of discharge will be controlled so as to have the proper dilution factor where the discharge is mixed with the dilution flow. The discharge flow rate will be determined in accordance with the techniques specified in GGNS's Offsite Dose Calculation Manual (ODCM).

Control of liquid releases from the liquid radwaste system includes a radiation monitor, an effluent flow control valve, and dilution water flow rate monitoring equipment. The system design provides an automatic isolation signal in the event that the measured radioactivity level, or release rate departs from preset ranges of values. For dilution flow, the system design provides an automatic isolation signal or manual isolation in the event the measured dilution water flow rate departs from a preset range of values. This design ensures radioactive liquid releases will be controlled in accordance with applicable regulations and impacts to offsite areas will be consistent with ALARA concepts.

Calculations of the annual releases of radioactivity to the environment in liquid effluents assumed Unit 1 to be operational. The calculations are performed by the BWR-GALE Code given in the USNRC's NUREG-0016 Report (Ref. 1) which is a companion document to Regulatory Guide 1.112, “Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors,” April 1976.

The following section contains historical information: [Parameter inputs to the BWR-GALE Code assumed single unit operation. These parameters are presented in Table 11.2-8.

The annual expected releases of activity to the environment in liquid effluents (including tritium) are presented in Table 11.2-10. (Table 11.2-10 contains data based on design calculations performed for effluent releases of liquid radwaste. Operating procedures allow up to 100% effluent release as long as ODCM requirements are maintained.) These releases are obtained directly from the BWR-GALE Code's output.]

11.2.3.1 Release Points

The primary release point of liquid radioactive waste is via the radwaste discharge pipe. This point is shown in Figures 11.2-9 and 11.2-16. The release point of this waste, together with other plant effluents, is shown on Figure 2.1-2. In addition to sample points at strategic places in all the subsystems, there is an automatic plug valve to assure that wastes not meeting regulatory requirements are not discharged. The discharge radiation monitor will measure gross beta-gamma radiation. Specific isotope analysis will be done in the laboratory on a periodic basis.

Low levels of tritium may be released via the storm drainage system, outfall 007. This release point will be sampled and evaluated in accordance with GGNS’s Offsite Dose Calculation Manual.

11.2.3.2 Dilution Factors

The offsite dose analysis is based on an average dilution flow rate of 11,370 gpm. The liquid waste discharge from the plant is via the radwaste discharge pipe to the discharge basin. This release flow will be diluted by circulating water cooling tower blowdown, Plant Service Water or by use of the low volume waste water basin. Prior to discharge, the allowable discharge flow rate will be determined in accordance with the techniques specified in GGNS's Offsite Dose Calculation Manual.

For releases via the storm drain system, the dilution factor is the environmental dilution derived from the lowest historical annual precipitation.

11.2.3.3 Estimated Doses

Release of the radioactive materials in liquid effluents to the discharge basin from where radioactive materials are subsequently released to and mix with the Mississippi River water, will result in minimal radiological exposures to individuals and the general

public. Since irrigation has not been found necessary or observed in the area around the Grand Gulf site (average rainfall for Vicksburg -50 inches) this pathway has not been considered in the evaluation of doses. Likewise, the dose due to drinking water has not been considered since the nearest point for potable use of water is below Baton Rouge, Louisiana, about 195 river miles downstream. Shoreline use is very limited with essentially no fishing from the bank, swimming or sunbathing and consequently is expected to be an insignificant pathway in comparison with the pathway of aquatic foods. Nevertheless, for purposes of conservatism, this pathway has been included in the evaluation of doses for the maximum exposed individual.

Estimated annual radiation exposures to the maximum (expected) exposed individual via the pathways of aquatic foods and shoreline deposits and to the population within a 50-mile radius of the Grand Gulf Nuclear Station via the pathway of aquatic foods are given in Tables 11.2-11 and 11.2-12, respectively. These doses have been evaluated using the models and the values for the required parameters given in Regulatory Guide 1.109 (Ref. 2). A single dilution factor was conservatively chosen for all points of exposure or harvest of aquatic food. For shore width, a value of 0.2 given in Reference 2 for river shore line was chosen. Expected population distribution by sectors and distances in the year 2000 given in subsection 2.1.3 and the commercial and sport aquatic food catch data provided in Table 11.2-13 were used to evaluate population exposures.

Low levels of tritium have been detected in the storm drain system (Ref. 5). Historically the amount of tritium released via the storm drain system contributes less than 10 percent of the total dose from all the release pathways at Grand Gulf, therefore it is not considered significant in accordance with Regulatory Guide 1.109 (Ref. 2). The storm drain system will be periodically sampled and evaluated in accordance with the GGNS’s Offsite Dose Calculation Manual.

As can be seen from Table 11.2-11, the maximum (expected) exposed individual annual doses from the discharge of radioactive materials in liquid effluents from Grand Gulf meets the guidelines of Appendix I to 10 CFR 50. Since the guidelines for the maximum individual exposure via hydrospheric pathways are much more restrictive (at least by a factor of 160) than the standards of 10 CFR Part 20, it can be inferred that radioactive releases in liquid effluents from Grand Gulf Nuclear Station meet

the standards on concentrations of released radioactive materials in water (accessible to a maximum exposed individual of the general public) as specified in Column 2 of Table II of 10 CFR 20.

11.2.4 References

1. USNRC NUREG-0016, (Rev. 1), "Calculations of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors" (BWR-GALE Code).

2. USNRC Regulatory Guide 1.109 Revision 1, October, 1977 "Calculation of Annual Doses to Man from Radioactive Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix 1."

3. Letter from W. T. Cottle to NRC Document Control Desk, GNRO-91/00148, August 15, 1991, Subject: Schedule for UFSAR Changes Reflecting Termination of Construction Permit No. CPPR-119 for GGNS Unit 2.

4. General Electric Document 22A2703V, Rev. 4.

5. Radiological Assessment of Storm Drain Tritium Discharges at the Grand Gulf Nuclear Station. GIN 2005-00562

TABLE 11.2-1: DESIGN SPECIFIC ACTIVITIES IN TRANSFER, COLLECTOR, AND SAMPLE LIQUID RADWASTE SYSTEM TANKS

	Floor Drain Wastes (µCi/cc)		Equipment Drain Wastes (µCi/cc)			Miscellaneous Chemical Wastes (µCi/cc)	
Isotope	**Collector Tank**	**Sample Tank**	**Collector Tank**	**Surge Tank**	**Sample Tank**	**Receiver Tank**	**Sample Tank**
F-18	4.00E-06	4.00E-08	1.09E-03	2.40E-04	9.72E-06	4.00E-06	4.00E-08
Na-24	2.00E-06	2.00E-08	5.46E-04	1.20E-05	4.86E-06	2.00E-06	2.00E-08
P-32	2.00E-08	2.00E-10	5.46E-06	1.20E-06	4.86E-08	2.00E-08	2.00E-10
Cr-51	5.00E-07	5.00E-09	1.37E-04	3.00E-05	1.22E-06	5.00E-07	5.00E-09
Mn-54	4.00E-08	4.00E-10	1.09E-05	2.40E-06	9.72E-08	4.00E-08	4.00E-10
Mn-56	5.00E-05	5.00E-07	1.37E-02	3.00E-03	1.22E-04	5.00E-05	5.00E-07
Fe-59	8.00E-08	8.00E-10	2.18E-05	4.80E-06	1.94E-07	8.00E-08	8.00E-10
Co-58	5.00E-06	5.00E-08	1.37E-03	3.00E-04	1.22E-05	5.00E-06	5.00E-08
Co-60	5.00E-07	5.00E-09	1.37E-04	3.00E-05	1.22E-06	5.00E-07	5.00E-09
Zn-65	2.00E-09	2.00E-11	5.46E-07	1.20E-07	4.86E-09	2.00E-09	2.00E-11
Zn-69m	3.00E-08	3.00E-10	8.19E-06	1.80E-06	7.29E-08	3.00E-08	3.00E-10
Ni-65	3.00E-07	3.00E-09	8.19E-05	1.80E-05	7.29E-07	3.00E-07	3.00E-09
Br-83	1.30E-05	1.30E-07	3.55E-03	7.80E-04	3.16E-05	1.30E-05	1.30E-07
Br-84	2.80E-05	2.80E-07	7.64E-03	1.68E-03	6.80E-05	2.80E-05	2.80E-07
Br-85	1.90E-05	1.90E-07	5.19E-03	1.14E-03	4.62E-05	1.90E-05	1.90E-07
Sr-89	2.30E-06	2.30E-08	6.28E-04	1.38E-04	5.59E-06	2.30E-06	2.30E-08
Sr-90	1.70E-07	1.70E-09	4.64E-05	1.02E-05	4.13E-07	1.70E-07	1.70E-09
Sr-91	5.70E-05	5.70E-07	1.56E-02	3.42E-03	1.39E-04	5.70E-05	5.70E-07
Sr-92	1.00E-04	1.00E-06	2.73E-02	6.00E-03	2.43E-04	1.00E-04	1.00E-06
Zr-95	3.00E-08	3.00E-10	8.19E-06	1.80E-06	7.29E-08	3.00E-08	3.00E-10
Nb-95	3.10E-08	3.10E-10	8.46E-06	1.86E-06	7.53E-08	3.10E-08	3.10E-10
Zr-97	2.50E-08	2.50E-10	6.83E-06	1.50E-06	6.08E-08	2.50E-08	2.50E-10
Mo-99	1.70E-05	1.70E-07	4.64E-03	1.02E-03	4.13E-05	1.70E-05	1.70E-07
Tc-99m	6.90E-05	6.90E-07	1.88E-02	4.14E-03	1.68E-04	6.90E-05	6.90E-07

TABLE 11.2-1: DESIGN SPECIFIC ACTIVITIES IN TRANSFER, COLLECTOR, AND SAMPLE LIQUID RADWASTE SYSTEM TANKS (CONTINUED)

	Floor Drain Wastes (μCi/cc)		Equipment Drain Wastes (μCi/cc)			Miscellaneous Chemical Wastes (μCi/cc)	
Isotope	**Collector Tank**	**Sample Tank**	**Collector Tank**	**Surge Tank**	**Sample Tank**	**Receiver Tank**	**Sample Tank**
Tc-101	1.60E-05	1.60E-06	4.37E-02	9.60E-03	3.89E-04	1.60E-04	1.60E-06
Ru-103	1.50E-04	1.50E-10	4.10E-06	9.00E-07	3.65E-08	1.50E-08	1.50E-10
Ru-106	1.90E-09	1.90E-11	5.19E-07	1.14E-07	4.62E-09	1.90E-09	1.90E-11
Ag-110m	6.00E-08	6.00E-10	1.64E-05	3.60E-06	1.46E-07	6.00E-08	6.00E-10
Te-129m	2.60E-07	2.60E-09	7.10E-05	1.56E-05	6.32E-07	2.60E-07	2.60E-09
Te-132	1.10E-05	1.10E-07	3.00E-03	6.60E-04	2.67E-05	1.10E-05	1.10E-07
I-131	1.10E-05	1.10E-07	3.00E-03	6.60E-04	2.67E-05	1.10E-05	1.10E-07
I-132	1.10E-04	1.10E-06	3.00E-02	6.60E-03	2.67E-04	1.10E-04	1.10E-06
I-133	7.40E-05	7.40E-07	2.02E-02	4.44E-03	1.80E-04	7.40E-05	7.40E-07
I-134	2.30E-04	2.30E-06	6.28E-02	1.38E-02	5.59E-04	2.30E-04	2.30E-06
I-135	1.10E-04	1.10E-06	3.00E-02	6.60E-03	2.67E-04	1.10E-04	1.10E-06
Cs-134	1.20E-07	6.00E-09	3.28E-05	7.20E-06	1.46E-06	1.20E-07	6.00E-09
Cs-136	8.00E-08	4.00E-09	2.18E-05	4.80E-06	9.72E-07	8.00E-08	4.00E-09
Cs-137	1.80E-07	9.00E-09	4.91E-05	1.08E-05	2.19E-06	1.80E-07	9.00E-09
Cs-138	2.00E-04	1.00E-05	5.46E-02	1.20E-02	2.43E-03	2.00E-04	1.00E-05
Ba-139	1.60E-04	1.60E-06	4.37E-02	9.60E-03	3.89E-04	1.60E-04	1.60E-06
Ba-140	6.70E-06	6.70E-08	1.83E-03	4.02E-04	1.63E-05	6.70E-06	6.70E-08
Ba-141	1.90E-04	1.90E-06	5.19E-02	1.14E-02	4.62E-04	1.90E-04	1.90E-06
Ba-142	1.90E-04	1.90E-06	5.19E-02	1.14E-02	4.62E-04	1.90E-04	1.90E-06
Ce-141	3.00E-08	3.00E-10	8.19E-06	1.80E-06	7.29E-08	3.00E-08	3.00E-10
Ce-143	2.70E-08	2.70E-10	7.37E-06	1.62E-06	6.56E-08	2.70E-08	2.70E-10
Ce-144	2.60E-08	2.60E-10	7.10E-06	1.56E-06	6.32E-08	2.60E-08	2.60E-10
Pr-143	2.90E-08	2.90E-10	7.92E-06	1.74E-06	7.05E-08	2.90E-08	2.90E-10
Nd-147	1.10E-08	1.10E-10	3.00E-06	6.60E-07	2.67E-08	1.10E-08	1.10E-10

TABLE 11.2-1: DESIGN SPECIFIC ACTIVITIES IN TRANSFER, COLLECTOR, AND SAMPLE LIQUID RADWASTE SYSTEM TANKS (CONTINUED)

	Floor Drain Wastes (µCi/cc)		Equipment Drain Wastes (µCi/cc)			Miscellaneous Chemical Wastes (µCi/cc)	
Isotope	**Collector Tank**	**Sample Tank**	**Collector Tank**	**Surge Tank**	**Sample Tank**	**Receiver Tank**	**Sample Tank**
W-187	3.00E-06	3.00E-08	8.19E-04	1.80E-04	7.29E-06	3.00E-06	3.00E-08
Np-239	1.90E-04	1.90E-06	5.19E-02	1.14E-02	4.62E-04	1.90E-04	1.90E-06
11-2-25Total	2.01E-03	2.82E-05	5.50E-01	1.21E-01	6.84E-03	2.01E-03	2.82E-05

Note: The above values are based on Design Primary Coolant Activities documented in GE Document 22A2703V (Rev. 4) using radioactive half-life values obtained from Lange's Handbook of Chemistry, Twelfth Edition, McGraw-Hill Book Company.

TABLE 11.2-2: DESIGN ACTIVITIES IN EVAPORATOR BOTTOMS, SPENT RESIN, RWCU PHASE SEPARATOR DECAY, AND CONDENSATE PHASE SEPARATOR TANKS

Inventory After Collection (in Curies)

Isotope	Evaporator Bottoms Tank, Regenerant Wastes (Note 1,6)	Evaporator Bottoms Tank, Chemical Wastes (Note 1,6)	Spent Resin Tank (Note 2,3,6)	RWCU Phase Separator Decay Tank (Note 2,4,6)	Condensate Phase Separator Tank (Note 2,5,6)
F-18	1.76E-01	2.33E-04	1.57E-03	N	3.36E-03
Na-24	3.64E-02	9.57E-04	6.41E-03	N	1.37E-02
P-32	1.39E-02	2.19E-04	1.46E-03	8.54E-02	3.15E-03
Cr-51	5.88E-01	1.06E-02	6.53E-02	6.62E+01	1.53E-01
Mn-54	8.98E-02	4.72E-03	1.26E-02	2.15E+02	1.08E-01
Mn-56	1.56E-01	4.12E-03	2.76E-02	0.00E+00	5.91E-02
Fe-59	1.22E-01	2.72E-03	1.46E-02	4.87E+01	4.02E-02
Co-58	8.91E+00	2.59E-01	1.13E+00	7.50E+03	3.92E+00
Co-60	1.19E+00	7.70E-02	1.73E-01	3.79E+03	2.45E+00
Zn-65	4.40E-03	2.18E-04	6.15E-04	9.79E+00	4.71E-03
Zn-69m	N	N	8.87E-05	N	1.89E-04
Ni-65	9.24E-04	2.44E-05	1.65E-04	N	3.53E-04
Br-83	1.51E+00	9.97E-04	6.68E-03	N	1.43E-02
Br-84	3.48E-01	4.73E-04	3.18E-03	N	6.80E-03
Br-85	2.30E-02	3.04E-05	2.03E-04	N	4.35E-04
Y-90	3.91E-01	2.70E-02	N	N	N
Y-91	5.62E-01	1.46E-02	N	N	N
Y-91m	4.07E-01	1.08E-02	N	N	N
Y-92	3.24E-01	8.56E-03	N	N	N
Sr-89	3.68E+00	9.11E-02	4.53E-01	1.97E+03	1.34E+00
Sr-90	4.07E-01	2.73E-02	5.98E-02	1.36E+03	9.24E-01
Sr-91	6.69E-01	1.77E-02	1.18E-01	N	2.53E-01
Sr-92	3.24E-01	8.56E-03	5.81E-02	0.00E+00	1.24E-01
Zr-95	5.22E-02	1.45E-03	6.55E-03	3.88E+01	2.16E-02
Nb-95	6.56E-02	2.20E-03	4.78E-03	9.06E+00	1.19E-02
Zr-97	N	N	9.10E-05	N	1.95E-04
Mo-99	1.75E+00	3.60E-02	2.43E-01	N	5.21E-01
Tc-99m	N	N	8.94E-02	N	1.91E-01
Tc-101	N	N	7.99E-03	0.00E+00	1.71E-02
Ru-103	2.15E-02	4.54E-04	2.51E-03	6.31E+00	6.54E-03
Ru-106	4.32E-03	2.35E-04	6.12E-04	1.10E+01	5.76E-03
Ag-110m	1.33E-01	6.63E-03	1.86E-02	2.99E+02	1.45E-01
Te-129m	N	N	3.94E-02	7.02E+01	9.77E-02
Te-132	N	N	83E-01	N	3.92E-01
I-131	8.42E+01	6.78E-02	4.55E-01	2.95E-01	9.75E-01

TABLE 11.2-2: DESIGN ACTIVITIES IN EVAPORATOR BOTTOMS, SPENT RESIN, RWCU PHASE SEPARATOR DECAY, AND CONDENSATE PHASE SEPARATOR TANKS (CONTINUED)

Inventory After Collection (in Curies)

Isotope	Evaporator Bottoms Tank, Regenerant Wastes	Evaporator Bottoms Tank, Chemical Wastes	Spent Resin Tank	RWCU Phase Separator Decay Tank	Condensate Phase Separator Tank
I-132	6.13E+00	8.00E-03	5.32E-02	N	1.14E-01
I-133	3.69E+01	4.78E-02	3.22E-01	N	6.89E-01
I-134	4.81E+00	6.36E-03	4.27E-02	N	9.14E-02
I-135	1.78E+01	2.35E-02	1.57E-01	N	3.37E-01
Cs-134	2.54E-01	1.70E-02	2.02E-01	8.22E+02	4.86E-01
Cs-136	4.82E-02	8.40E-04	2.79E-02	2.55E-01	1.21E-02
Cs-137	3.90E-01	2.90E-02	3.17E-01	1.44E+03	9.80E-01
Cs-138	1.17E-01	3.42E-03	1.15E-01	0.00E+00	4.92E-02
Ba-139	2.68E-01	7.07E-03	4.74E-02	0.00E+00	1.02E-01
Ba-140	4.20E+00	6.54E-02	4.38E-01	1.32E+01	9.45E-01
La-140	4.41E+00	6.54E-02	N	0.00E+00	N
Ba-141	6.97E-02	1.84E-03	1.22E-02	0.00E+00	2.62E-02
Ba-142	4.09E-02	1.08E-03	7.46E-03	0.00E+00	1.60E-02
Ce-141	1.35E-01	2.58E-03	4.40E-03	6.93E+00	1.07E-02
Ce-143	1.16E-03	2.84E-05	1.91E-04	N	4.09E-04
Ce-144	5.80E-02	2.98E-03	8.15E-03	1.36E+02	6.76E-02
Pr-143	1.64E-02	2.53E-04	2.01E-03	8.74E-02	4.34E-03
Nd-147	N	N	6.23E-04	6.67E-03	1.34E-03
W-187	8.90E-02	2.28E-03	1.54E-02	N	3.29E-02
Np-239	N	N	2.29E+00	N	4.91E+00
Total	1.82E+02	9.67E-01	7.25E+00	1.78E+04	2.07E+01

Note 1: The Evaporator Bottoms Tanks activity data presented above are for historical purposes only since this equipment has been abandoned in place.

Note 2: Decay correction during filter or demineralizer service life has been incorporated into the activity values presented above.

Note 3: The Spent Resin Tank waste volume is assumed to be 1337 ft^3 with 297 ft^3 Equipment Drain resins and 1040 ft^3 floor drain resins.

Note 4: The RWCU Phase Separator Decay Tank includes a 120 day decay correction and assumes a volume of 1428 ft^3 (23.6% RWCU resins and 76.4% FPC&CU resins).

TABLE 11.2-2 DESIGN ACTIVITIES IN EVAPORATOR BOTTOMS, SPENT RESIN, RWCU PHASE SEPARATOR DECAY, AND CONDENSATE PHASE SEPARATOR TANKS (CONTINUED)

Note 5: The Condensate Phase Separator Tank assumes contents of 1160 ft^3 of spent Condensate Demineralizer resins (approximately 4 bed volumes).

Note 6: "N" denotes those activities that have negligible concentrations or those isotopes that were not analyzed for the associated waste stream.

TABLE 11.2-3: DESIGN ACTIVITIES DEPOSITED ON FILTERS AND DEMINERALIZERS (IN CURIES)

Isotope	Floor Drain Filter	Floor Drain Demin	Equipment Drain Filter	Equipment Drain Demin	RWCU Filter/Demin	Condensate Demin (1 bed)	Fuel Pool Filter/Demin
F-18	1.77E-05	1.77E-06	7.40E-03	7.40E-04	4.32E-01	8.39E-04	2.64E-02
Na-24	7.23E-05	7.23E-06	3.03E-02	3.03E-03	1.77E+00	3.44E-03	1.08E-01
P-32	9.33E-06	1.24E-06	2.14E-03	6.89E-04	4.03E-01	7.87E-04	1.90E-02
Cr-51	2.79E-04	4.10E-05	5.83E-02	3.09E-02	1.87E+01	3.83E-02	6.34E-01
Mn-54	2.69E-05	4.44E-06	5.07E-03	6.00E-03	4.12E+00	2.71E-02	6.95E-02
Mn-56	3.11E-04	3.11E-05	1.30E-01	1.30E-02	7.59E+00	1.48E-02	4.64E-01
Fe-59	4.83E-05	7.44E-06	9.67E-03	6.91E-03	4.33E+00	1.00E-02	1.16E-01
Co-58	3.16E-03	5.00E-04	6.17E-01	5.37E-01	3.47E+02	9.80E-01	7.80E+00
Co-60	3.41E-04	5.70E-05	6.39E-02	8.24E-02	5.76E+01	6.12E-01	8.94E-01
Zn-65	1.34E-06	2.20E-07	2.53E-04	2.92E-04	2.00E-01	1.18E-03	3.45E-03
Zn-69m	1.00E-06	1.00E-07	4.19E-04	4.19E-05	2.43E-02	4.73E-05	1.49E-03
Ni-65	1.86E-06	1.86E-07	7.80E-04	7.80E-05	4.54E-02	8.83E-05	2.78E-03
Br-83	7.54E-05	7.54E-06	3.16E-02	3.16E-03	1.84E+00	3.58E-03	1.12E-01
Br-84	3.59E-05	3.59E-06	1.50E-02	1.50E-03	8.75E-01	1.70E-03	5.35E-02
Br-85	2.29E-06	2.29E-07	9.60E-04	9.60E-05	5.60E-02	1.09E-04	3.42E-03
Sr-89	1.41E-03	2.20E-04	2.80E-01	2.15E-01	1.36E+02	3.35E-01	3.42E+00
Sr-90	1.16E-04	1.95E-05	2.17E-02	2.84E-02	1.99E+01	2.31E-01	3.05E-01
Sr-91	1.33E-03	1.33E-04	5.58E-01	5.58E-02	3.25E+01	6.32E-02	1.99E+00
Sr-92	6.55E-04	6.55E-05	2.74E-01	2.74E-02	1.60E+01	3.11E-02	9.78E-01
Zr-95	1.88E-05	2.97E-06	3.69E-03	3.11E-03	2.00E+00	5.40E-03	4.62E-02
Nb-95	1.80E-05	2.71E-06	3.68E-03	2.27E-03	1.39E+00	2.99E-03	4.20E-02
Zr-97	1.03E-06	1.03E-07	4.30E-04	4.30E-05	2.51E-02	4.88E-05	1.53E-03
Mo-99	2.70E-03	2.74E-04	9.75E-01	1.15E-01	6.70E+01	1.30E-01	4.09E+00
Tc-99M	1.01E-03	1.01E-04	4.22E-01	4.22E-02	2.46E+01	4.79E-02	1.50E+00
Tc-101	9.02E-05	9.02E-06	3.78E-02	3.78E-03	2.20E+00	4.28E-03	1.35E-01
Ru-103	8.88E-06	1.35E-06	1.80E-03	1.19E-03	7.38E-01	1.64E-03	2.10E-02
Ru-106	1.28E-06	2.12E-07	2.41E-04	2.91E-04	2.00E-01	1.44E-03	3.32E-03
Ag-110m	4.02E-05	6.61E-06	7.60E-03	8.82E-03	6.03E+00	3.63E-02	1.04E-01
Te-129M	1.51E-04	2.26E-05	3.08E-02	1.87E-02	1.15E+01	2.44E-02	3.50E-01
Te-132	2.01E-03	2.06E-04	6.95E-01	8.65E-02	5.04E+01	9.81E-02	3.08E+00

TABLE 11.2-3: DESIGN ACTIVITIES DEPOSITED ON FILTERS AND DEMINERALIZERS (IN CURIES) (CONTINUED)

Isotope	Floor Drain Filter	Floor Drain Demin	Equipment Drain Filter	Equipment Drain Demin	RWCU Filter/Demin	Condensate Demin (1 bed)	Fuel Pool Filter/Demin
I-131	3.95E-03	4.69E-04	1.03E+00	2.15E-01	1.25E+02	2.44E-01	7.08E+00
I-132	6.01E-04	6.01E-05	2.52E-01	2.52E-02	1.47E+01	2.85E-02	8.96E-01
I-133	3.63E-03	3.63E-04	1.52E+00	1.52E-01	8.86E+01	1.72E-01	5.42E+00
I-134	4.82E-04	7.82E-05	2.02E-01	2.02E-02	1.18E+01	2.29E-02	7.18E-01
I-135	1.78E-03	1.78E-04	7.44E-01	7.44E-02	4.33E+01	8.43E-02	2.65E+00
Cs-134	4.53E-05	6.78E-05	8.50E-03	9.62E-02	1.34E+01	1.21E-01	2.13E-01
Cs-136	2.04E-05	2.43E-05	4.72E-03	1.32E-02	1.55E+00	3.02E-03	7.40E-02
Cs-137	6.85E-05	1.03E-04	1.28E-02	1.51E-01	2.11E+01	2.45E-01	3.23E-01
Cs-138	1.44E-04	1.30E-04	6.03E-02	5.43E-02	6.33E+00	1.23E-02	3.87E-01
Ba-139	5.35E-04	5.35E-05	2.24E-01	2.24E-02	1.31E+01	2.54E-02	7.99E-01
Ba-140	3.00E-03	3.91E-04	7.03E-01	2.07E-01	1.21E+02	2.36E-01	5.96E+00
Ba-141	1.38E-04	1.38E-05	5.77E-02	5.77E-03	3.36E+00	6.54E-03	2.06E-01
Ba-142	8.42E-05	8.42E-06	3.53E-02	3.53E-03	2.06E+00	4.00E-03	1.26E-01
Ce-141	1.72E-05	2.58E-06	3.54E-03	2.09E-03	1.27E+00	2.69E-03	3.99E-02
Ce-143	2.15E-06	2.15E-07	8.82E-04	9.02E-05	5.26E-02	1.02E-04	3.21E-03
Ce-144	1.74E-05	2.88E-06	3.30E-03	3.87E-03	2.65E+00	1.69E-02	4.51E-02
Pr-143	1.33E-05	1.75E-06	3.08E-03	9.51E-04	5.57E-01	1.08E-03	2.67E-02
Nd-147	4.63E-06	5.87E-07	1.12E-03	2.95E-04	1.72E-01	3.35E-04	8.91E-03
W-187	1.73E-04	1.73E-05	7.22E-02	7.26E-03	4.23E+00	8.22E-03	2.58E-01
Np-239	2.57E-02	2.59E-03	9.68E+00	1.08E+00	6.32E+02	1.23E+00	3.86E+01
Total Accumulation	5.43E-02	6.25E-03	1.89E+01	3.43E+00	1.92E+03	5.17E+00	9.02E+01
Time, in days	17.0	28.5	7.6	99.7	120	730	30

TABLE 11.2-3: DESIGN ACTIVITIES DEPOSITED ON FILTERS AND DEMINERALIZERS (IN CURIES) (CONTINUED)

Note 1: The above data are based on Design Reactor Coolant Activities obtained from GE Document 22A2703V (Rev 4.). [4]

Note 2: Decay correction during service life has been incorporated into the activity values presented above.

Note 3: “N” denotes isotopes with negligible concentrations or isotopes not analyzed for the associated waste stream.

TABLE 11.2-4: (SHEETS 1 THROUGH 3 DELETED)

TABLE 11.2-5: (SHEETS 1 THROUGH 3 DELETED)

TABLE 11.2-6: (SHEETS 1 THROUGH 4 DELETED)

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM

A. Source Term

Item	Value		Reference
Primary coolant specific activities (PCA)			
Design:	Table 11.2-9		GE Document 22A2703V (Rev. 4)[4]
Partition factor for steam activities $\left(\frac{\mu Ci}{gm}\right)$			
Halogens:	0.02		GE Document 22A2703V (Rev. 4)[4]
Others:	0.001		GE Document 22A2703V (Rev. 4)[4]

B. High Purity (Equipment Drain) Waste

Item	Value		Reference
Flow rate into collector tank (gpd)	17,499		Fig. 11.2-13
Effective PCA fraction for collector tank	0.243		Fig. 11.2-13
Flow rate into surge tank (gpd)	2,778		Fig. 11.2-13
Effective PCA fraction for surge tank	0.060		Fig. 11.2-13
Collection time for the collector tank (days)	1.7		GALE Code Output
Decontamination factors (DFs) for the processing equipment	Cs&Rb 20	Others 100	Table 11.2-8 NUREG-0016

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM (Continued)

Item	Value			Reference
Equipment drain filter efficiency for insolubles	0.95			Subsection 11.2.2.7.1
Loading time for filter (days)	7.6			Fig. 11.2-13
Demineralizer efficiency for capturing radioisotopes	Cs&Rb 0.9	Insolubles 0.9	Others 0.9	NUREG-0016
Demineralizer loading time (days)	99.7			Fig. 11.2-13

C. Low Purity (Floor Drain Waste)

Item	Value			Reference
Flow rate into collector tank (gpd)	11,775			Fig. 11.2-14
Effective PCA fraction for collector tank	0.001			Fig. 11.2-14
Collection time for the collector tank (days)	0.94			Gale Code Output
Decontamination factors (DFs) for the processing equipment	C_s&R_b 20	Others 100		Table 11.2-8
Filter efficiency for capturing insolubles	0.95			Subsection 11.2.2.7.1
Loading time for filter (days)	17			Fig. 11.2-14
Demineralizer efficiency for capturing radioisotopes	Cs&Rb 0.9	Insolubles 0.9	Others 0.9	NUREG-0016
Demineralizer loading time (days)	28.5			Fig. 11.2-14

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM (Continued)

D. Chemical Wastes

Item	Value		Reference
Flow rate into chemical waste receiver tank (gpd)	4000		Fig. 11.2-15
Effective PCA fraction for receiver tank	0.001		Fig. 11.2-15
Collection time for receiver tank (days)	N/A		Gale Code Output
Decontamination factors (DFs) for the processing equipment	Cs-Rb 20	Others 100	NUREG-0016

E. Regenerant Wastes

Item	Value	References
Flow rate into regenerant solution receiving tank (gpd)	Not Used	Section 11.2.2.3
Effective PCA fraction for solution	N/A	N/A
Collection time for receiving tank (days)	N/A	N/A
DFs for the processing equipment	N/A	N/A

F. Miscellaneous

Item	Value	Reference

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM (Continued)

Chemical waste evaporator bottoms tank inventory after collection in the bottoms tank (Ci):	Not used		Section 11.2.2.3
Item	**Value**		**Reference**
Period of accumulation (days)	N/A		N/A
Accumulation rate	N/A		N/A
Regenerant waste evaporator bottoms tank inventory after collection in the bottoms tank:	Not Used		Section 11.2.2.3
Number of batches	N/A		N/A
Batch activity	N/A		N/A
Decay for batches (days)after accumulation for 60 days:	First batch	Second batch	Fig. 11.2-13 & 11.2-14
Design:	0	0	
Spent resin tank (SRT) inventory:			
Collection time (days)	99.7		Fig. 11.2-16
Number of equipment drain demineralizer batches to SRT	1		Fig. 11.2-13
Batch activity for equipment drain demineralizer	Activity accumulated over a period of 99.7 days		Fig. 11.2-13
Number of floor drain demineralizer batches to SRT:	3		Fig. 11.2-16

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM (Continued)

Batch activity for floor drain demineralizer	Activity accumulated over a period of 28.5 days	Fig. 11.2-14
Number of ARCS/URC batches	48/yr	Fig. 11.2-13
Activity (PCA fraction) (This is also an input for the floor drain system. It has been included here for conservatism.)	0.05	NUREG-0016
Item	**Value**	**Reference**
RWCU phase separator decay tank Inventory (Ci):	5187	Fig. 11.2-17
Collection time (days)	730	
Number of batches (RWCU demineralizer) (Here batch means, activity associated with 1 RWCU demineralizer bed)	20 batches	Fig. 11.2-17
Batch activity (RWCU demineralizer)	Activity accumulated in 120 days	Fig. 11.2-17
Number of batches due to fuel pool cleanup (Fuel pool demineralizer bed)	24	Fig. 11.2-17
Decay in the decay tank after collection (days)	70	Fig. 11.2-17
RWCU filter/demineralizer bed inventory (Ci):	1920	Fig. 11.2-17
Flow rate through 1 bed (gpm) Table 11.2-8	180	Table 11.2-8
Loading time (days)	120	Fig. 11.2-17
Demineralizer efficiencies for capturing isotopes	1.0	100% Eff. Assumed for Design Purposes

TABLE 11.2-7: PARAMETERS FOR CALCULATING CONCENTRATIONS AND ACTIVITIES IN LIQUID RADWASTE SYSTEM (Continued)

Condensate demineralizer bed inventory (Ci):		
Flow rate of condensate through demineralizer bed (gpm)	3550	Table 11.2-8
Loading time (days)	60	Table 11.2-8
Demineralizer efficiencies for capturing isotopes	Same as given for RWCU system for design and expected cases	Same as given for RWCU system

Item	**Value**	**Reference**
Fuel pool cleanup demineralizer bed inventory (Ci):		
Flow rate of fuel pool water through demineralizer bed (gpm)	1100	Fig. 9.1-29
Loading time (days)	30	Fig. 11.2-17
Demineralizer efficiencies for capturing isotopes	Same as given for RWCU system for design and expected cases	Same as given for RWCU system

Notes

(1) Specific activities in collector and receiver tanks have been calculated ignoring decay during collection in these tanks.

(2) Activities accumulated on the filter demineralizer beds include decay credit during collection in the respective processing vessel.

TABLE 11.2-8: PARAMETERS INPUT TO BWR-GALE CODE

[This table is historical]

NOTE: All relevant parameters have been adjusted to 102 percent of rated power level except as noted.

A. General

Description	**Input**
Maximum core thermal power level, Mwt	4,496

B. Nuclear Steam Supply System (NSSS)

Description	**Input**
Total steam flow rate, lb/hr	19.428×10^6
Mass of coolant in reactor vessel and recirculation lines at full power, lb	5.587×10^5

C. Reactor Coolant Cleanup System

Description	**Input**
Cleanup demineralizer flow rate, lb/hr	1.78×10^5
Condensate demineralizer regeneration time (days)	720
Fission product carry-over fraction (Cs, Rb and other isotopes)	0.001
Halogen carry-over fraction	0.02
Condenser Tubing Material 0=No Copper	0
Fraction of feedwater through condensate demineralizers	0.647

D. High-Purity Waste

Description	**Input**
Name of Waste Stream	Equipment Drain
Flow rate - (gal/day	20,334

TABLE 11.2-8: PARAMETERS INPUT TO BWR-GALE CODE (Continued)

[This table is historical]

Activity as a fraction of Primary Coolant Activity	0.243
DF for Anions	10^2
DF for Cs, Rb	20
DF for other isotopes	10^2
Collection time (days)	1.708
Decay time based on waste processing and discharge time (days)	0.102
Fraction of Wastes Discharged	0.1

E. Low-Purity Waste

Description	**Input**
Name of Waste Stream	Floor Drain
Flow rate - (gal/day)	11,801
Activity as a fraction of Primary Coolant Activity	0.001
DF for Anions	10^2
DF for Cs, Rb	20
DF for other isotopes	10^2
Collection time (days)	0.9392
Sum of waste processing and discharge time (days)	0.0503
Fraction of Wastes Discharged	0.6

F. Chemical Waste

Description	**Input**
Name of Waste Stream	Not Applicable
Flow rate - (gal/day)	0.0
Activity as a fraction of Primary Coolant Activity	0.0
DF for Anions	1.0

TABLE 11.2-8: PARAMETERS INPUT TO BWR-GALE CODE (Continued)

[This table is historical]

DF for Cs, Rb	1.0
DF for other	1.0
Collection time (days)	0.0
Sum of waste processing and discharge time (days)	0.0
Fraction of Wastes Discharged	0.0

G. Regenerant Solutions Waste

Description	**Input**
Name of Waste Stream	Not Applicable
Flow rate - (gal/day)	0.0
DF for Anions	1.0
DF for Cs, Rb	1.0
DF for other	1.0
Collection time (days)	0.0
Sum of waste processing and discharge time (days)	0.0
Fraction of Wastes Discharged	0.0

H. Miscellaneous

Description	**Input**
Detergent Waste	0.0

Note: For all wastes, the discharge rate to the environment will be determined in accordance with the techniques specified in the GGNS Offsite Dose Calculation Manual. For the offsite dose analysis, a discharge flow rate of 5.04×10^4 gpd has been used.

TABLE 11.2-9: DESIGN CONCENTRATION IN PRIMARY COOLANT

Nuclide	Half-life (days)	Concentration in Primary Coolant (μCi/ml) (Note 1)	Nuclide	Half-life (days)	Concentration in Primary Coolant (μCi/ml) (Note 1)
Corrosion and activation products					
Na-24	6.23-01	2.00E-3	F-18	7.62E-2	4.00E-3
P-32	1.43+01	2.0E-5	Cr-51	2.78+01	5.0E-4
Mn-54	3.03+02	4.0E-5	Mn-56	1.08-01	5.0E-2
			Fe-59	4.50+01	8.0E-2
Co-58	7.13+01	5.0E-3	Co-60	1.92+03	5.0E-4
			Ni-65	1.07-01	3.0E-4
Zn-69M	5.75-01	3.0E-5	Zn-65	2.45+02	2.0E-6
Np-239	2.35+00	1.90E-1	W-187	9.96-01	3.0E-3
Fission Products			Br-83	1.00-01	1.30E-2
Br-84	2.21-02	2.8E-2	Br-85	2.08-03	1.9E-2
			Sr-89	5.20+01	2.30E-3
Sr-90	1.03+04	1.70E-4	Sr-91	4.03-01	5.70E-2
			Sr-92	1.13-01	1.00E-1
Zr-95	6.50+01	3.00E-5	Nb-95	3.50+01	3.10E-5
Zr-97	7.08-01	2.50E-5			
Mo-99	2.79+00	1.70E-2	Tc-99m	2.50-01	6.90E-2
Tc-101	9.72-03	1.60E-1	Ru-103	3.96+01	1.50E-5
Ru-106	3.67+02	1.90E-6	Ag-110m	2.53+02	6.00E-5
Te-129m	3.40+01	2.60E-4			
I-131	8.05+00	1.1E-2	Te-132	3.25+00	1.10E-2
I-132	9.58-02	1.1E-1	I-133	8.75-01	7.40E-2
I-134	3.67-02	2.30E-1	Cs-134	7.49+02	1.20E-4
I-135	2.79-01	1.1E-1	Cs-136	1.30+01	8.00E-5
Cs-137	1.10+04	1.80E-4	Cs-138	2.24-02	2.00E-1
Ba-139	5.76-02	1.60E-1	Ba-140	1.28+01	6.70E-3
Ba-141	1.25-02	1.90E-1	Ce-141	3.24+01	3.00E-5
Ba-142	7.64-03	1.90E-1			
Ce-143	1.37+00	2.70E-5	Pr-143	1.37+01	2.90E-5
Ce-144	2.84+02	2.60E-5	Nd-147	1.11+01	1.10E-5

Total = 2.01E00 $\frac{\mu Ci}{ml}$

Note 1: Reference GE Document 22A2703V (Rev. 4) [4]

TABLE 11.2-10: LIQUID EFFLUENT RELEASES

[This table is historical]

(Curies/Year)

GRAND GULF

THERMAL POWER LEVEL (MEGAWATTS)	4496.00000
PLANT CAPACITY FACTOR	1.00000
TOTAL STEAM FLOW (MILLION LBS/HR)	19.42800
MASS OF WATER IN REACTOR VESSEL (MILLION LBS)	.58870
CLEAN-UP DEMINERALIZER FLOW (MILLION LBS/HR)	.17800
CONDENSATE DEMINERALIZER REGENERATION TIME (DAYS)	720.0000
FISSION PRODUCT CARRY-OVER FRACTION	.00100
HALOGEN CARRY-OVER FRACTION	.02000
FRACTION FEED WATER THROUGH CONDENSATE DEMIN	.64700

LIQUID WASTE INPUTS

						DECONTAMINATION FACTORS		
STREAM	FLOW RATE (GAL/DAY)	FRACTION OF PCA	FRACTION OF DISCHARGED	COLLECTION TIME (DAYS)	DECAY TIME (DAYS)	I	CS	OTHERS
HIGH PURITY WASTE	2.03E+04	.243	.100	1.708	.102	1.00E+02	2.00E+01	1.00E+02
LOW PURITY WASTE	1.18E+04	.001	.600	.939	.050	1.00E+02	2.00E+01	1.00E+02
CHEMICAL WASTE	0.00E+00	.000	.000	.000	.000	1.00E+00	1.00E+00	1.00E+00
REGENERANT SOLS	0.00E+00		.000	.000	.000	1.00E+00	1.00E+00	1.00E+00

TABLE 11.2-10: LIQUID EFFLUENT RELEASES (CONTINUED)

GASEOUS WASTE INPUTS

[This table is historical]

GLAND SEAL STEAM FLOW (THOUSAND LBS/HR)	.00000
GLAND SEAL HOLDUP TIME (HOURS)	.00000
AIR EJECTOR OFFGAS HOLDUP TIME (HOURS)	.16700
CONTAINMENT BUILDING IODINE RELEASE FRACTION	.01000
PARTICULATE RELEASE FRACTION	.01000
TURBINE BUILDING IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	1.00000
GLAND SEAL VENT, IODINE PF	1.00000
AIR EJECTOR OFFGAS IODINE PF	.00000
AUXILIARY BUILDING IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	1.00000
RADWASTE BUILDING IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	.01000
THERE IS A CHARCOAL DELAY SYSTEM	
KRYPTON HOLDUP TIME (DAYS)	2.01779
XENON HOLDUP TIME (DAYS)	46.31317
KRYPTON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	105.00000
XENON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	2410.00000
MASS OF CHARCOAL (THOUSAND LBS)	48.00000
THERE IS NOT A PERMANENT ONSITE LAUNDRY	

TABLE 11.2-10: LIQUID EFFLUENT RELEASES (CONTINUED)

[This table is historical]

ANNUAL RELEASES TO DISCHARGE CANAL

NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	CHEMICAL (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)	DETERGENT WASTES (CI/YR)	TOTAL WASTES (CI/YR)
CORROSION AND ACTIVATION PRODUCTS									
NA-24	6.25E-01	1.19E-02	.03262	.00069	.00000	.03331	.03803	.00000	.03800
P-32	1.43E+01	2.43E-04	.00158	.00002	.00000	.00161	.00183	.00000	.00180
CR-51	2.78E+01	7.28E-03	.04855	.00070	.00000	.04926	.05624	.00000	.05600
MN-54	3.03E+02	8.50E-05	.00058	.00001	.00000	.00059	.00067	.00000	.00067
MN-56	1.07E-01	5.71E-02	.01833	.00066	.00000	.01899	.02168	.00000	.02200
FE-55	9.50E+02	1.21E-03	.00828	.00012	.00000	.00840	.00959	.00000	.00960
FE-59	4.50E+01	3.64E-05	.00025	.00000	.00000	.00025	.00028	.00000	.00028
CO-58	7.13E+01	2.43E-04	.00164	.00002	.00000	.00167	.00190	.00000	.00190
CO-60	1.92E+03	4.86E-04	.00332	.00005	.00000	.00336	.00384	.00000	.00380
NI-65	1.07E-01	3.42E-04	.00011	.00000	.00000	.00011	.00013	.00000	.00013
CU-64	5.33E-01	3.57E-02	.08572	.00189	.00000	.08761	.10002	.00000	.10000
ZN-65	2.45E+02	2.43E-04	.00165	.00002	.00000	.00168	.00192	.00000	.00190
vZN-69M	5.75E-01	2.38E-03	.00610	.00013	.00000	.00623	.00711	.00000	.00710
W-187	9.96E-01	3.60E-04	.00134	.00002	.00000	.00136	.00156	.00000	.00160
NP-239	2.35E+00	9.66E-03	.05029	.00081	.00000	.05111	.05835	.00000	.05800
FISSION PRODUCTS									
BR-83	1.00E-01	6.64E-03	.00190	.00007	.00000	.00197	.00225	.00000	.00230
BR-84	2.21E-02	7.58E-03	.00004	.00001	.00000	.00004	.00005	.00000	.00005
SR-89	5.20E+01	1.21E-04	.00083	.00001	.00000	.00084	.00096	.00000	.00096
SR-90	1.03E+04	8.50E-06	.00006	.00000	.00000	.00006	.00007	.00000	.00007
SR-91	4.03E-01	4.73E-03	.00874	.00021	.00000	.00895	.01022	.00000	.01000
Y-91	5.88E+01	4.86E-05	.00049	.00001	.00000	.00049	.00056	.00000	.00056

TABLE 11.2-10: LIQUID EFFLUENT RELEASES (CONTINUED)

[This table is historical]

ANNUAL RELEASES TO DISCHARGE CANAL

NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	CHEMICAL (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)	DETERGENT WASTES (CI/YR)	TOTAL WASTES (CI/YR)
SR-92	1.13E-01	1.14E-02	.00398	.00014	.00000	.00412	.00471	.00000	.00470
Y-92	1.47E-01	6.91E-03	.01029	.00030	.00000	.01059	.01209	.00000	.01200
Y-93	4.25E-01	4.74E-03	.00923	.00022	.00000	.00945	.01079	.00000	.01100
ZR-95	6.50E+01	9.71E-06	.00007	.00000	.00000	.00007	.00008	.00000	.00008
NB-95	3.50E+01	9.71E-06	.00007	.00000	.00000	.00007	.00008	.00000	.00008
ZR-97	7.08E-01	7.17E-06	.00002	.00000	.00000	.00002	.00003	.00000	.00002
NB-98	3.54E-02	4.42E-03	.00012	.00001	.00000	.00013	.00015	.00000	.00015
MO-99	2.79E+00	2.42E-03	.01312	.00021	.00000	.01333	.01521	.00000	.01500
TC-99M	2.50E-01	2.34E-02	.03526	.00084	.00000	.03610	.04121	.00000	.04100
RU-103	3.96E+01	2.43E-05	.00016	.00000	.00000	.00017	.00019	.00000	.00019
TC-104	1.25E-02	8.66E-02	.00002	.00001	.00000	.00003	.00004	.00000	.00004
RU-105	1.85E-01	2.32E-03	.00169	.00005	.00000	.00174	.00199	.00000	.00200
RU-106	3.67E+02	3.64E-06	.00002	.00000	.00000	.00003	.00003	.00000	.00003
TE-129M	3.40E+01	4.85E-05	.00033	.00000	.00000	.00033	.00038	.00000	.00038
TE-131M	1.25E+00	1.20E-04	.00050	.00001	.00000	.00051	.00058	.00000	.00058
I-131	8.05E+00	4.20E-03	.02650	.00039	.00000	.02690	.03071	.00000	.03100
TE-132	3.25E+00	1.21E-05	.00007	.00000	.00000	.00007	.00008	.00000	.00008
I-132	9.58E-02	6.63E-02	.01761	.00066	.00000	.01827	.02086	.00000	.02100
I-133	8.75E-01	5.65E-02	.19521	.00375	.00000	.19896	.22716	.00000	.23000
I-134	3.67E-02	1.09E-01	.00335	.00023	.00000	.00358	.00409	.00000	.00410
CS-134	7.49E+02	3.60E-05	.00123	.00002	.00000	.00124	.00142	.00000	.00140
I-135	2.79E-01	5.61E-02	.06909	.00188	.00000	.07097	.08103	.00000	.08100
CS-136	1.30E+01	2.39E-05	.00078	.00001	.00000	.00079	.00090	.00000	.00090
CS-137	1.10E+04	9.59E-05	.00327	.00005	.00000	.00332	.00379	.00000	.00380

TABLE 11.2-10: LIQUID EFFLUENT RELEASES (CONTINUED)

[This table is historical]

ANNUAL RELEASES TO DISCHARGE CANAL

NUCLIDE	HALF-LIFE (DAYS)	CONCENTRATION IN PRIMARY COOLANT (MICRO CI/ML)	HIGH PURITY (CURIES)	LOW PURITY (CURIES)	CHEMICAL (CURIES)	TOTAL LWS (CURIES)	ADJUSTED TOTAL (CI/YR)	DETERGENT WASTES (CI/YR)	TOTAL WASTES (CI/YR)
CS-138	2.24E-02	1.08E-02	.00030	.00004	.00000	.00033	.00038	.00000	.00038
BA-139	5.76E-02	1.12E-02	.00109	.00005	.00000	.00114	.00130	.00000	.00130
BA-140	1.28E+01	4.85E-04	.00315	.00005	.00000	.00319	.00365	.00000	.00360
CE-141	3.24E+01	3.64E-05	.00027	.00000	.00000	.00028	.00032	.00000	.00032
LA-142	6.39E-02	5.61E-03	.00079	.00004	.00000	.00083	.00094	.00000	.00094
CE-143	1.38E+00	3.61E-05	.00016	.00000	.00000	.00016	.00018	.00000	.00018
PR-143	1.37E+01	4.85E-05	.00032	.00000	.00000	.00033	.00038	.00000	.00038
CE-144	2.84E+02	3.64E-06	.00002	.00000	.00000	.00003	.00003	.00000	.00003
ND-147	1.11E+01	3.64E-06	.00002	.00000	.00000	.00002	.00003	.00000	.00003
ALL OTHERS		1.23E-01	.02016	.00042	.00000	.02058	.02350	.00000	.02400
TOTAL (EXCEPT TRITIUM)		7.32E-01	.69068	.01487	.00000	.70555	.80555	.00000	.81000

TRITIUM RELEASE 84 CURIES PER YEAR

Note:.00000 indicates that the value is less than 1.0E-5. A value of 0.00000 means zero.

All others refers to:

NI 63	ZN 69	U235	PU239	BR 85	RB 89	Y 90	Y 91M	ZR 93	NB 93M
NB 95M	NB 97M	NB 97	TC 99	TC101	RH103M	RH105M	RH105	RH106	AG110M
AG110	TE129	I129	TE131	CS135	BA137M	LA140	BA141	LA141	BA142
PR144	PM147								

TABLE 11.2-10: LIQUID EFFLUENT RELEASES (CONTINUED)

[This table is historical]

ANNUAL RELEASES TO DISCHARGE CANAL

Note

The amounts of P-32, Cu-64, Zn-65, Zn-69M, and Zn-69 will be negligible in liquid effluents because Grand Gulf does not use admiralty metal for condenser tubes, and depleted zinc oxide is used in the zinc injection system.

TABLE 11.2-11: ESTIMATED INDIVIDUAL DOSES FROM LIQUID EFFLUENTS (MREM/YR)

Pathway	Annual Dose	
	Total Body	Thyroid[1]
Aquatic Foods	0.45	0.68
Shoreline deposits	0.0001	0.0011
Total from all pathways	0.45	0.68
10 CFR 50 Appendix I Guidelines	3.0	10.0

Note: (1) Doses to other organs are less than thyroid doses.

TABLE 11.2-12: ESTIMATED POPULATION DOSES FROM LIQUID EFFLUENTS

Item	Annual Dose man-rem/yr
Total body	8.17
Thyroid	4.35

TABLE 11.2-13: COMMERCIAL AND SPORT AQUATIC FOOD CATCH DATA

Type of Catch	Amount Caught kg/year
Fish	4.47 + 5
Invertebrate	3.51 + 3

TABLE 11.2-14: MATERIALS OF CONSTRUCTION FOR MAJOR COMPONENTS OF THE LIQUID RADWASTE SYSTEM

	Quantity	Material of Construction
Tanks		
Distillate sample tank	2	304 S.S.
Fresh resin addition tank	1	304 S.S.
Spent resin tank	1	304 S.S.
Evaporator bottoms tank (not used)	2	304 S.S.
Condensate demineralizer regeneration solution receiving tank	2	304 S.S.
Miscellaneous chemical waste receiver tank	1	304 S.S.
RWCU phase separator decay tank	2	304 S.S.
Floor drain collector tank	1	304 S.S.
Floor drain sample tank	2	304 S.S.

TABLE 11.2-14: MATERIALS OF CONSTRUCTION FOR MAJOR COMPONENTS OF THE LIQUID RADWASTE SYSTEM (Continued)

	Quantity	Material of Construction
Chemical addition tank	1	304 S.S.
Body feed tank	1	304 S.S.
Precoat addition tank	1	304 S.S.
Equipment drain collector tank	2	304 S.S.
Equipment drain sample tank	2	304 S.S.
Waste surge tank	2	304 S.S.
Condensate phase separator tank	2	304 S.S.
Pumps		
Distillate sample pump	2	316 S.S.
Spent resin pump	1	316 S.S.
Evaporator bottoms pump (not used)	2	316 S.S.

TABLE 11.2-14: MATERIALS OF CONSTRUCTION FOR MAJOR COMPONENTS OF THE LIQUID RADWASTE SYSTEM (Continued)

	Quantity	Material of Construction
Condensate demineralizer regeneration solution receiving pump (not used)	1	316 S.S.
Miscellaneous chemical waste receiver pump	1	316 S.S.
RWCU phase separator discharge pump	1	316 S.S.
Pumps		
RWCU phase separator decant pump	1	316 S.S.
Floor drain sample pump	1	316 S.S.
Body feed pump	2	316 S.S.
Chemical addition pump	1	316 S.S.
Precoat pump	1	316 S.S.
Floor drain oil separator flushing header pump	1	

TABLE 11.2-14: MATERIALS OF CONSTRUCTION FOR MAJOR COMPONENTS OF THE LIQUID RADWASTE SYSTEM (Continued)

	Quantity	Material of Construction
Equipment drain collector pump	1	316 S.S.
Equipment drain sample pump	1	316 S.S.
Waste surge pump	1	316 S.S.
Floor drain collector pump	1	316 S.S.
Condensate phase separator pump	2	316 S.S.
<u>Miscellaneous</u>		
Miscellaneous chemical waste evaporator package (not used)	1	304 S.S., 316 S.S. Incoloy 825, Carbon Steel
Floor drain evaporator package (not used)	1	304 S.S., 316 S.S. Incoloy 825, Carbon Steel
Floor drain filter	1	304 S.S.

TABLE 11.2-14: MATERIALS OF CONSTRUCTION FOR MAJOR COMPONENTS OF THE LIQUID RADWASTE SYSTEM (Continued)

	Quantity	Material of Construction
Floor drain demineralizer	1	304 S.S.
Floor drain oil separator	1	Carbon Steel
Floor drain oil separator oil removal pump	1	Cast Iron, Carbon Steel
Equipment drain filter	1	304 S.S.
Equipment drain demineralizer	1	304 S.S.
Floor drain oil separator flushing header pump	1	Cast Iron, Carbon Steel, Bronze

*S.S. = Stainless Steel

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Heater drain tank	1	Turbine bldg	Analog computer level indications	Level alarm high, low, & low-low (See Note 1)	Bypass to condenser
Moisture separator drain tank	2	Turbine bldg	Analog computer level indications	Level alarm high (See Note 1)	Bypass to condenser
1st stage reheater drain tank	2	Turbine bldg	Analog computer level indications	Level alarm high (See Note 1)	Bypass to condenser
2nd stage reheater drain tank	2	Turbine bldg	Analog computer level indications	Level alarm high (See Note 1)	Bypass to condenser

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Condensate drain tank	1	Turbine bldg	Analog computer level indications	Level alarm high & low (See Note 1)	Turbine bldg west equipment drain sump
Ultrasonic resin cleaner	1	Turbine bldg	Level indication (See Note 2)	Level alarm high & low (See Note 1)	Closed system to condensate clean waste tank
Resin separation & cation regeneration tank	1	Turbine bldg	None (See Note 10)	None (See Note 10)	Closed system to condensate clean waste tank
Anion regeneration tank	1	Turbine bldg	None (See Note 10)	None (See Note 10)	Closed system to condensate clean waste tank
Resin mix and storage tank	1	Turbine bldg	None (See Note 10)	None (See Note 10)	Closed system to condensate clean waste tank

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Condensate storage tank	1	Yard	Level Indication (See Note 3)	Level alarm high & low (See Note 3)	Waste surge tank
Fuel pool drain tank	1	Auxiliary bldg	Redundant level indication (See Note 4)	Level alarm high (See Note 1)	Not required (See Note 11)
Condensate clean waste tank	1	Turbine bldg	Digital computer level indication	Level alarm high (See Note 6)	Turbine bldg west floor drain sump
Floor drain sample tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg floor drain sump
Floor drain collect or tank	1	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg floor drain sump

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Equipment drain collector tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg floor drain sump
Equipment drain equip-sample tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg floor drain sump
Waste surge tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg floor drain sump
Spent resin tank	1	Radwaste bldg	Digital computer level indication	4 level indications and high and low level alarms (See Note 6)	Radwaste bldg floor drain sump
Distillate sample tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg equipment drain sump

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Evaporator bottoms tank (not used)	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg chemical waste sump
RWCU phase separator decay tank	2	Radwaste bldg	Digital Computer level indication	Level alarm high & low (See note 6)	Overflow crosstie between the two tanks. Decant to equipment drain collector tank
Miscellaneous chemical waste receiver tank	1	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg chemical waste sump
Condensate demineralizer regeneration solution receiving tank	2	Radwaste bldg	Continuous level recording (See Note 6)	Level alarm high & low (See Note 6)	Radwaste bldg chemical waste sump

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Fuel pool backwash receiving tank	1	Auxiliary bldg	Continuous level indication (See Note 5)	Level alarm high	Auxiliary bldg equipment drain sump
Waste holding tank	3	Radwaste bldg	Level indication (Note 7)	Level alarm high & low (See Note 7)	Radwaste bldg floor drain sump
Condensate demineralizer regeneration solution collector tank	1	Turbine bldg	Level indication (See Note 6)	Level alarm high & low (See Note 6)	Turbine bldg south chemical waste sump
Auxiliary bldg equipment drain transfer tank	1	Auxiliary bldg	Level indication (See Note 6)	Level alarm high-high (See Note 6)	Auxiliary bldg south floor drain sump
Auxiliary bldg floor drain transfer tank	1	Auxiliary bldg	Level indication (See Note 6)	Level alarm high-high (See Note 6)	Auxiliary bldg south floor drain sump

TABLE 11.2-15: TANKS LOCATED OUTSIDE THE CONTAINMENT WHICH CONTAIN POTENTIALLY RADIOACTIVE FLUID (Continued)

Tank	Quantity	Location	Tank Level Monitoring	Annunciation	Overflow Control
Moisture separator shell drain tank	2	Turbine bldg	Analog computer level indication	Level alarm high (See Note 1)	Condenser bypass
Refueling water storage tank	1	Yard	Level indication (See Note 3)	Level alarm high (See Note 3)	To waste surge tank
Condensate phase separator tank	2	Radwaste bldg	Digital computer level indication and continuous level indication (See Note 6)	8 level indications and high and low level alarms (See Note 6)	Radwaste bldg floor drain sump

Notes

1. Located on operator's control console (control room).

2. Located on ultrasonic resin control panel, water inventory control station (radwaste bldg).

3. Located on auxiliary control benchboard (control room).

4. Located on Division 1 leak detection vertical board and Division 2 leak detection vertical board (control room).

5. Located on fuel pool cooling and cleanup filter demineralizer control panel (auxiliary bldg).

6. Located on liquid radwaste control console, water inventory control station (radwaste bldg).

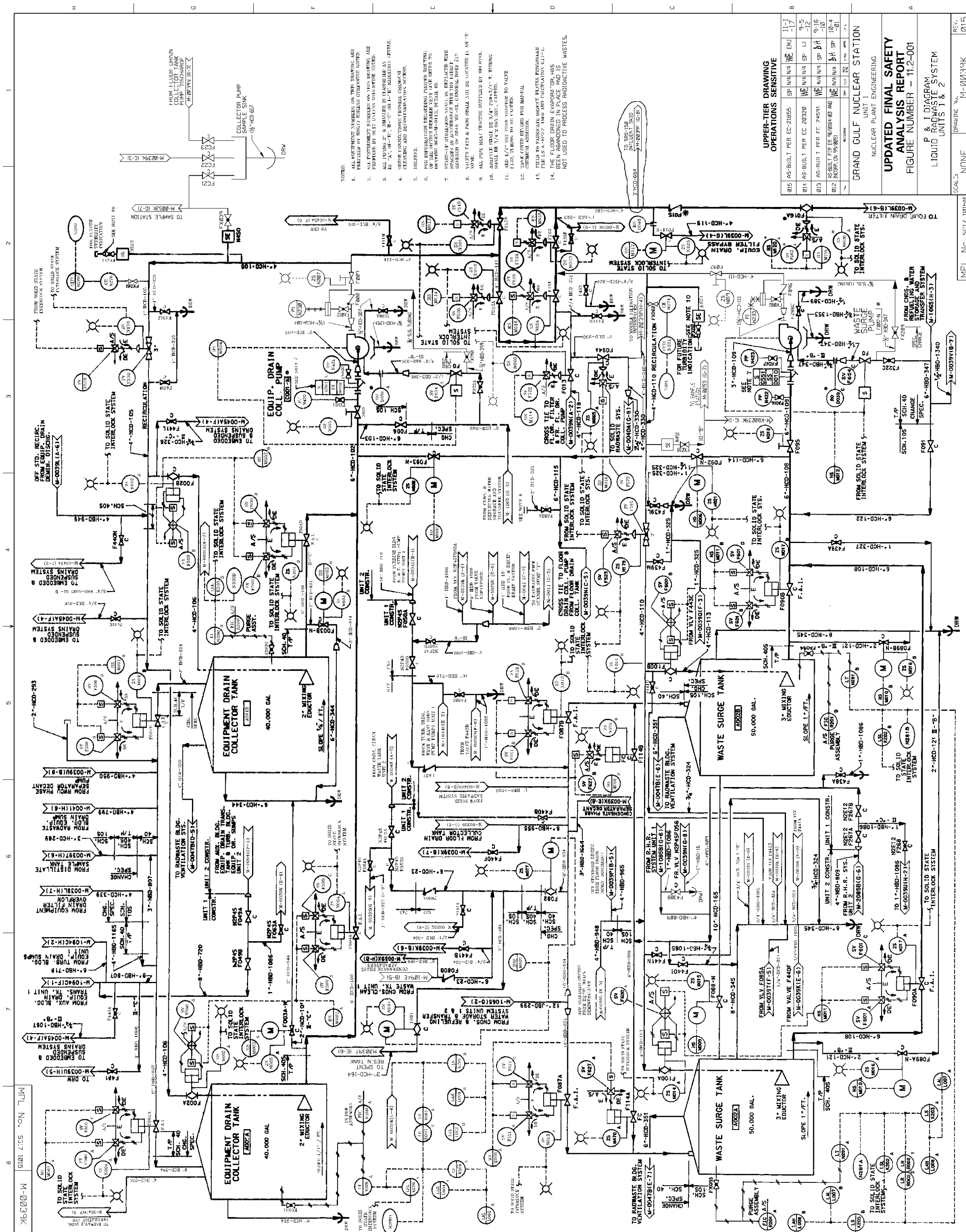
7. Located on solid radwaste control console, water inventory control station (radwaste bldg).

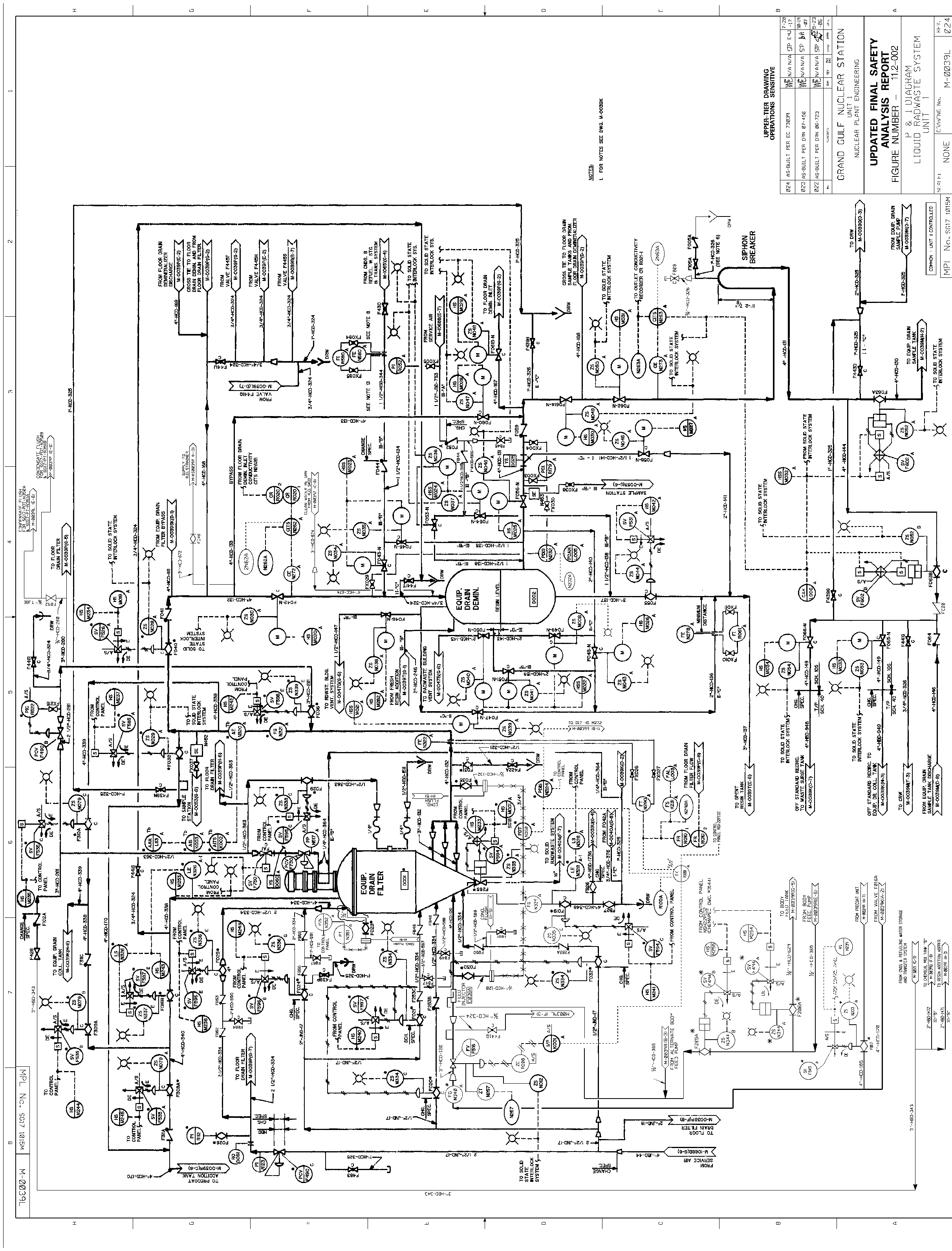
8. Mounted on the tank.

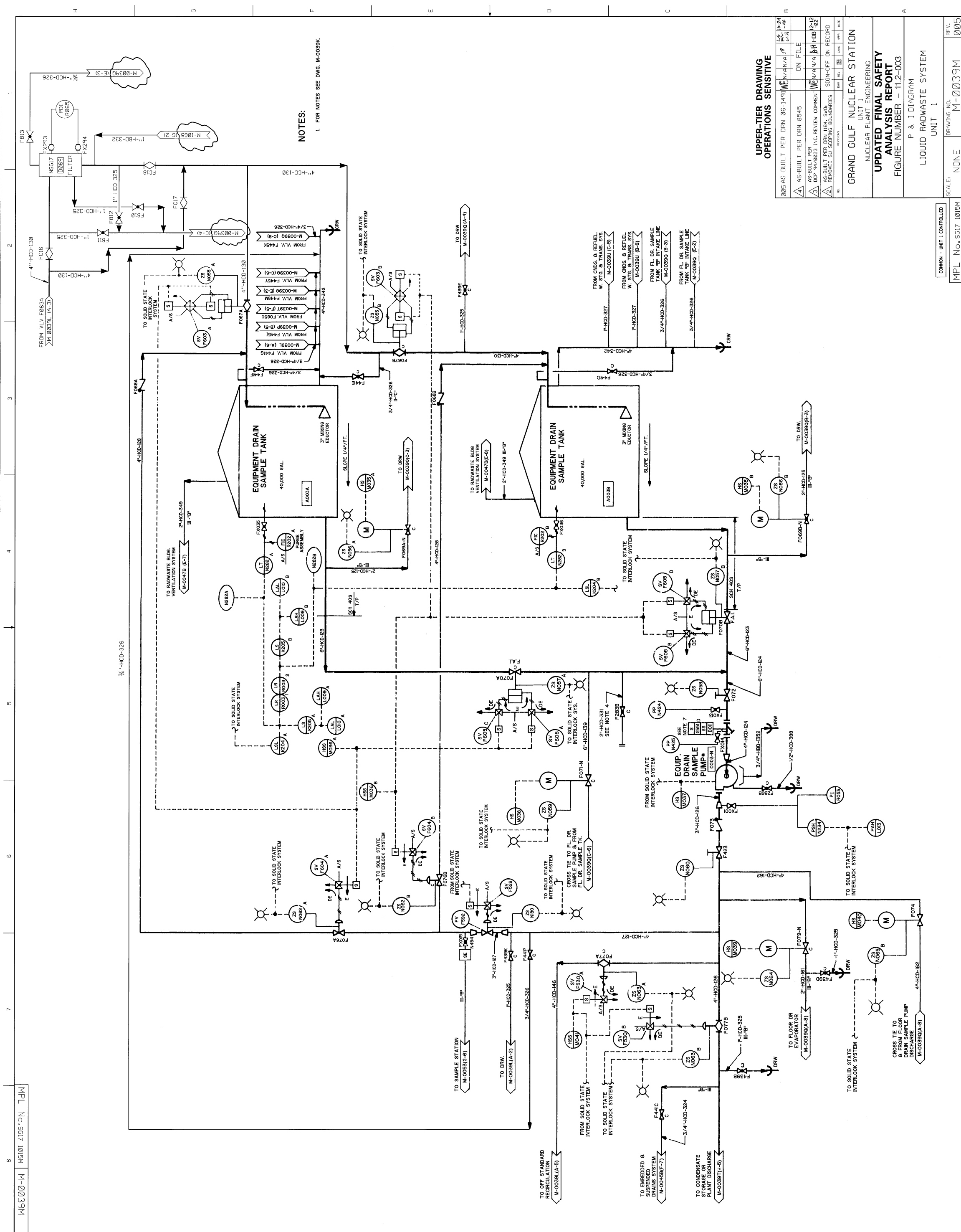
9. Deleted

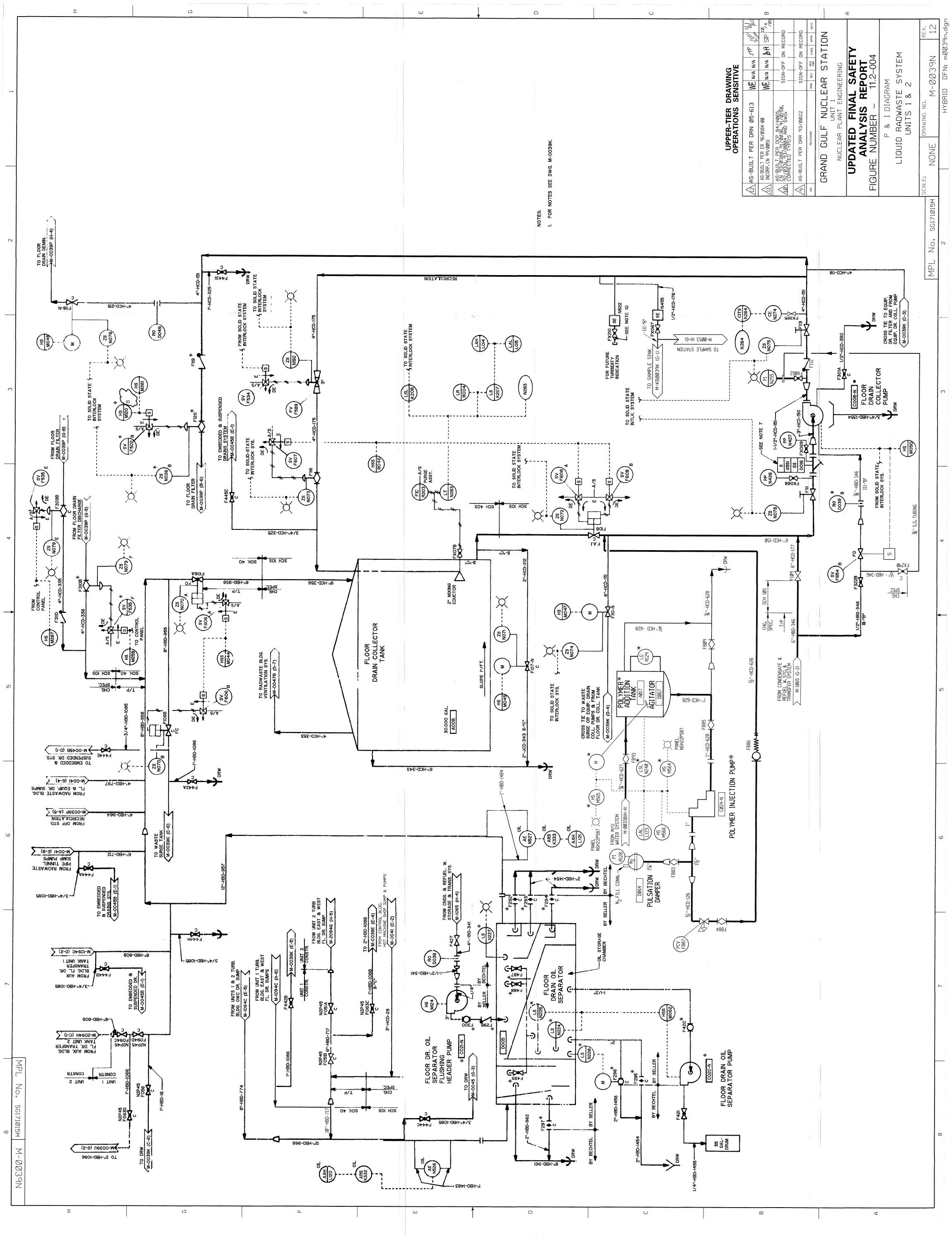
10. Tank capacity is larger than that of the vessel from which it is receiving flow.

11. The tank vent extends to an elevation higher than the maximum water level possible in the fuel pool. Tank overflow condition cannot occur.

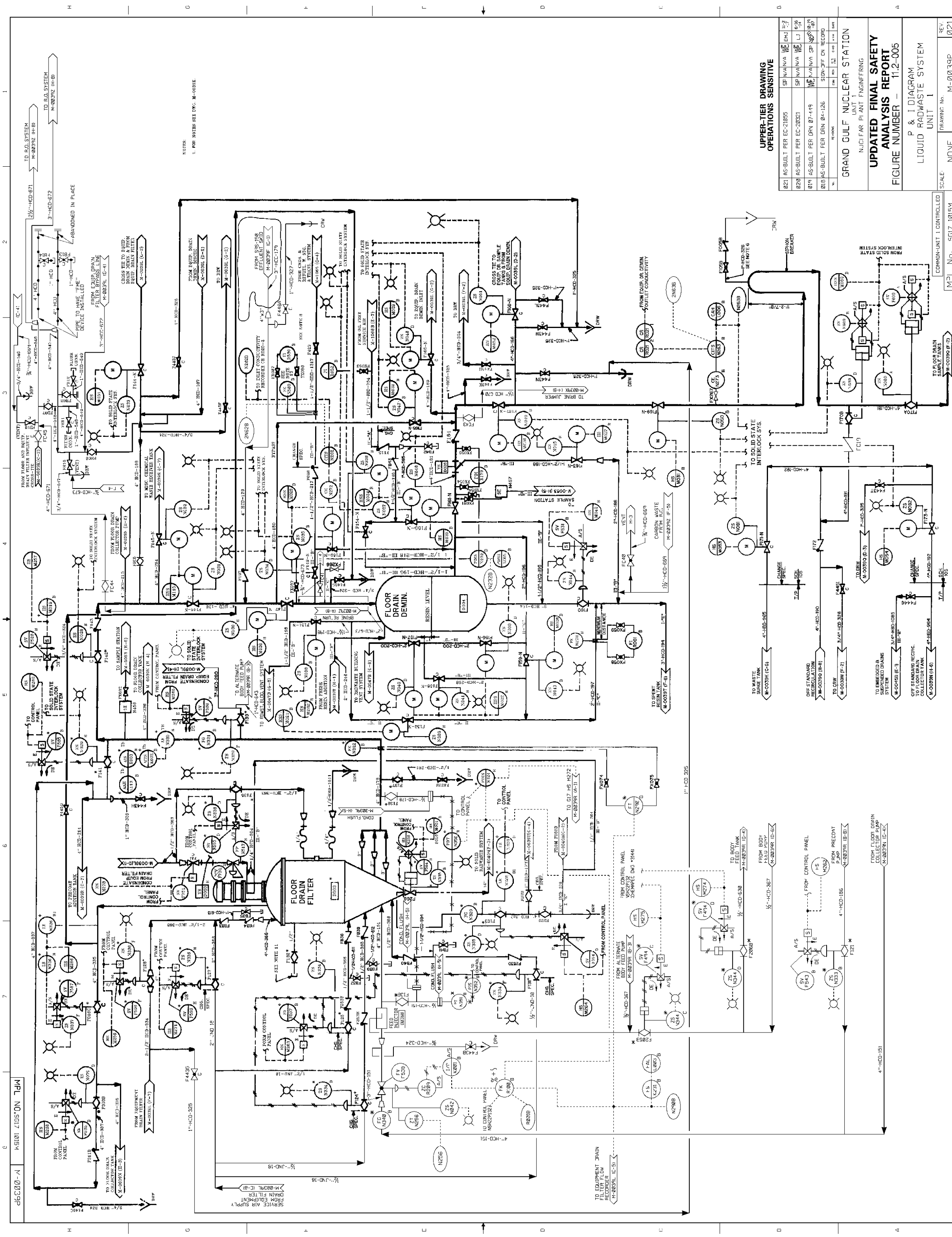

UPPER-TIER DRAWING
OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY
ANALYSIS REPORT
FIGURE NUMBER – 11.2-001
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
M-0039K
EQUIPMENT DRAIN
COLLECTOR TANK
40,000 GAL
WASTE SURGE TANK
50,000 GAL.


GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER 11.2-002
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
UPPER-TIER DRAWING OPERATIONS SENSITIVE
EQUIP. DRAIN DEMIN.
EQUIP. DRAIN FILTER
SIPHON BREAKER
M-0039L

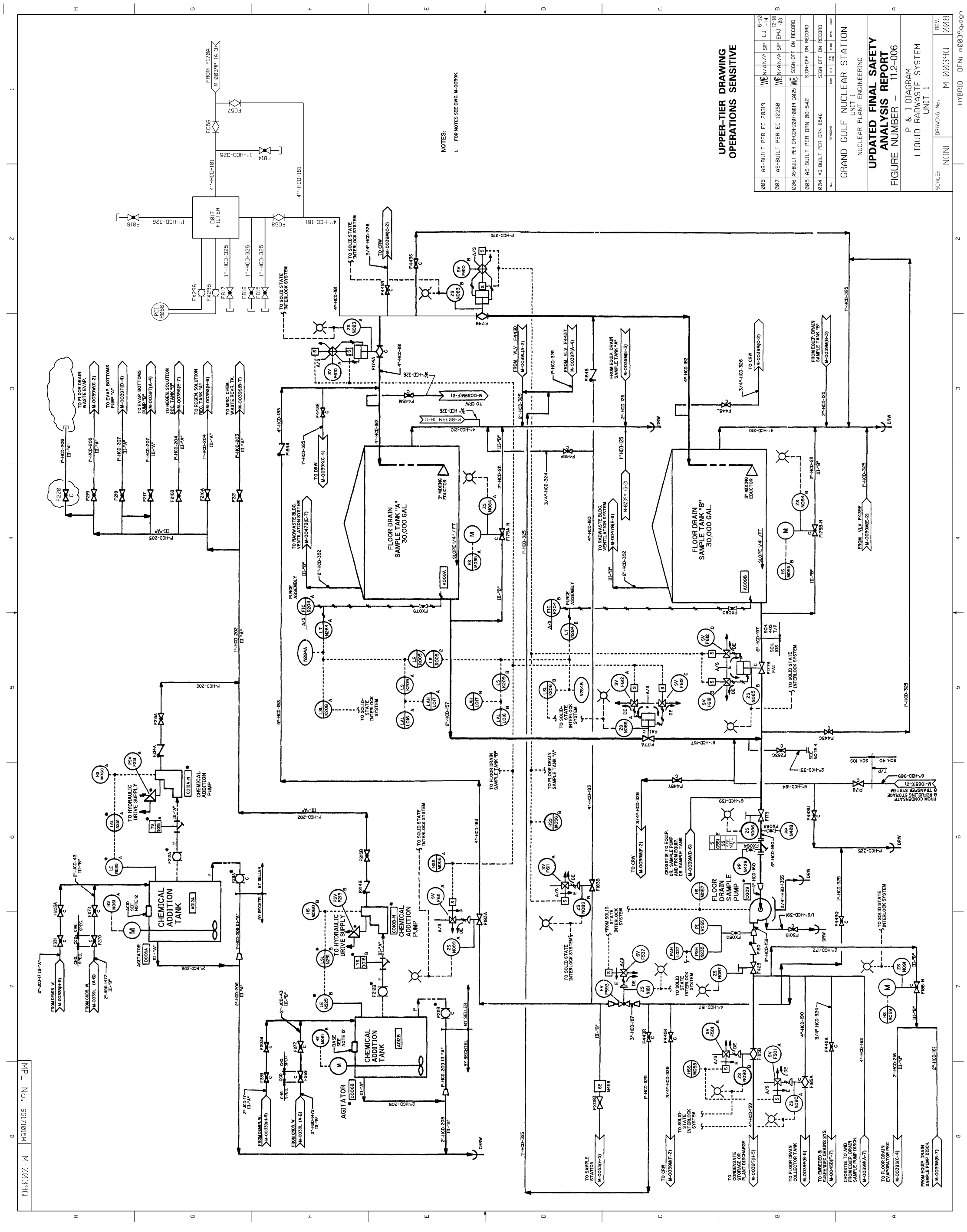

UPPER-TIER DRAWING
OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY
ANALYSIS REPORT
FIGURE NUMBER - 11.2-003
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
M-0039M
EQUIPMENT DRAIN
SAMPLE TANK
40,000 GAL.
EQUIP.
DRAIN
SAMPLE
PUMP
NOTES:

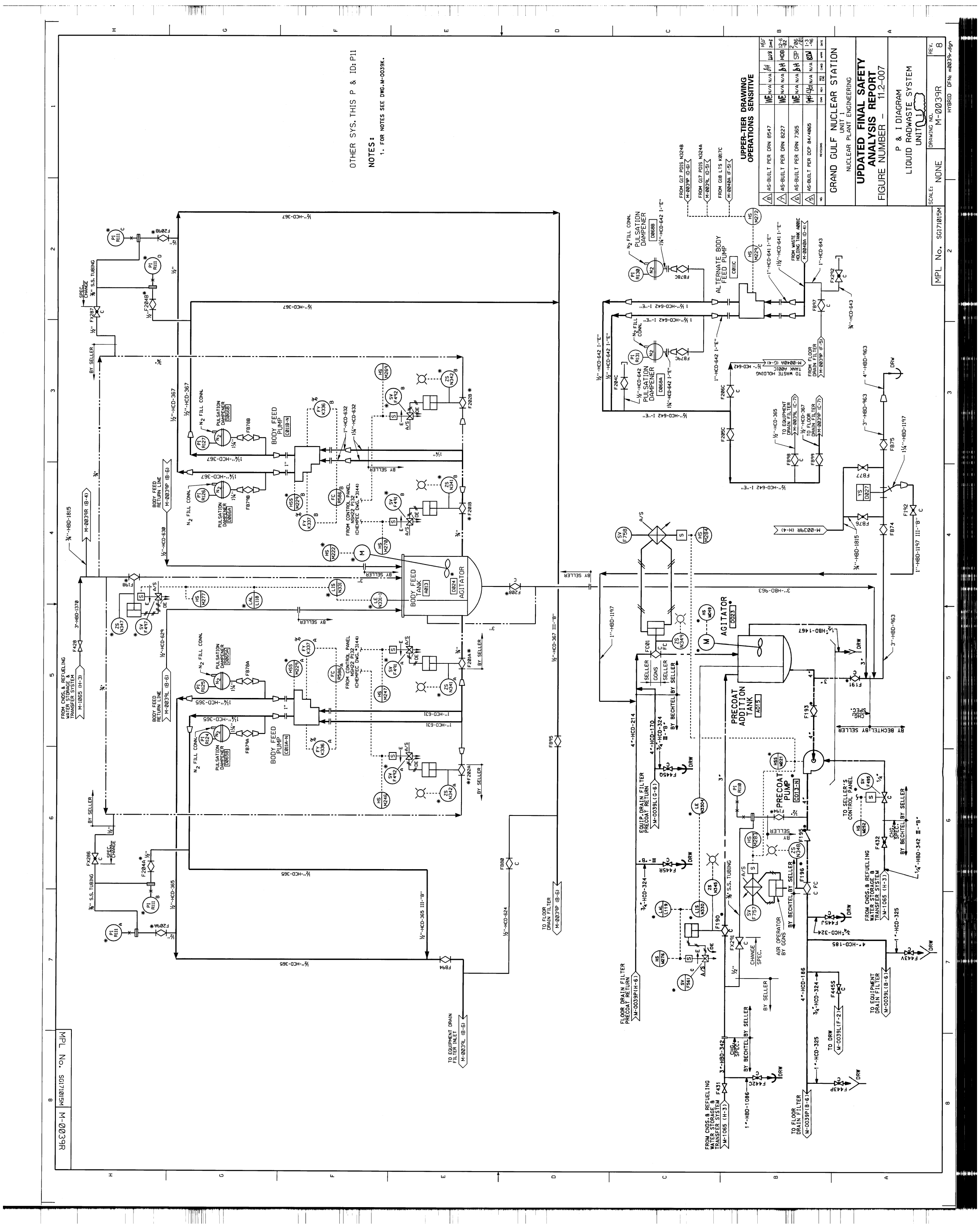


UPPER-TIER DRAWING OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER 11.2-004
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
M-0039N
FLOOR DRAIN COLLECTOR TANK
FLOOR DRAIN COLLECTOR PUMP
POLYMER INJECTION PUMP
FLOOR DRAIN OIL SEPARATOR
FLOOR DRAIN OIL SEPARATOR PUMP

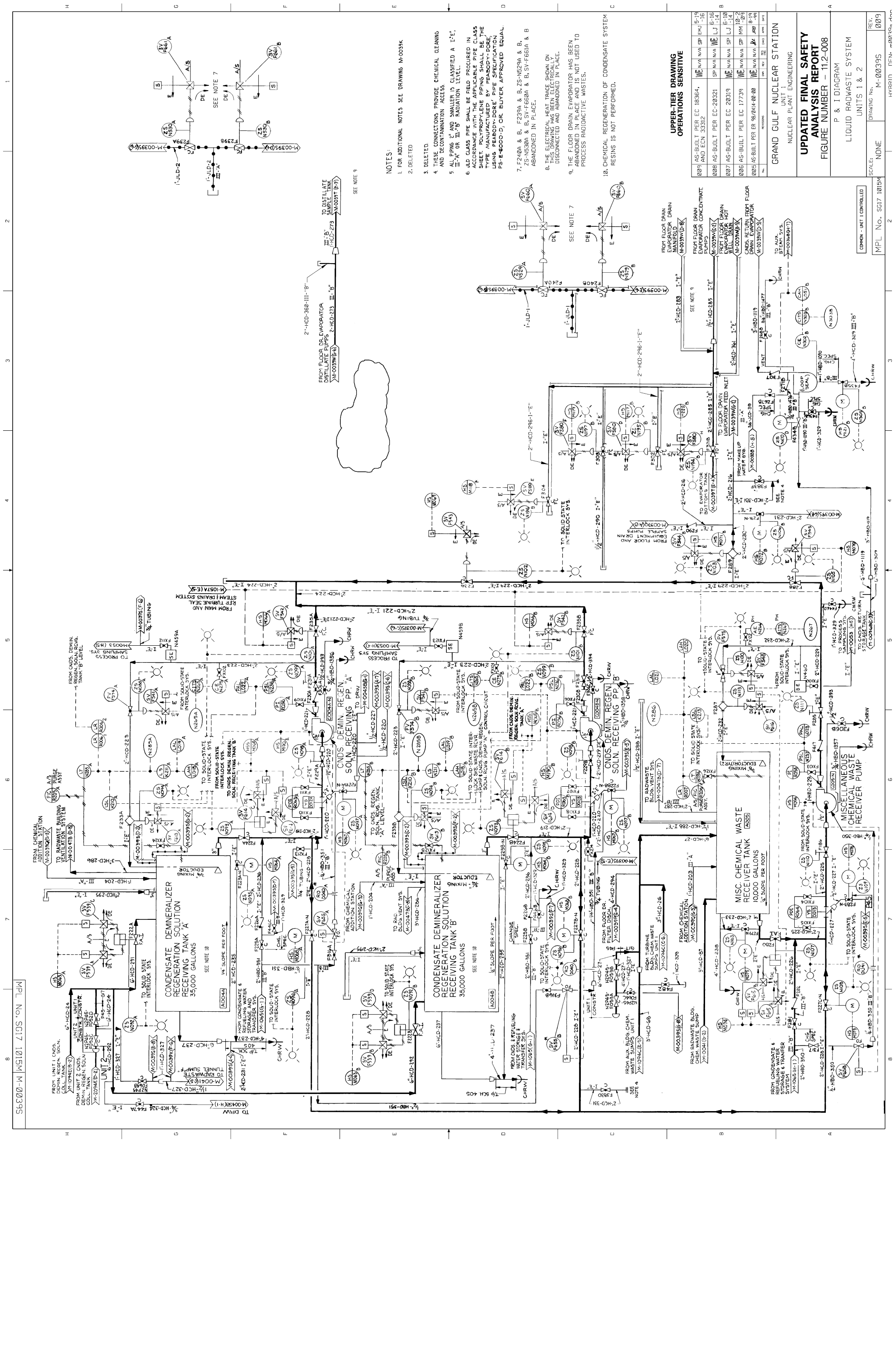


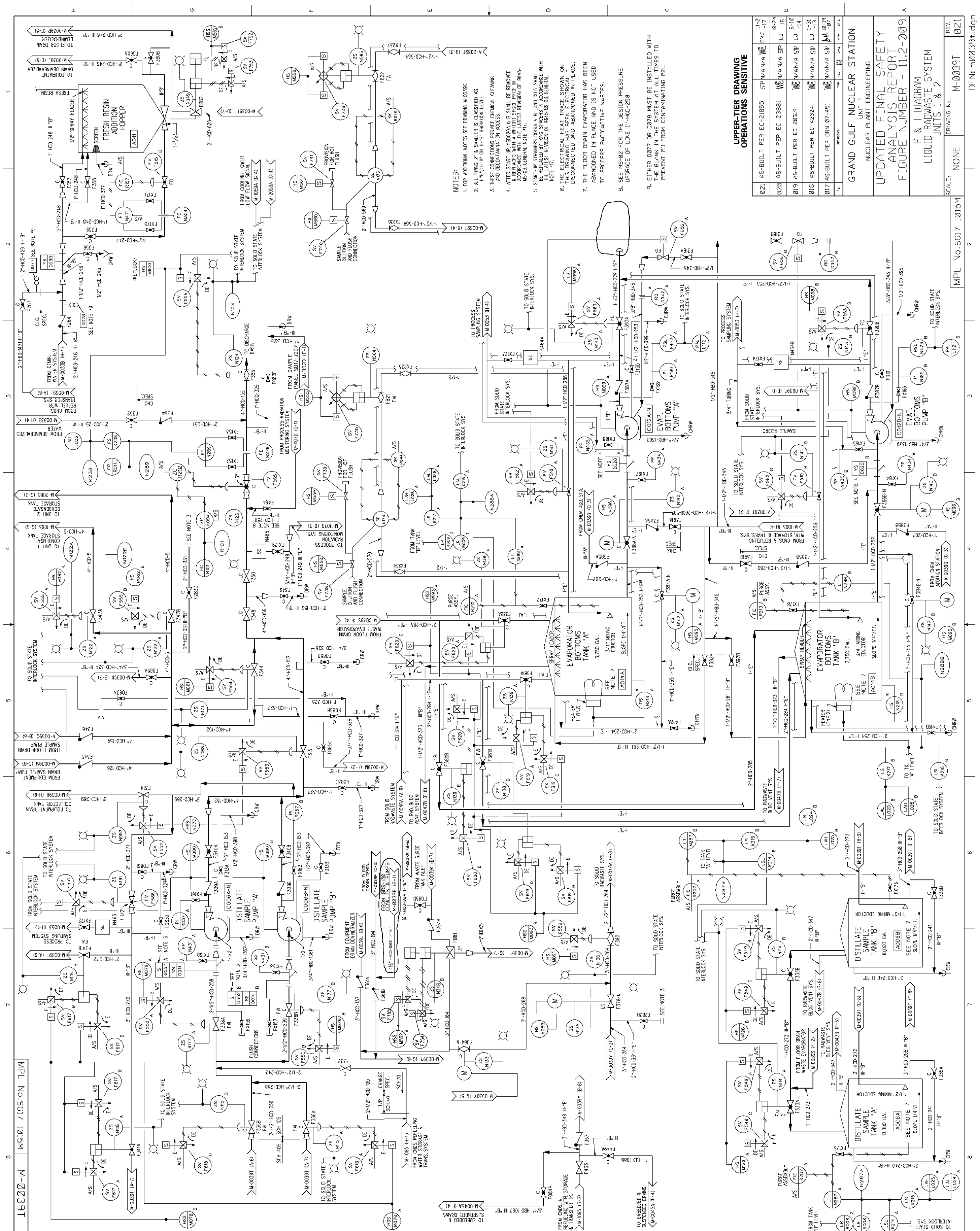
UPPER-TIER DRAWING OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-005
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
M-0039P
FLOOR DRAIN DEMIN.
FLOOR DRAIN FILTER


UPPER-TIER DRAWING
OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY
ANALYSIS REPORT
FIGURE NUMBER 11.2-006
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
M-0039G
FLOOR DRAIN
SAMPLE TANK "A"
30,000 GAL.
FLOOR DRAIN
SAMPLE TANK "B"
30,000 GAL.
CHEMICAL
ADDITION
TANK
FLOOR
DRAIN
SAMPLE
PUMP



GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.2-007
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
M-0039R
BODY FEED TANK
PRECOAT ADDITION TANK
PRECOAT PUMP
AGITATOR


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-008
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2



GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-009
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
M-0039T

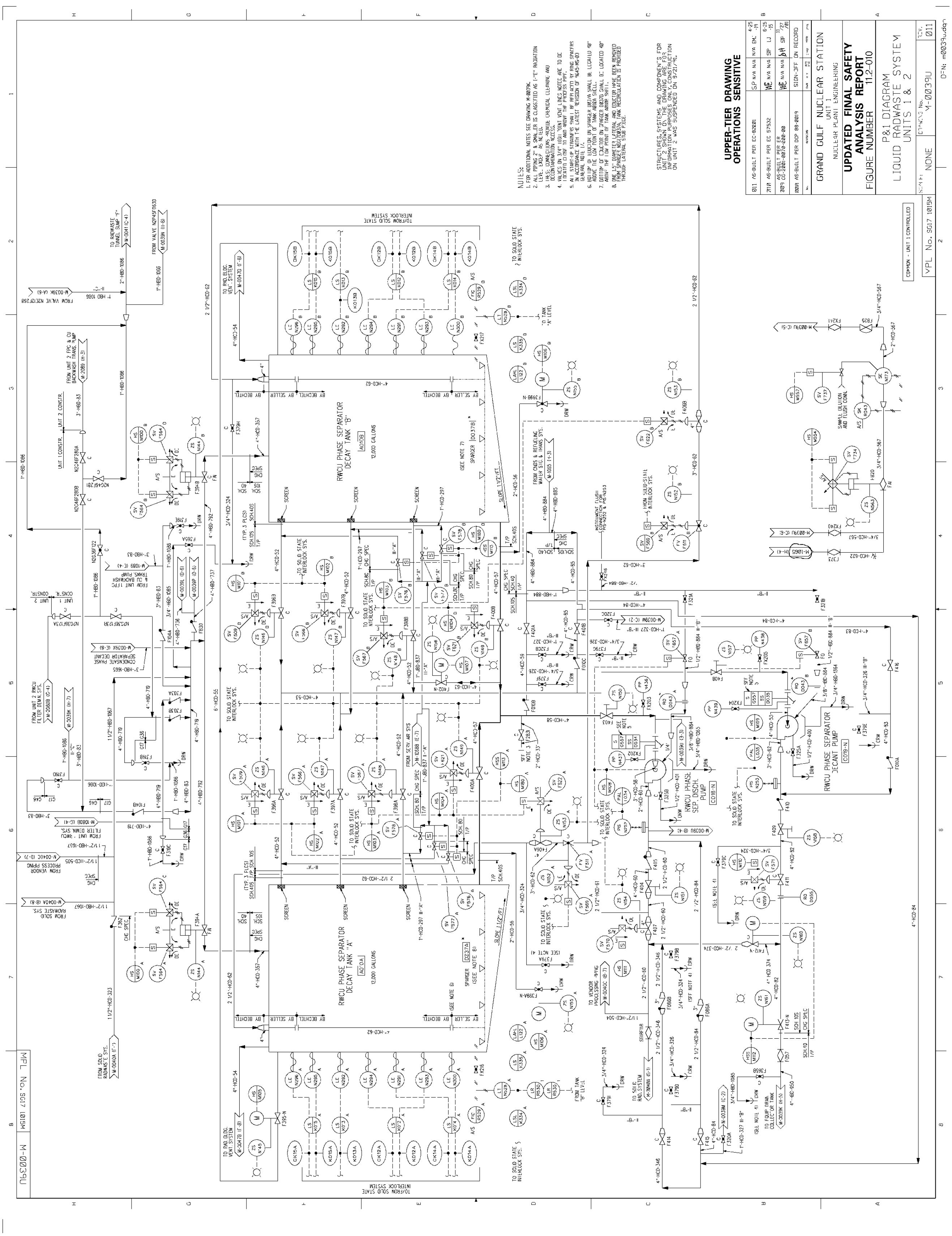
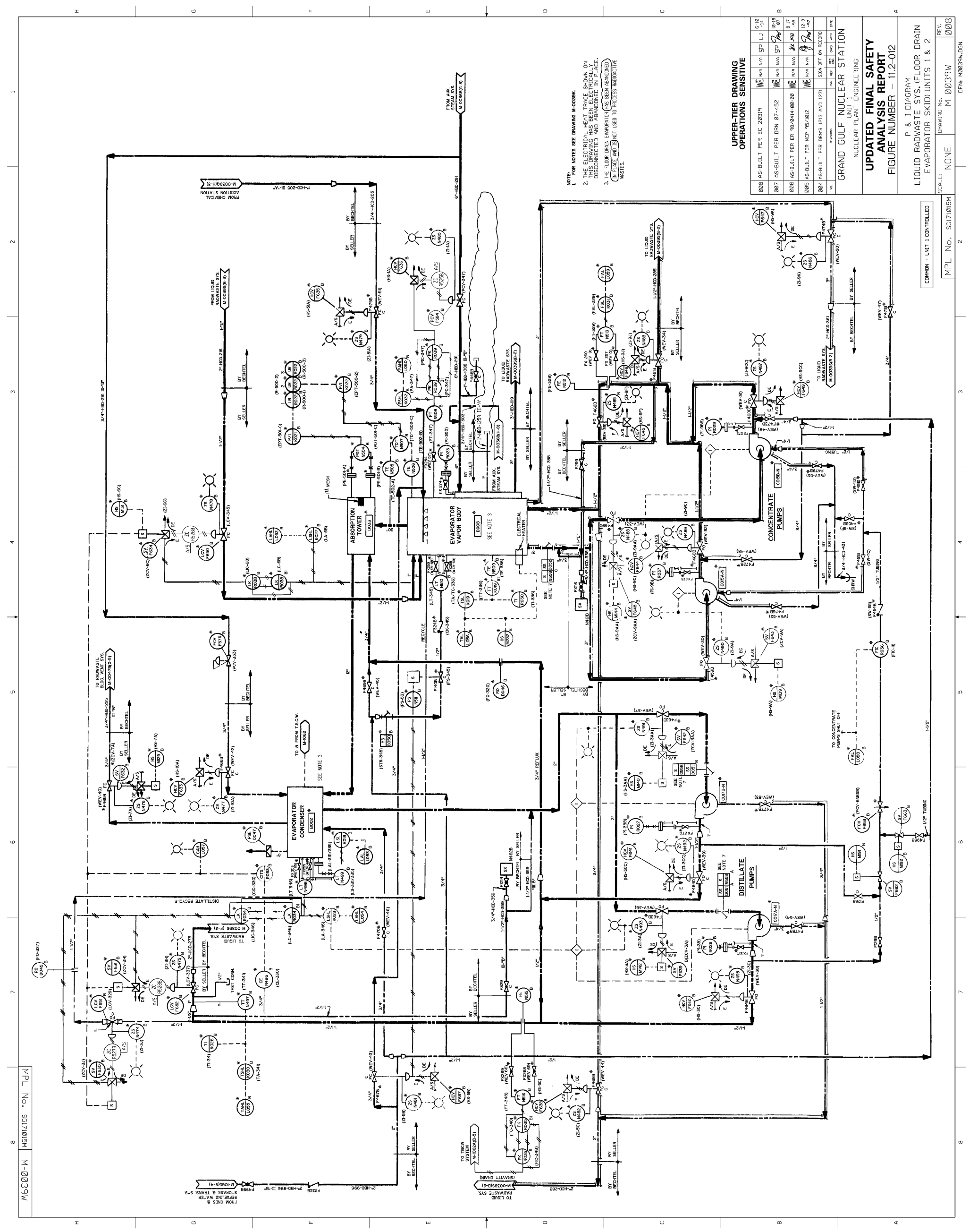
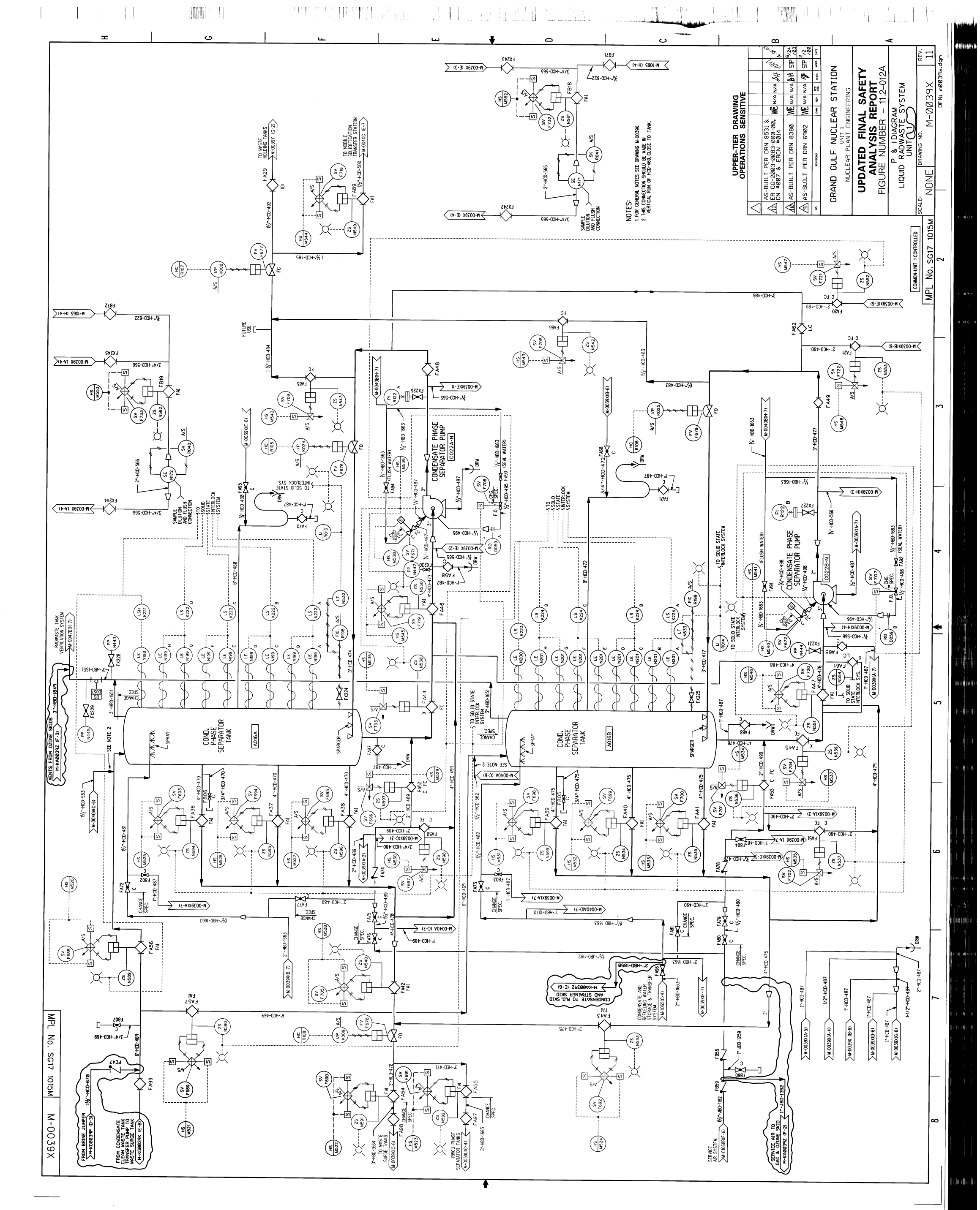

GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER 11.2-010
P&I DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
M-0039U
RWCU PHASE SEPARATOR DECAY TANK "B"
RWCU PHASE SEPARATOR DECAY TANK "A"
RWCU PHASE SEPARATOR DECANT PUMP
RWCU PHASE SEP. DISCH. PUMP

Figure 11.2-011

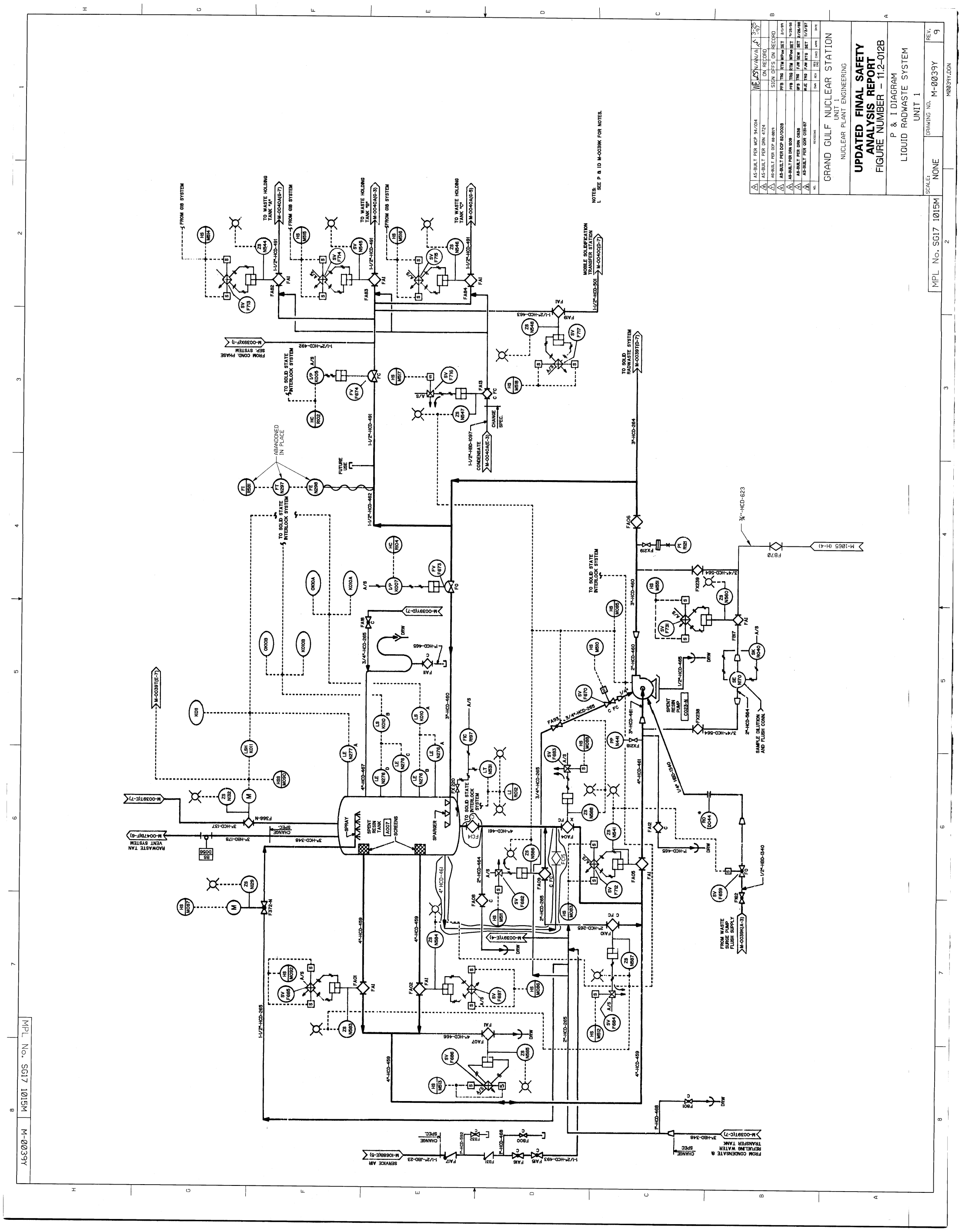
Deleted



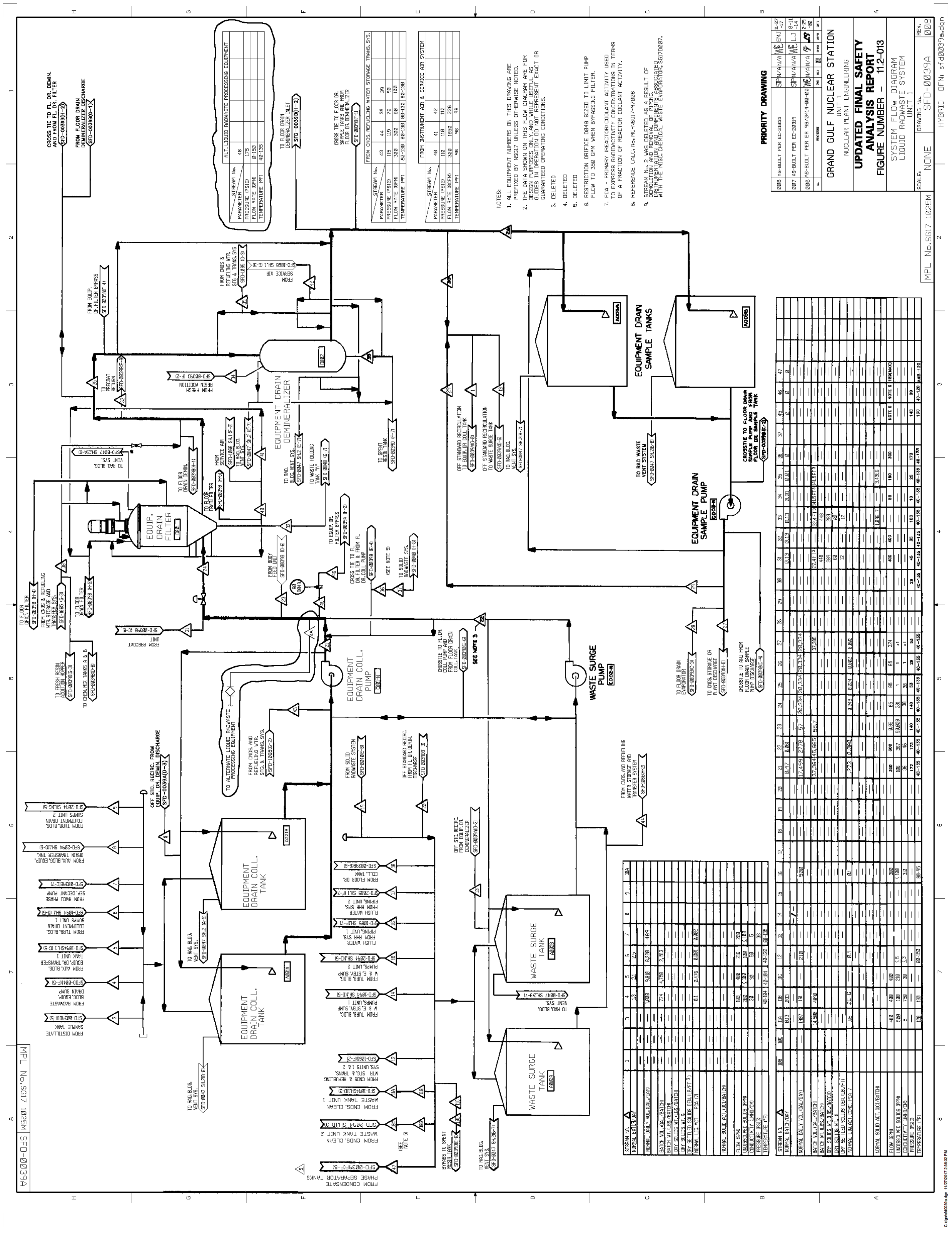
GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-012
P & I DIAGRAM
LIQUID RADWASTE SYS.(FLOOR DRAIN EVAPORATOR SKID) UNITS 1 & 2
UPPER-TIER DRAWING OPERATIONS SENSITIVE
EVAPORATOR VAPOR BODY
ABSORPTION TOWER
EVAPORATOR CONDENSER
CONCENTRATE PUMPS
DISTILLATE PUMPS

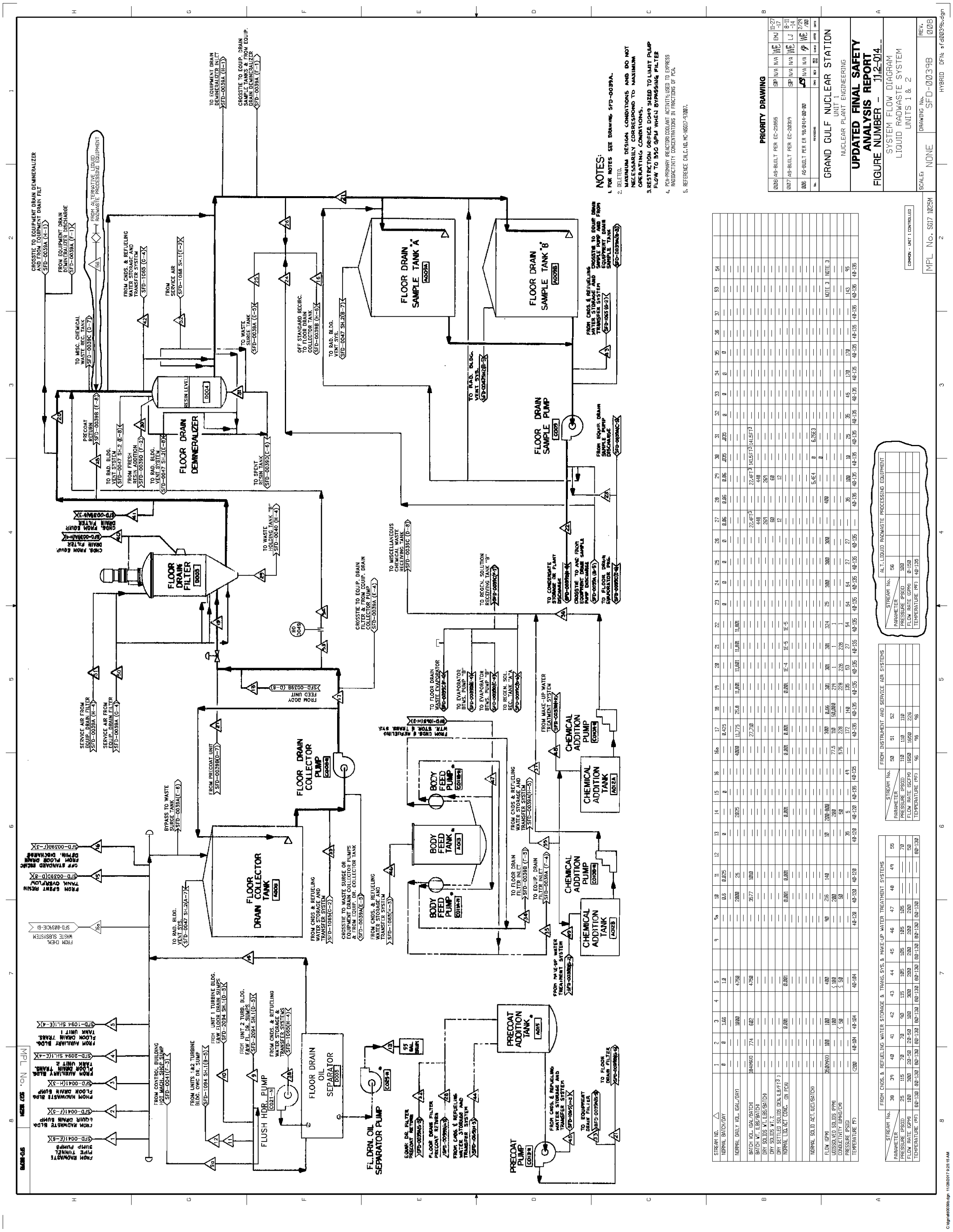


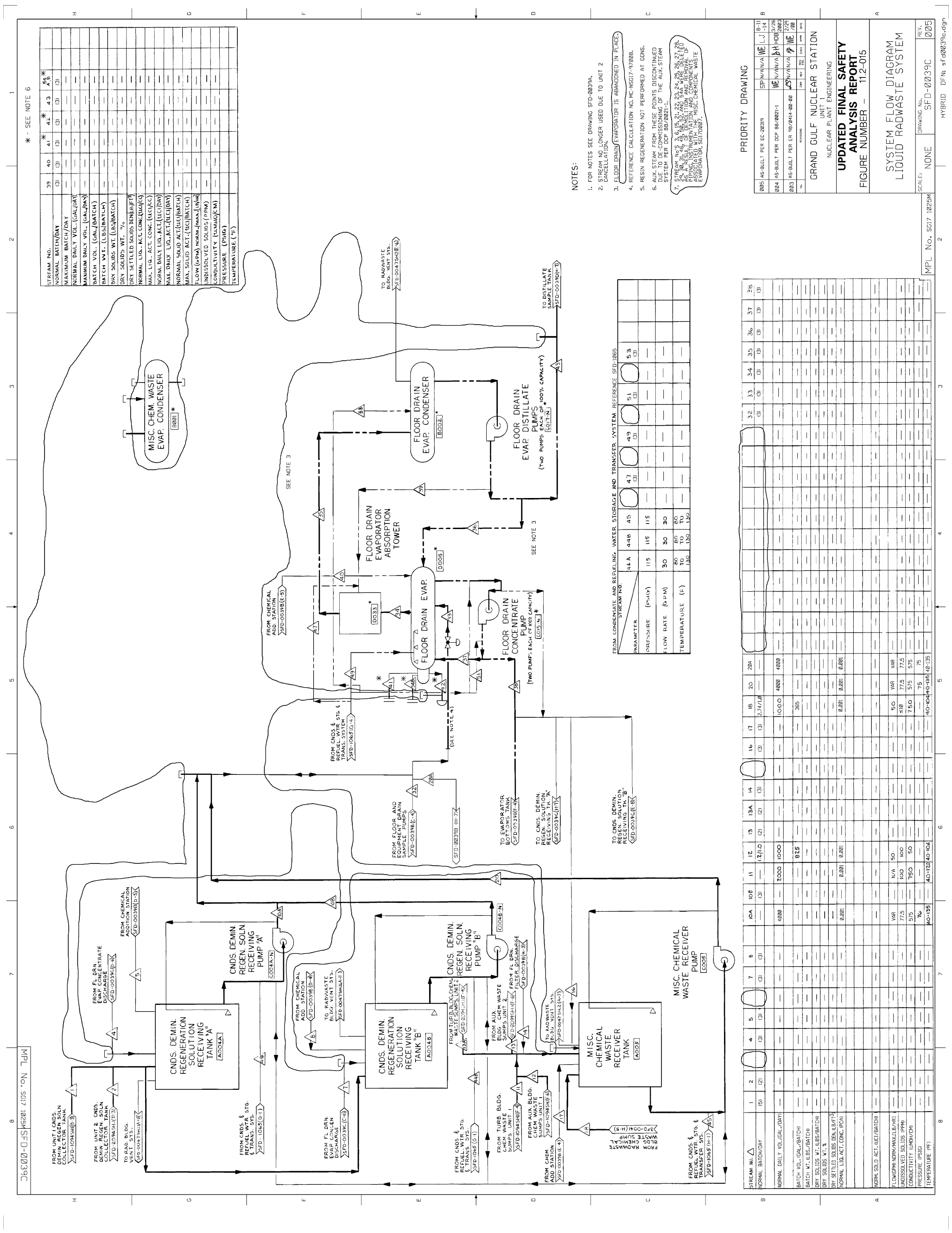
UPPER-TIER DRAWING OPERATIONS SENSITIVE
AS-BUILT PER DRN 8531 & ER GG-2003-0083-000-00, CN #007 & ERCN #014
AS-BUILT PER DRN 8380
AS-BUILT PER DRN 6902
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-012A
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
SCALE: NONE
DRAWING NO. M-0039X
REV. 11
DFN: m0039x.dgn
MPL No. SG17 1015M
COMMON-UNIT 1 CONTROLLED
CONDENSATE PHASE SEPARATOR PUMP
COND. PHASE SEPARATOR TANK

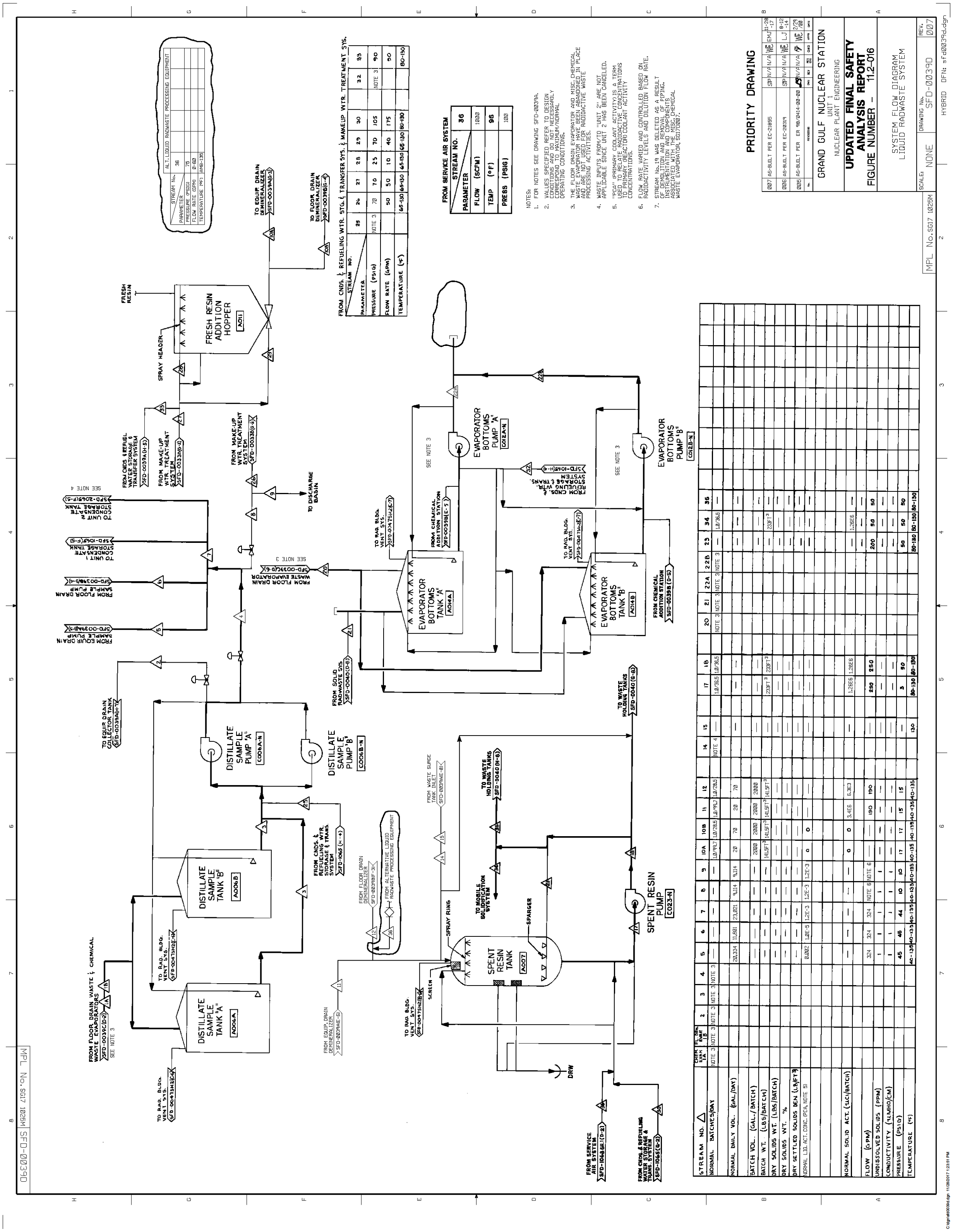


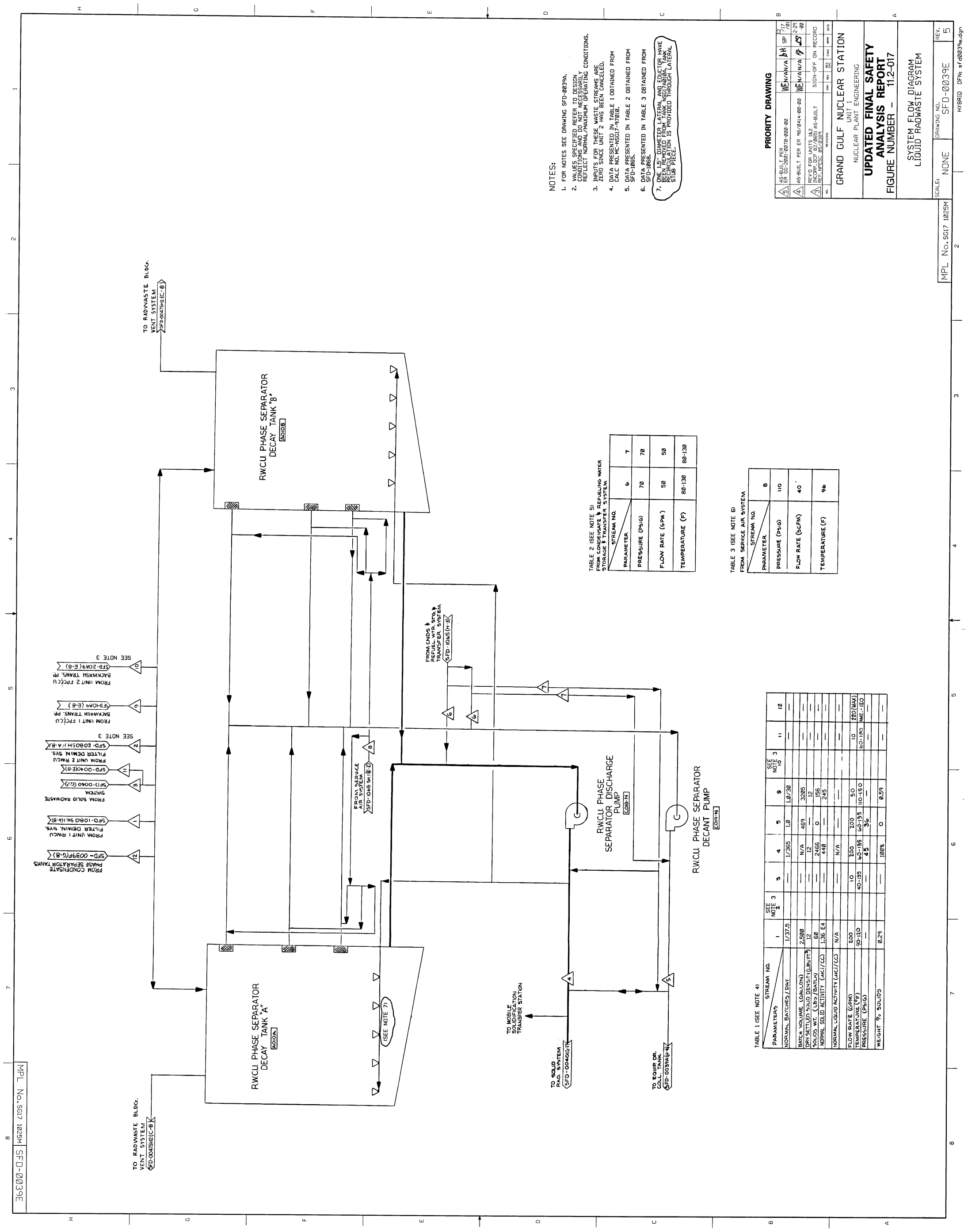
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.2-012B
P & I DIAGRAM
LIQUID RADWASTE SYSTEM
UNIT 1
SCALE: NONE
DRAWING NO. M-0039Y
REV. 9
MPL No. SG17 1015M

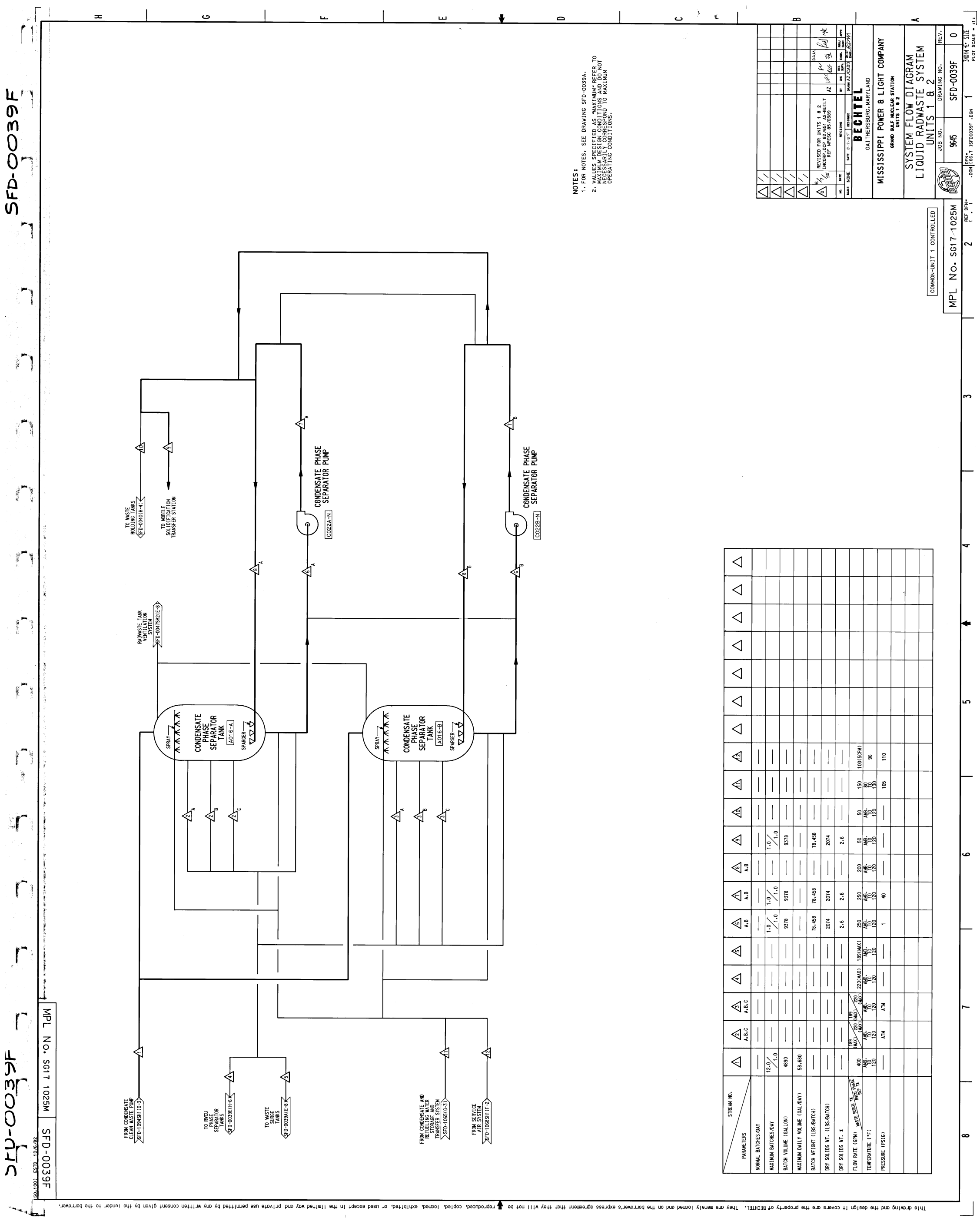

GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-013
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
SFD-0039A


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-014
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
SFD-0039B


GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-015
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
PRIORITY DRAWING
NOTES:
FLOOR DRAIN EVAP.
FLOOR DRAIN EVAP. CONDENSER
FLOOR DRAIN EVAPORATOR ABSORPTION TOWER
FLOOR DRAIN CONCENTRATE PUMP
FLOOR DRAIN EVAP. DISTILLATE PUMPS
MISC. CHEM. WASTE EVAP. CONDENSER
CNDS. DEMIN. REGENERATION SOLUTION RECEIVING TANK "A"
CNDS. DEMIN. REGENERATION SOLUTION RECEIVING TANK "B"
CNDS DEMIN REGEN. SOLN RECEIVING PUMP "A"
CNDS DEMIN REGEN. SOLN RECEIVING PUMP "B"
MISC. CHEMICAL WASTE RECEIVER TANK
MISC. CHEMICAL WASTE RECEIVER PUMP
SFD-0039C


PRIORITY DRAWING
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-016
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
SFD-0039D
MPL No. SG17 1025M


GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.2-017
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
SFD-0039E
PRIORITY DRAWING
RWCU PHASE SEPARATOR DECAY TANK 'B'
RWCU PHASE SEPARATOR DECAY TANK 'A'
RWCU PHASE SEPARATOR DISCHARGE PUMP
RWCU PHASE SEPARATOR DECANT PUMP
TO RADWASTE BLDG. VENT SYSTEM


SFD-0039F
MPL No. SG17-1025M
CONDENSATE PHASE SEPARATOR PUMP
CONDENSATE PHASE SEPARATOR PUMP
CONDENSATE PHASE SEPARATOR TANK
CONDENSATE PHASE SEPARATOR TANK
COMMON-UNIT 1 CONTROLLED
BECHTEL
MISSISSIPPI POWER & LIGHT COMPANY
SYSTEM FLOW DIAGRAM
LIQUID RADWASTE SYSTEM
UNITS 1 & 2
SFD-0039F

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

The gaseous waste management systems include all systems that have the potential to release airborne radioactive materials into the environment during normal operation and anticipated operational occurrences. Included are the vent systems of normally and potentially radioactive components, building ventilation systems, the offgas system and the mechanical vacuum pump system.

The waste gases originating in the reactor coolant consist mainly of hydrogen and nitrogen with trace amounts of radioactive gases. The function of the offgas system is to collect and isolate these radioactive noble gases, airborne halogens, and particulates, and to reduce their activity through decay.

The plant ventilation exhaust systems accommodate other potential release paths for gaseous radioactivity from miscellaneous leakages and aerated vents from systems containing radioactive fluids. Systems which handle these gases are included here to the extent that they represent potential release paths for gaseous radioactivity. Potential sources of gaseous releases are discussed in subsection 11.3.3.

11.3.1 Design Bases

11.3.1.1 Design Objective

The objective of the gaseous waste management systems is to process and control the release of gaseous radioactive effluents to the site environs so as to maintain as low as reasonably achievable, the exposure of persons in unrestricted areas, to radioactive gaseous effluents (Appendix I to 10 CFR 50, May 5, 1975). This is to be accomplished while maintaining occupational exposure as low as reasonably achievable and without limiting plant operation or availability.

11.3.1.2 Design Criteria

The gaseous effluent treatment systems are designed to limit the dose to offsite persons from routine station releases to significantly less than the limits specified in 10 CFR 20 and to operate within the emission rate limits established in the station operating license.

As a design basis for the offgas system, an annual average noble radiogas source term (based on 30-min decay) of 100,000 µCi/sec of the "1971 Mixture" has been used. Table 11.3-1 indicates the design basis noble radiogas source terms referenced to 30-min decay. The radiation dose design basis for the treated offgas is to delay the gas until the required fraction of the radionuclides has decayed and the daughter products are retained by the charcoal and the HEPA filters.

The gaseous radwaste equipment is selected, arranged and shielded to maintain occupational exposure as low as reasonably achievable in accordance with Nuclear Regulatory Commission Regulatory Guide 8.8.

The gaseous effluent treatment systems are designed to the requirements of General Design Criteria as follows:

General Design Criterion 60

The systems have sufficient capacity to reduce the offgas activity to permissible levels for release during normal operation, including anticipated operational occurrences, and to alleviate any termination of releases or limitation of plant operation due to unfavorable site environmental conditions.

General Design Criterion 64

Implementation of General Design Criterion 64 is discussed in Section 11.5.

11.3.1.3 Equipment Design Criteria

A list of the offgas system major equipment items which includes materials, rates process conditions, and number of units supplied is provided in Table 11.3-2. Equipment and piping will be designed and constructed in accordance with the requirements of the applicable codes as given in Table 3.2-1 and will comply with the welding and material requirements. Seismic Category, safety class, quality assurance requirements, and principal construction codes information is contained in Section 3.2.

The failure of the offgas system is analyzed in subsection 15.7.1.

The containment, turbine building, and radwaste building contain radioactive gas sources. The design bases for the ventilation systems for these three buildings are described in Section 9.4.

11.3.2 System Description

The offgas from the main condenser steam-jet air ejector is treated by means of a system utilizing catalytic recombination and low-temperature charcoal adsorption. Descriptions of the major process components including design temperature and pressure are given in Table 11.3-2 and in the following paragraphs.

11.3.2.1 Main Condenser Steam Jet Air Ejector Low-Temp System

Noncondensable radioactive offgas is continuously removed from the main condenser by the air ejector during plant operation.

The following paragraph contains historical information (bracketed):
The air ejector offgas will normally contain activation gases, principally N-16, 0-19, and N-13. The N-16 and 0-19 have short half-lives and are readily decayed. [The 10-min N-13 is present in small amounts that are further reduced by decay.]

The air ejector offgas will also contain radioactive nobles gases including parents of biologically significant Sr-89, Sr-90, Ba-140, and Cs-137. The concentration of these noble gases depends on the amount of tramp uranium in the coolant and on the cladding surfaces (usually extremely small) and the number and size of fuel cladding leaks.

11.3.2.1.1 Process Description

The following paragraph contains historical information:
[A main condenser offgas system has been incorporated in the plant design to reduce the gaseous radwaste emission from the station. The offgas system uses a catalytic recombiner to recombine radiolytically dissociated hydrogen and oxygen. After cooling (to approximately 130 F) to strip the condensibles and reduce the volume, the remaining noncondensibles (principally air with traces of krypton and xenon) will be delayed in the 10-min holdup system. The gas is cooled to 45 F and filtered through a HEPA filter. The gas is then passed through a desiccant dryer that reduces the dew point to approximately -90 F and is then chilled to about 0 F. Charcoal adsorption beds, operating in a refrigerated vault at about 0 F, selectively adsorb and delay the xenons and kryptons from the bulk carrier gas (principally dry air). After the delay, the gas is again passed through a HEPA filter and discharged to the environment through the plant vent.]

11.3.2.1.1.1 Process Flow Diagram

Figures 11.3-1 through 11.3-4 are the process flow diagrams for the system. The process data for startup and normal operating conditions are submitted as proprietary data under separate cover as Table 11.3-3.

The information supporting the process data is presented in Reference 2. The radwaste building vent is the single release point for this system. The location of this vent is indicated on the site plan on Figure 2.1-2.

11.3.2.1.2 Noble Gas Radionuclide Source Term and Decay

The following paragraph contains historical information:
[The design basis isotopic source terms for the annual average activity input of the main condenser offgas treatment system are given in Table 11.3-1 at t=30 minutes. The system is mechanically capable of processing three times the source terms of Table 11.3-1 without affecting delay time of the noble gases. Also listed is the isotopic distribution at t=0. With an air inleakage of 30 scfm, this treatment system results in a delay of 46 hr for krypton and 42 days for xenon.

Table 11.3-1 lists isotopic activities at the discharge of the system, and the decontamination factor for each noble gas isotope can be determined.]

11.3.2.1.3 Piping and Instrumentation Diagram (P&ID)

The P&ID is provided as Figures 11.3-5 through 11.3-8. Figure 11.3-6 is submitted as proprietary data under separate cover. The main process routing is indicated by a heavy line.

11.3.2.1.4 Recombiner Sizing

The basis for sizing the recombiner is to maintain the hydrogen concentration below 4 percent (including steam) at the inlet and below 4 percent at the outlet on a dry basis. The exit hydrogen concentration is normally well below the 4 percent maximum allowed. The hydrogen generation rate of the reactor is based on data from nine BWRs. The hydrogen generation rate is given in the data referenced in subsection 11.3.2.1.1.1.

11.3.2.1.5 Process Design Parameters

The Kr and Xe holdup time is closely approximated by the following equation:

$$T = \frac{K_D M}{V}$$

where:

T = holdup time of a given gas

K_D = dynamic adsorption coefficient for the given gas

M = weight of charcoal

V = flow rate of the carrier gas in consistent units.

Dynamic adsorption coefficient values for xenon and krypton were reported by Browning (Ref. 1). General Electric has performed pilot plant tests at their Vallecitos Laboratory and the results were reported at the 12th AEC Air Cleaning Conference (Ref. 3). Moisture has a detrimental effect on adsorption coefficients. It is to prevent moisture from reaching the charcoal that the -90 F dew point fully redundant, adsorbent air driers are supplied. There are redundant moisture analyzers that will alarm on breakthrough of the drier beds; however, breakthrough is not expected since the drier beds will be regenerated on a time basis. The system is slightly pressurized which, together with very stringent leak rate requirements, prevents leakage of moist air into the charcoal.

Carrier gas is the air inleakage from the main condenser after the radiolytic hydrogen and oxygen are removed by the recombiner. The air inleakage design basis is conservatively sized at 40 scfm total. The Sixth Edition of Heat Exchange Institute Standards for Steam Surface Condensers (Ref. 4) Par. S.1(c) (2) indicates that with certain conditions of stable operation and suitable construction, noncondensibles (not including radiological decomposition products) should not exceed 6 scfm for large condensers. Dresden 2, Monticello, Fukushima 1, Tsuruga, and KRB have all operated at 6 scfm or below after initial startup. Dilution air is not added to the system unless the air inleakage is less than 6 scfm. In that event, 6 scfm will be added to

provide for dilution of residual hydrogen from the recombiner. An initial bleed of oil-free air is added on startup until the recombiner comes up to temperature.

11.3.2.1.6 Charcoal Absorbers

11.3.2.1.6.1 Charcoal Temperature

The following paragraph contains historical information (bracketed):
[The charcoal absorbers operate at a nominal 0°F temperature.] The decay heat is sufficiently small that, even in the no-flow condition, there is no significant loss of adsorbed noble gases due to temperature rise in the absorbers. The absorbers are located in a shielded room, and maintained at a constant temperature by a redundant vault refrigeration system (Figure 11.3-9). Failure of the refrigeration system will cause an alarm in the control room. In addition, a radiation monitor is provided to monitor the radiation level in the charcoal bed vault. High radiation will cause an alarm in the control room.

11.3.2.1.6.2 Gas Channeling in the Charcoal Adsorber

Channeling in the charcoal absorbers is prevented by supplying an effective flow distributor on the inlet, having long columns and having a high bed-to-particle diameter ratio of approximately 500. Underhill has stated that channeling or wall effects may reduce efficiency of the holdup bed if this ratio is not greater than 12 (Ref. 5).

11.3.2.1.6.3 Charcoal Bypass Mode

Two valves in series are provided to bypass the charcoal absorbers. The main purpose of this bypass is to protect the charcoal during preoperation and startup testing when gas activity is zero or very low. An additional purpose is to allow isolation of the charcoal adsorbers in the unlikely event of a charcoal fire. Following isolation, a nitrogen purge supply is available to aid in extinguishing the fire and lowering charcoal bed temperatures.

It may be desirable to use the bypass for short periods during startup or normal operations. This bypass mode would not be used for normal operation unless some unforeseen system malfunction would necessitate shutting down the power plant or operating in the bypass mode and remaining within release limits. The activity release is controlled by a process monitor upstream of the vent isolation valve that will cause the bypass valves to close on a

high radiation alarm. This interlock can be defeated only by a keylock switch. The alarm setting is covered in subsection 7.6.1.3. In addition, there is a high high-high alarm on the same monitor that will cause the offgas system to be isolated from the vent if established release limits are exceeded.

11.3.2.1.7 Leakage of Radioactive Gases

Leakage of radioactive gases from the system is limited by welding piping connections where possible and using bellows stem seals or equivalent valving. The system operates at a maximum of 7 psig during startup and less than 2 psig during normal operation so that the differential pressure to cause leakage is small.

11.3.2.1.8 Hydrogen Concentration

Hydrogen concentration of gases from the air ejector is kept below the flammable limit by maintaining adequate process steam flow for dilution at all times. This steam flow rate is monitored and alarmed.

11.3.2.1.9 Field Run Piping

Piping and tubing 2 inches and under is field routed. This does not include major process piping but does include drain lines, steam lines, and sample lines which are shown on the P&ID (Figures 11.3-5 through 11.3-8). Figure 11.3-6 is submitted as proprietary data under separate cover.

11.3.2.1.10 Liquid Seals

There are several liquid seals to prevent gas escape through drains shown on the P&ID (Figures 11.3-5 through 11.3-8). These seals are protected against permanent loss of liquid by an enlarged section downstream of the seal that can hold the seal volume and will drain by gravity back into the loop after the momentary pressure surge has passed. Each seal has a manual valve that can be used to fill the loop. Seals are also equipped with solenoid valves that close if release from this system exceeds established limits.

11.3.2.1.11 System Performance

The following section contains historical information (bracketed):
[Noble gas activity release is about 49-59/µCi/sec from the steam jet air ejector system based upon 30 scfm air inleakage and an input of 100,000 µCi/sec of 30-min-old "1971 Mixture."] The isotopic composition is given in Table 11.3-1 in units of µCi/sec and Ci/yr.

Iodine input into the offgas system is small by virtue of its retention in reactor water and condensate. The iodine remaining is essentially removed by adsorption in the charcoal. This is supported by the fact that charcoal filters remove 99.9 percent of the iodine in 2 inches of charcoal, whereas this system has approximately 76 ft. of charcoal in the flow path.

The following section contains historical information (bracketed):
[Particulates are removed with a 99.95 percent efficiency by a HEPA filter as gas exits the 10-min holdup.] The noble gas decays within the interstices of the activated charcoal and daughters are entrapped there. The charcoal serves as an excellent filter for other particulates and essentially no particulates exit from the charcoal. The charcoal is followed with a HEPA filter which is a safeguard against escape of charcoal dust. Particulate activity discharged from this system is essentially zero.

The charcoal adsorber trains are capable of being bypassed, thereby decreasing the delay time of the system to approximately the 10 minutes provided by the delay line at design basis normal flow. This bypass line is intended to be used only during preoperational testing, and perhaps initial system startup operation until proper functioning of upstream equipment is established, to prevent possible degradation of charcoal adsorption coefficients by introduction of excessive moisture, etc. Thereafter, it is intended that the spectacle flange in the bypass line be closed, so as to assure zero leakage flow and effective administrative control over use of the line.

The bypass line should then be used only when it is, for some reason, impracticable to operate through the charcoal adsorbers, and the activity input is low enough to allow bypassing operation while staying within administrative release limits.

No other portion of the system is capable of being bypassed.

11.3.2.1.12 Isotopic Inventory

The isotopic inventory of each equipment piece is given in Table 11.3-4 for 30 scfm flow, 100,000 µCi/sec mixing, and 1 year buildup time.

11.3.2.1.13 Previous Experience

Performance of a similar system operating at ambient temperatures and the results of experimental testing performed by GE have been submitted in the General Electric Company proprietary topical report, "Experimental and Operational Confirmation of Offgas System Design Parameters," (Ref. 2). Nonproprietary portions of this information are reported in Reference 3.

11.3.2.1.14 Single Failures and Operator Errors

Design provisions are incorporated which preclude the uncontrolled release of radioactivity to the environment as a result of any single operator error or of any single failure short of the catastrophic failures described in Chapter 15. A comprehensive discussion of single failures is provided in Table 11.3-5.

Design precautions taken to prevent uncontrolled releases of activity include the following:

a. The system design seeks to eliminate ignition sources so that a hydrogen detonation is highly unlikely even in the event of a recombiner failure.

b. The system pressure boundary is detonation-resistant, despite the measures taken to avoid a possible detonation.

c. All discharge paths to the environment are monitored: the normal effluent path by the Process Radiation Monitoring System; equipment areas by the Area Radiation Monitoring System.

d. Dilution steam flow to the steam jet air ejector is monitored and alarmed, and the valving is required to be such that loss of dilution steam cannot occur without coincident loss of motive steam, so that the process gas is sufficiently diluted if it is flowing at all.

11.3.2.1.15 Cost-Benefit Ratio

A cost benefit ratio is not required as stated in Paragraph II.D of Appendix I of 10 CFR 50.

11.3.2.1.16 Maintainability of Offgas System

Design features which reduce or ease required maintenance include the following:

a. Redundant components for all active, in-process equipment pieces.

b. No rotating equipment in the process stream, and elsewhere in the system only where maintenance can be performed while the system is in operation.

Design features which reduce leakage and releases of radioactive material include the following:

a. Extremely stringent leak rate requirements placed upon all equipment, piping, and instruments, and enforced by requiring as-installed helium leak tests of the entire process system during initial installation. For modifications made after initial installation, NDE will be conducted in accordance with approved procedures to ensure acceptable leakage rates are maintained.

b. Use of welded joints wherever practicable.

c. Specification of valve types with extremely low leak rate characteristics, i.e., bellows seal, double stem seal, or equal.

d. Use of loop seals with enlarged discharge section to avoid siphoning and to be self-refilling following a pressure surge.

e. Specification of stringent seat-leak characteristics for valves and lines discharging to the environment via other systems.

11.3.2.2 System Design Description

11.3.2.2.1 Main Condenser Steam Jet Air Ejector Offgas Low-Temp System

11.3.2.2.1.1 Quality Classification and Construction and Testing Requirements

Equipment and piping will be designed and constructed in accordance with the requirements of the applicable codes as given in Table 11.3-6 and will comply with the welding and material requirements and the system construction and testing requirements as follows.

11.3.2.2.1.2 Seismic Design

11.3.2.2.1.2.1 Equipment

Equipment and components used to collect, process, or store gaseous radioactive waste are designed in accordance with the criteria in Table 3.2-1.

11.3.2.2.1.2.2 Buildings Housing Offgas Processing Systems

The turbine building, which houses portions of the offgas system is a nonseismic Category I building. The radwaste building, which houses the major portion of the offgas system including the charcoal adsorbers, complies with the guidelines stated in Branch Technical Position ETSB 11-1, Revision 1.

11.3.2.2.1.3 Quality Control

A program is established that is sufficient to assure that the design, construction, and testing requirements are met. The following areas are included in the program:

a. Design and Procurement Document Control - Procedures are established to ensure that requirements are specified and included in design and procurement documents and that deviations therefrom are controlled.

b. Control of Purchased Material, Equipment, and Services - Procedures are established to assure that purchased material, equipment, and construction services conform to the procurement documents.

c. Inspection - A program for inspection of activities affecting quality is established and executed by or for the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity.

d. Handling, Storage, and Shipping - Procedures are established to control the handling, storage, shipping, cleaning, and preservation of material and equipment in accordance with work and inspection instructions to prevent damage or deterioration.

e. Inspection, Test, and Operating Status - Procedures are established to provide for the identifications of items which have satisfactorily passed required inspections and tests.

f. Corrective Action - Procedures are established to assure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances are promptly identified and corrected.

11.3.2.2.1.4 Welding

All welding constituting the pressure boundary of pressure retaining components is performed by qualified welders employing qualified welding procedures per Table 11.3-6.

11.3.2.2.1.5 Materials

Materials for pressure retaining components of process systems are selected from those covered by the material specifications listed in Section II, Part A of the ASME Boiler and Pressure Vessel Code, except that malleable, wrought or cast-iron materials will not be used. Plastic pipe will not be utilized in the gaseous radwaste system. The components meet all of the mandatory requirements of the material specifications with regard to manufacture, examination, repair, testing, identification, and certification.

A description of the major process equipment including the design temperature and pressure and the materials of construction is given in Table 11.3-2.

Impact testing of carbon steel components operating at cold temperatures is in accordance with Paragraph UG84, Section VIII, of ASME “Pressure Vessel - Division 1."

11.3.2.2.1.6 Construction of Process Systems

Pressure retaining components of process systems utilize welded construction to the maximum practicable extent. Process piping systems include the first root valve on sample and instrument lines. Process lines are not less than 3/4-inch nominal pipe size. Sample and instrument lines are not considered as portions of the process systems. Flanged joints or suitable rapid disconnect fittings are not used except where maintenance requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seal are not used. Screwed connections backed up by seal welding or mechanical joints used only on lines of 3/4-inch nominal pipe size. In lines 3/4-inch or greater, but less than 2-1/2-inch nominal pipe size, socket type welds are used. In lines 2-1/2-inch nominal pipe size and larger, pipe welds will be of the butt joint type, but backing rings are not used in lines carrying sludges, resins, etc.

11.3.2.2.1.7 System Integrity Testing

Completed process systems are pressure tested to the maximum practicable extent. Piping systems are hydrostatically tested in their entirety, utilizing available valves or temporary plugs at atmospheric tank connections. Hydrostatic testing of piping systems is performed at a pressure 1.5 times the design pressure, but in no case at less than 75 psig. The test pressure is held for a minimum of 30 minutes with no leakage indicated. Pneumatic testing may be substituted for hydrostatic testing in accordance with the applicable codes.

11.3.2.2.1.8 Instrumentation and Control

This system is monitored by flow, temperature, pressure, and humidity instrumentation, and by hydrogen analyzers to ensure correct operation and control.

Instrumentation and controls are described in subsection 7.7.1.10. The operator is in control of the system at all times.

A radiation monitor after the offgas condenser continuously monitors radioactivity release from the reactor and input to the charcoal adsorbers. This radiation monitor is used to provide an alarm on high radiation in the offgas.

A radiation monitor is also provided at the outlet of the charcoal adsorbers to continuously monitor the rate from the adsorber beds. This radiation monitor is used to isolate the offgas system on high radioactivity to prevent treated gas of unacceptably high activity from entering the vent.

The activity of the gas entering and leaving the offgas treatment system is continuously monitored. Thus, system performance is known to the operator at all times. Provision is made for sampling and periodic analysis of the influent and effluent gases for purposes of determining their compositions. This information is used in calibrating the monitors and in relating the release to calculated environs dose. Process radiation instrumentation is described in subsection 7.6.1.2.

Environmental monitoring will be used; however, at the estimated low dose levels, it is doubtful that the measurements can distinguish doses from the plant from normal variation in background radiation.

11.3.2.2.1.9 Detonation Resistance

The pressure boundary of the system is designed to be detonation resistant. The pressure vessels are designed to withstand 350 psig static pressure, and piping and valving are designed to resist dynamic pressures encountered in long runs of piping at the design temperature. This analysis is covered in a proprietary report submitted to the NRC (Ref. 6).

By this procedure a designer can obtain the required wall thickness of a specific equipment design, which normally or possibly contains a detonable mixture of hydrogen and oxygen, which is then translated to the corresponding detonation-containing, static equipment pressure rating by using an appropriate code calculation.

The method assumes the absence of simultaneous secondary events such as earthquakes.

This procedure is the simplest that has been found that does not include a detailed and laborious analysis of the gas dynamics of the system. It results in a design that will sustain the whole envelope of feasible detonations.

11.3.2.2.1.10 Operator Exposure Criteria and Controls

This system is normally operated from the main control room. Equipment and process valves containing radioactive fluid are placed in shielded cells maintained at a pressure negative to normally occupied areas.

11.3.2.2.1.11 Equipment Malfunction

Malfunction analysis, indicating consequences and design precautions taken to accommodate failure of various components of the system, is given in Table 11.3-5.

11.3.2.2.1.12 Previous Experience

A system with similar equipment is in service at the KRB plant in Germany. Its performance is reviewed in Reference 2. The Tsuruga and Fukushima I plants in Japan have similar recombiners in service. Similar systems (ambient temperature charcoal) are in service at Dresden 2 and 3, Pilgrim, Quad Cities 1 and 2, Nuclenor, Hatch, Browns Ferry 1, 2 and 3, and Duane Arnold.

11.3.2.3 <u>Operating Procedure</u>

11.3.2.3.1 Treated (Delayed) Radioactive Gas Sources

11.3.2.3.1.1 Main Condenser Steam Jet Air Ejector Offgas Low-Temp System

11.3.2.3.1.1.1 Prestartup Preparations

The following paragraph contains historical Information:
[Prior to starting the main steam jet air ejectors (SJAE), the charcoal vault is cooled to near 0 F, the glycol cooler is chilled to near 35 F and glycol is circulated through the cooler condenser, a desiccant dryer is regenerated and valved in, the offgas condenser cooling water is valved in, and the recombiner heaters are turned on.]

11.3.2.3.1.1.2 Startup

As the reactor is pressurized, preheater steam is supplied and air is bled through the preheater and recombiner. The recombiner is preheated to at least 225 F with this air bleed and/or by admitting steam to the final SJAE. With the recombiners preheated, and the desiccant drier and charcoal adsorbers valved in, the SJAE string is started. The bleed air is terminated when no longer required. As the condenser is pumped down and the reactor power increases, the recombiner inlet stream is diluted to less than 4 percent hydrogen by volume by a fixed steam supply, and the offgas condenser outlet is maintained at less than 4 percent hydrogen by volume.

11.3.2.3.1.1.3 Normal Operation

After startup, the noncondensibles pumped by the SJAE will stabilize. Recombiner performance is closely followed by the recorded temperature profile in the recombiner catalyst bed. The hydrogen effluent concentration is measured by a hydrogen analyzer.

Normal operation is terminated following a normal reactor shutdown or a scram by terminating steam to the SJAEs and the preheater.

Plant operating procedures will be written covering Radioactive Waste Management.

11.3.2.3.1.1.4 Previous Experience

Previous experience is reviewed in subsection 11.3.2.2.1.12.

11.3.2.4 <u>Offgas System Performance Tests</u>

11.3.2.4.1 Treated (Delayed) Radioactive Gas Sources

11.3.2.4.1.1 Main Condenser Steam Jet Air Ejector Offgas Low-Temp System

This system is used on a routine basis and does not require specific testing to assure operability. Monitoring equipment will be calibrated and maintained on a specific schedule and on indication of malfunction.

11.3.2.4.1.1.1 Recombiner

Recombiner performance is continuously monitored and recorded by catalyst bed thermocouples that monitor the bed temperature profile and by a hydrogen analyzer that measures the hydrogen concentration of the effluent.

11.3.2.4.1.1.2 Prefilter

These particulate filters are tested at the time of filter installation or replacement using DOP (dioctylphthalate) aerosol to determine whether an installed filter meets the minimum in-place efficiency of 99.95 percent rejection.

The DOP from filter testing is not allowed into the desiccant or the activated charcoal. This equipment is isolated during filter DOP testing and is bypassed until the process lines have been purged clear of test material.

Because the DOP would have a detrimental effect on the desiccant and charcoal, this filter is not periodically tested. This is justified because the main function of this prefilter is to prevent the long-lived daughters of the radioactive xenons generated in the holdup pipe from depositing in the downstream equipment as a maintenance aid. Leakage through the filter would be unimportant to environmental release.

11.3.2.4.1.1.3 Desiccant Gas Drier

Desiccant gas drier performance is continuously monitored by an onstream humidity analyzer.

11.3.2.4.1.1.4 Charcoal Performance

The ability of the charcoal to delay the noble gases can be continuously evaluated by comparing activity measured and recorded by the process activity monitors at the exit of the offgas condenser and at the exit of the charcoal adsorbers.

Experience with boiling water reactors has shown that the calibration of the offgas and vent effluent monitors changes with isotopic content. Isotopic content can change depending on the presence or absence of fuel cladding leaks in the reactor and the nature of the leaks. Because of this possible variation, the monitors are calibrated against grab samples periodically and

whenever the radiation monitor after the offgas condenser shows significant variation in noble gas activity indicating a significant change in plant operations.

Grab sample points are located upstream and downstream of the first charcoal bed and downstream of the last charcoal bed and can be used for periodic sampling if the monitoring equipment indicates degradation of system delay performance.

11.3.2.4.1.1.5 Post Filter

On installation, replacements, and at periodic intervals during operation, these particulate filters are tested using a DOP smoke test or equivalent.

11.3.2.4.1.1.6 Previous Experience

Previous experience is reviewed in subsection 11.3.2.2.1.12.

11.3.2.5 Other Radioactive Gas Sources

There are four buildings that contain radioactive gas sources; they are the containment, the auxiliary building, the turbine building, and the radwaste building. The ventilation systems for these buildings are described in Section 9.4. The ventilation flow rates are described in subsection 9.4.7 for the containment, 9.4.6 for the auxiliary building, 9.4.4 for the turbine building, and 9.4.3 for the radwaste building. The mechanical vacuum pumps are described in subsection 10.4.2. The primary noble gases which have been shown to exist during operation of the mechanical vacuum pump are the xenon 133 and 135 isotopes, which are daughters of iodine 133 and 135. The effluent from the mechanical vacuum pump is routed to the turbine building vent for discharge to the environment.

11.3.3 Radioactive Releases

11.3.3.1 Calculated Releases

Calculations of the annual releases of radioactivity to the environment in gaseous effluents from GGNS (per UFSAR Section 1.1.1, Unit 2 has been canceled) have been performed using the BWR-GALE Code described in Reference 7. Parameters input to the

BWR-GALE Code which are specific to GGNS (per UFSAR Section 1.1.1, Unit 2 has been canceled) and references for their bases are presented in Table 11.3-8.

The calculated annual releases of activity to the environment in gaseous effluents are presented in Table 11.3-9. They include releases of tritium, noble gases, iodine, and particulates from ventilation systems of the containment, auxiliary, turbine and radwaste buildings, from operation of the mechanical vacuum pump and from the condenser offgas treatment system. Expected annual releases of carbon 14 and argon-41 (Ref. 7) are added to the release table.

11.3.3.2 Release Points

Gaseous effluents are released from the radwaste building vent, the turbine building vent, the containment vent, and the auxiliary vent. The mechanical vacuum pump exhausts to the turbine building vent, and the offgas system exhausts to the radwaste building vent. Figure 2.1-2 shows the release points on a plot plan. Table 11.3-10 describes these release points.

11.3.3.3 Dilution Factors

Atmospheric dilution factors (χ/Q) and deposition factors (D/Q) corresponding to ground level releases required to evaluate doses to the maximum exposed individual at locations of cows, vegetable gardens, and residences within 5 miles have been calculated using pertinent data and methodology given in Regulatory Guide 1.111 (Ref. 8) and these are given in Table 11.3-11. χ/Q's and D/Q's corresponding to ground level releases required to evaluate population doses within a radius of 50 miles of the plant have been calculated in the same manner as described above and these are given in Section 2.3. These dilution and deposition factors do not include recirculation factors. Updates to χ/Q’s and D/Q’s used to calculate dose to the public are located in and controlled by the Offsite Dose Calculation Manual.

11.3.3.4 Estimated Doses

Release of the radioactive materials in gaseous effluents from a single Grand Gulf unit to the environment will result in minimal radiological exposure to individuals and the general public. Calculated annual radiation exposures to the maximum exposed individual and the population within a 50-mile radius of the Grand Gulf Nuclear Station via the pathways of submersion, ground

contamination, inhalation and ingestion are given in Tables 11.3-12 and 11.3-13 respectively. The annual Radioactive Effluent Release Report (per ODCM 5.6.3) contains current information and data. The report includes an assessment of the radiation doses due to the radioactive liquid and gaseous effluents released from the station during the year. The report also includes an assessment of the radiation doses from radioactive liquid and gaseous effluents to members of the public due to their activities inside the site boundary. The Radioactive Effluent Release Report also provides an assessment of radiation does to the likely most exposed member of the public from reactor releases, including doses from primary effluent pathways and direct radiation.

[HISTORIACAL INFORMATION] [The noble gas submersion doses were evaluated using the semi-infinite cloud model given in reference 9. Doses due to radionuclides and particulates were evaluated using the models given in reference 9. Release data given in Table 11.3-9 and the values of required parameters given in reference 9 were used for the dose evaluation. Annual production rates of vegetables, meat, and milk and the population distribution within a 50-mile radius of the Grand Gulf Nuclear Station given in Section 2.1 of the Final Environmental Report for the Grand Gulf Nuclear Station were used to evaluate population exposures.

As can be seen from Table 11.3-12, annual doses to the maximum exposed individual due to release of radioactive materials in gaseous effluents from a single Grand Gulf unit meet the guidelines of Appendix I to 10 CFR 50. Since the guidelines of Appendix I to 10 CFR 50 for maximum individual exposures via atmospheric pathways are much more restrictive (by a factor of ~ 100) than the standards of 10 CFR 20, it can be inferred that radioactive releases via gaseous effluents from Grand Gulf (per UFSAR Section 1.1.1, Unit 2 has been canceled) meet the standards for concentrations of released radioactive materials in air at the location of maximum annual dose to an individual and hence at all locations accessible to the general public as specified in Column 1 of Table II of 10 CFR 20.]

11.3.4 Recent BWR Iodine 133 Release Experience

Leakage of fluids from the process system will result in the release of radionuclides into plant buildings. In general, the noble radiogases will remain airborne and will be released to the atmosphere with little delay via the building ventilation exhaust

ducts. The radioiodines will partition between air and water to approach equilibrium conditions. Airborne iodines will "plate out" on most surfaces, including pipe, concrete, and paint. A significant amount of radioiodine remains in air or is desorbed from surfaces. Radioiodines are found in ventilation air as methyl iodide and as inorganic iodine which is here defined as particulate, elemental, and hypoiodous acid forms of iodine. Particulates will also be present in the ventilation exhaust air.

[HISTORICAL INFORMATION] [Recent BWR operation plant experience applied to Grand Gulf indicates that the expected per unit average annual release of I-131 is 107 millicuries in elemental form. Other forms of I-131 amount to 178 millicuries per year. These forms of I-131 include hypoiodous acid, particulates, and methyl iodide. The basis for these releases is as follows:

a. A calendar year consisting of 300 days of power operations and one refueling/maintenance shutdown period

b. A concentration of I-131 in reactor water of 8.75µ µCi/kg

c. A carryover of I-131 from reactor water to steam of 1.5 percent

d. Forward-pumped heater drains

e. Use of "clean" steam from an auxiliary boiler for the turbine gland seals

Note: GGNS presently uses the seal steam generator (heat exchanger) as the auxiliary boiler has been abandoned.

The results in Tables 11.3-14 and 11.3-15 were calculated from normalized releases of I-131 as reported in reference 11 and adjusted according to the above assumptions. A value for the I-131 reactor water concentration of 5 µCi/kg is reported in reference 12. The concentration of 8.75 µCi/kg for this plant includes the effect of forward pumped heater drains.]

11.3.5 References

1. Browning, W. E., et al., "Removal of Fission Product Gases from Reactor Off-Gas Streams by Adsorption," (ORNL) CF59-6-47, June 11, 1959.

2. Miller, C. W., "Experimental and Operational Confirmation of Off-Gas System Design Parameters," NEDO-10751, January 1973. (Proprietary)

3.

4. Standards for Steam Surface Condensers, Sixth Edition, Heat Exchange Institute, New York, NY (1970).

5. Underhill, Dwight, et al., "Design of Fission Gas Holdup Systems," Proceedings of the Eleventh AEC Air Cleaning Conference, p. 217, 1970.

6. Nesbitt, L. B., "Design Basis for New Gas Systems," NEDE-11146, July 1971. (Proprietary)

7. USNRC NUREG-0016, Rev. 1, "Calculation of Releases of Radioactive materials in Gaseous and Liquid effluents from boiling water reactors (BWR-GALE Code)" - January 1979.

8. USNRC Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light Water Cooled Reactors" - July 1977. (Revision 1)

9. USNRC Regulatory Guide 1.109, "Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I" (Revision 1) October 1977

10. Slade, David H., "Meteorology and Atomic Energy, TID-24190, July 1968.

11. "Airborne Releases from BWRs for Environmental Impact Evaluations," NEDO-21159-2, 1978.

12. American Nuclear Society, ANSI Std. 18.1, and ANSI Std. N237-1976, Table 5

13. Letter from W. T. Cottle to NRC Document Control Desk, GNRO-91/00148, August 15, 1991, Subject: Schedule for

UFSAR Changes Reflecting Termination of Construction Permit No. CPPR-119 for GGNS Unit 2

14. Deleted

TABLE 11.3-1: ESTIMATED AIR EJECTOR OFFGAS RELEASE RATES FOR A SINGLE UNIT

(30 scfm inleakage)

Release rates are based on the 1971 Mixture

				Normal Discharge from Charcoal Adsorbers		Additional Discharge from Charcoal Adsorbers During Startup	
Isotope	Half-Life	T=0 µCi/Sec	T=30 Minutes µCi/sec	µCi/sec	Ci/yr[b]	Ci/sec	Ci/startup
Kr-83m	1.86 hr	3.4×10^{3}	2.9×10^{3}	-			
Kr-85m	4.4 hr	6.1×10^{3}	5.6×10^{3}	4.3	1.2×10^{1}	1.1×10^{1}	1.4
Kr-85(a)	10.74 yr	10 - 20	10 - 20	10 - 20	280 - 560	0	
Kr-87	76 min	2.0×10^{4}	1.5×10^{4}	-			
Kr-88	2.79 hr	2.0×10^{4}	1.8×10^{4}	2.1×10^{-1}	6.0	1.4	1.7×10^{-1}
Kr-89	3.18 min	1.3×10^{5}	1.8×10^{2}	-			
Kr-90	32.3 sec	2.8×10^{5}	-	-			
Kr-91	8.6 sec	3.3×10^{5}	-	-			
Kr-92	1.84 sec	3.3×10^{5}	-	-			
Kr-93	1.29 sec	9.9×10^{4}	-	-			
Kr-94	1.0 sec	2.3×10^{4}	-	-			
Kr-95	0.5 sec	2.1×10^{3}	-	-			
Kr-97	1 sec	1.4×10^{1}	-	-			
Xe-131m	11.96 day	1.5×10^{1}	1.5×10^{1}	1.3	3.7×10^{1}	3.0×10^{-2}	1.07×10^{-1}
Xe-133m	2.26 day	2.9×10^{2}	2.8×10^{2}	-			
Xe-133	5.27 day	8.2×10^{3}	8.2×10^{3}	$3.3\times10^{+1}$	9.4×10^{2}	1.9	6.8
Xe-135m	15.7 min	2.6×10^{4}	6.9×10^{3}	-	-		
Xe-135	9.16 hr	2.2×10^{4}	2.2×10^{4}	-			
Xe-137	3.82 min	1.5×10^{5}	6.7×10^{2}	-			
Xe-138	14.2 min	8.9×10^{4}	2.1×10^{4}	-			
Xe-139	40 sec	2.8×10^{5}	-	-			
Xe-140	13.6 sec	3.0×10^{5}	-	-			
Xe-141	1.72 sec	2.4×10^{5}	-	-			
Xe-142	1.22 sec	7.3×10^{4}	-	-			
Xe-143	0.96 sec	1.2×10^{4}	-	-			
Xe-144	9 sec	5.6×10^{2}	-	-			
TOTALS		$\sim2.5\times10^{6}$	$\sim1.0\times10^{5}$	49-59	1383-1663	14.3	8.5

TABLE 11.3-1: ESTIMATED AIR EJECTOR OFFGAS RELEASE RATES FOR A SINGLE UNIT

Notes:
Estimated from experimental observations.
This is based on curies present at time of release. No decay in environment is included.

TABLE 11.3-2: OFFGAS SYSTEM MAJOR EQUIPMENT ITEMS

Offgas Preheaters - 2 required.

Construction: Stainless steel tubes and carbon steel shell. 350 psig shell design pressure, 1000 psig tube design pressure. 40F/450F shell design temperature, 40F/575F tube design temperature.

Catalytic Recombiners - 2 required.

Construction: Carbon steel cartridge, carbon steel shell. Catalyst cartridge containing a precious metal catalyst on metal base or porous non-dusting ceramic. Catalyst cartridge to be replaceable without removing vessel. 350 psig design pressure. 900 F design temperature.

Offgas Condenser - 2 required

Construction: Low alloy steel shell. Stainless steel tubes. 350 psig shell design pressure. 250 psig tube design pressure. 900 F shell design temperature. 150 F tube design temperature.

Water Separator - 2 required.

Construction: Carbon steel shell, stainless steel wire mesh. 350 psig design pressure. 250 F design temperature.

Cooler-Condenser - 2 required.

Construction: Carbon or stainless steel shell. Stainless steel tubes. 100 psig tube design pressure. 350 psig shell design pressure. 150 F tube design temperature 32 F/150 F shell design temperature.

Moisture Separators (Downstream of cooler-condenser) - 2 required.

Construction: Carbon steel shell, stainless steel wire mesh. 350 psig design pressure 32 F/150 F design temperature.

Desiccant Dryer - 4 required.

Construction: Carbon steel shell packed with Linde Mol Sieve or equivalent. 350 psig design pressure, 32 F/500 F design temperature.

TABLE 11.3-2: OFFGAS SYSTEM MAJOR EQUIPMENT ITEMS (CONTINUED)

Desiccant Regeneration Skid- 2 required.

Dryer Chiller - 2 required.

Construction: Carbon steel shell, stainless steel tubes, design temperature 32 F/500 F. Design pressure 50 psig.

Regenerator Blower - 2 required

Construction: Electrical, design pressure 50 psig design temperature 32 F/150 F. Seller's Standard.

Dryer Heater - 2 required

Construction: Electrical, design temperature 32 F/500 F, design pressure 50 psig.

Gas Cooler - 2 required

Construction: Carbon or stainless steel material. 1050 psig design temperature. -50 F/150 F design temperature.

Glycol Cooler Skid - 1 required.

Glycol Storage Tank - 1 required.

Construction: Carbon steel, 3,000 gal. Water-filled hydrostatic design pressure. 32 F design temperature.

Glycol Solution Refrigerators and Motor Drives - 3 required.

Construction: Conventional refrigeration units. Glycol solution exit temperature 35 F.

Glycol Pumps and Motor Drives - 3 required.

Construction: Cast iron, 3-in. connections, 0 F design temperature.

TABLE 11.3-2: OFFGAS SYSTEM MAJOR EQUIPMENT ITEMS (CONTINUED)

Prefilters and After Filters - 2 required of each type.

Construction: Carbon steel shell. High-efficiency, moisture¬resistant filter element. Flanged shell. 350 psig design pressure. -50 F/250 F design temperature.

Charcoal Adsorbers - 8 beds.

Construction: Carbon steel. Approximately 4-ft. o.d. x 21 ft vessels each containing ~3 tons of activated carbon. Design pressure 350 psig. Design temperature -50 F/250 F.

TABLE 11.3-3: PROCESS DATA FOR THE OFFGAS (RECHAR) SYSTEM

(PROPRIETARY)

TABLE 11.3-4: INVENTORY ACTIVITIES FOR OFFGAS RECHAR EQUIPMENT (LOW-TEMPERATURE) (MICROCURIES)*

	Pre-heater	Recomb	Offgas Cond	Water Sep	Holdup Pipe	Cooler Cond	Moist Sep	Pre-Filter	Dryer	Charcoal Vessels (Train)	Charcoal Vessels (First)	After-Filter
Times												
Gas Res	3.00-1S	9.00-1S	2.53+1S	3.60 S	1.00+1M	8.20 S	4.80 S	2.73+1S	2.18M	4.23 H	1.06 H	3.02+1S
Kr Res										1.92 D	1.15+1H	
Xe										4.20+1D	1.05+1D	
Oper Time	0.	0.	0.	0.	0.	0.	0.	1.00 Y	1.01+1 Y	1.01+1Y	1.01+1Y	1.00Y
S.D. Capture	0	0.	100	100	60	0	0	100	100	100	100	100
S.D. Washout			100	100	100			0	0	0	0	0
<u>Isotope</u>												
N-13	4.47+3	1.34+4	3.71+5	5.19+4	6.22+6	5.85+4	3.40+4	1.90+5	8.32+5	5.07+6	2.50+6	3.00-3
N-17	3.39+3	9.22+3	5.60+4	3.76+2	4.56+2	0	0	0	0	0	0	0
O-19	5.26+5	1.55+6	3.17+7	3.05+6	3.12+7	1.06	5.25-1	2.01	1.89	6.57-2	3.29-2	0
Kr-83M	1.04+3	3.12+3	8.76+4	1.24+4	2.01+6	2.66+4	1.56+4	8.85+4	4.21+5	3.10+7	1.53+7	3.61-3
Kr-85	7.14	2.14+1	6.02+2	8.56+1	1.43+4	1.95+2	1.14+2	6.50+2	3.12+3	3.99+6	4.97+5	7.27+2
Kr-85M	1.85+3	5.54+3	1.56+5	2.21+4	3.64+6	4.91+4	2.87+4	1.63+5	7.80+5	1.35+8	5.68+7	1.25+2
Kr-87	5.90+3	1.77+4	4.96+5	7.05+4	1.27+7	1.48+5	8.56+4	4.86+5	2.30+6	1.15+8	5.71+7	0.
Rb-87	0.	0.	0.	0.	0.	0.	0.	7.20-5	3.21-4	1.58-2	7.90-3	0.
Kr-88	6.05+3	1.82+4	5.10+5	7.25+4	1.18+7	1.58+5	9.26+4	5.26+5	2.51+6	2.77+8	1.30+8	6.11
Rb-88	5.93-1	8.89	4.59+3	8.51+1	1.23+6	2.13+4	1.28+4	4.65+6	2.51+6	2.77+8	1.30+8	6.11
Kr-89	3.63+4	1.09+5	2.91+6	3.93+5	2.65+7	9.93+4	5.68+4	3.05+5	1.11+6	1.82+6	9.09+5	0.
Rb-89	4.14	6.20+1	3.10+4	5.39+2	4.10+6	4.92+4	2.90+4	8.26+6	1.11+6	1.82+6	9.09+5	0.
Sr-89	0.	4.12-6	4.38-2	1.02-4	1.57+2	3.57	2.12	1.10+7	1.11+6	1.82+6	9.09+5	0.
Y-89M	0.	0.	1.04-2	3.94-6	1.43+2	3.39	2.02	1.10+7	1.11+6	1.82+6	9.09+5	0.

TABLE 11.3-4: INVENTORY ACTIVITIES FOR OFFGAS RECHAR EQUIPMENT (LOW-TEMPERATURE) (MICROCURIES)* (CONTINUED)

	Pre-heater	Recomb	Offgas Cond	Water Sep	Holdup Pipe	Cooler Cond	Moist Sep	Pre-Filter	Dryer	Charcoal Vessels (Train)	Charcoal Vessels (First)	After-Filter
Kr-90	6.31+4	1.87+5	4.01+6	4.14+5	5.14+6	2.08	1.06	4.31	5.08	3.23-1	1.61-1	0.
Rb-90	4.06+1	6.03+2	2.54+5	3.21+3	2.79+6	6.79+3	3.87+3	1.86+5	5.08	3.23-1	1.61-1	0.
Sr-90	0.	0.	1.80-3	2.95-6	8.02-1	1.16-2	6.81-3	4.86+4	1.09	6.88-2	3.44-2	0.
Y-90	0.	0.	0.	0.	5.24-4	1.33-5	7.94-6	4.81+4	1.09	6.87-2	3.43-2	0.
Kr-91	3.30+4	9.43+4	1.09+6	4.11+4	1.22+5	0.	0.	0.	0.	0.	0.	0.
Rb-91	5.95+1	8.67+2	2.28+5	9.17+2	7.32+4	4.01	2.17	3.66+1	0.	0.	0.	0.
Sr-91	1.19-4	7.33-3	1.79+1	2.25-2	7.31+2	7.88	4.61	4.83+4	0.	0.	0.	0.
Y-91	0.	0.	0.	0.	1.01-3	3.15-5	1.89-5	4.81+4	0.	0.	0.	0.
Kr-92	5.80+2	1.39+3	3.45+3	1.85-1	6.40-2	0.	0.	0.	0.	0.	0.	0.

*Note 1.00+5 indicates 1.00x10^5 Ci

Isotope												
Rb-92	1.35+1	1.72+2	5.09+3	5.16-2	3.84-2	0.	0.	0.	0.	0.	0.	0.
Sr-92	9.82-5	5.49-3	6.82	5.16-6	1.59-3	1.44-5	8.43-6	2.45-2	0.	0.	0.	0.
Y-92	0.	0.	3.69-3	0.	2.55-5	0.	0.	2.56-2	0.	0.	0.	0.
Kr-93	1.93+1	4.24+1	6.82+1	7.34-5	1.24-5	0.	0.	0.	0.	0.	0.	0.
Rb-93	3.47-1	4.26	1.18+2	1.74-5	7.44-6	0.	0.	0.	0.	0.	0.	0.
Sr-93	5.43-5	2.96-3	3.27	0.	4.44-6	0.	0.	1.96-6	0.	0.	0.	0.
Y-93	0.	0.	6.14-4	0.	0.	0.	0.	4.94-6	0.	0.	0.	0.
Zr-93	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Nb-93M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Kr-94	5.30-1	1.06	1.23	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 11.3-4: INVENTORY ACTIVITIES FOR OFFGAS RECHAR EQUIPMENT (LOW-TEMPERATURE) (MICROCURIES)* (CONTINUED)

	Pre-heater	Recomb	Offgas Cond	Water Sep	Holdup Pipe	Cooler Cond	Moist Sep	Pre-Filter	Dryer	Charcoal Vessels (Train)	Charcoal Vessels (First)	After-Filter
Rb-94	2.08-2	2.33-1	2.57	0.	0.	0.	0.	0.	0.	0.	0.	0.
Sr-94	1.91-5	9.75-4	4.86-1	0.	0.	0.	0.	0.	0.	0.	0.	0.
Y-94	0.	0.	3.13-3	0.	0.	0.	0.	0.	0.	0.	0.	0.
Kr-95	3.64-6	5.02-6	2.01-6	0.	0.	0.	0.	0.	0.	0.	0.	0.
Rb-95	0.	5.26-6	4.49-6	0.	0.	0.	0.	0.	0.	0.	0.	0.
Sr-95	0.	0.	5.15-6	0.	0.	0.	0.	0.	0.	0.	0.	0.
Y-95	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Zr-95	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Nb-95	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Kr-97	3.18-4	6.39-4	7.38-4	0.	0.	0.	0.	0.	0.	0.	0.	0.
Rb-97	1.57-4	6.81-4	8.58-4	0.	0.	0.	0.	0.	0.	0.	0.	0.
Sr-97	5.69-5	4.55-4	1.21-3	0.	0.	0.	0.	0.	0.	0.	0.	0.
Y-97	1.34-6	1.06-4	1.59-3	0.	0.	0.	0.	0.	0.	0.	0.	0.
Zr-97	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Nb-97	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Nb-97M	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Xe-131M	4.54	1.36+1	3.83+2	5.45+1	9.08+3	1.24+2	7.26+1	4.13+2	1.98+3	2.06+7	5.14+6	4.00+1
Xe-133	2.48+3	7.43+3	2.09+5	2.97+4	4.95+6	6.76+4	3.96+4	2.25+5	1.08+6	5.48+9	2.05+9	1.03+3
Xe-133M	8.32+1	2.49+2	7.01+3	9.98+2	1.66+5	2.27+3	1.33+3	7.55+3	3.62+4	7.79+7	3.74+7	1.03+3
Xe-135	6.67+3	2.00+4	5.62+5	8.00+4	1.33+7	1.82+5	1.07+5	6.06+5	2.91+6	1.08+9	5.38+8	0.
Xe-135M	7.82+3	2.35+4	6.53+5	9.20+4	1.24+7	1.34+5	7.81+4	4.39+5	1.99+6	1.96+7	9.82+6	0.
Cs-135	0.	0.	0.	0.	2.29-5	0.	0.	1.87	8.83	3.27+3	1.62+3	0.

TABLE 11.3-4: INVENTORY ACTIVITIES FOR OFFGAS RECHAR EQUIPMENT (LOW-TEMPERATURE) (MICROCURIES)* (CONTINUED)

	Pre-heater	Recomb	Offgas Cond	Water Sep	Holdup Pipe	Cooler Cond	Moist Sep	Pre-Filter	Dryer	Charcoal Vessels (Train)	Charcoal Vessels (First)	After-Filter
Xe-137	4.45+4	1.33+5	3.60+6	4.90+5	3.75+7	1.79+5	1.03+5	5.57+5	2.12+6	4.37+6	2.30+6	0.
Cs-137	4.85-6	7.27-5	3.68-2	6.43-4	6.32	9.00-2	5.32-2	3.59+5	4.37+5	9.03+5	4.72+5	0.
Ba-137M	0.	0.	1.44-3	3.48-6	3.54	6.90-2	4.08-2	3.59+5	4.37+5	9.03+5	4.72+5	0.
Xe-138	2.67+4	7.99+4	2.22+6	3.13+5	4.12+7	4.35+5	2.53+5	1.42+6	6.40+6	5.70+7	2.85+7	0.
Cs-138	1.44	2.15+1	1.11+4	2.02+2	2.67+6	4.38+4	2.62+4	1.67+7	6.40+6	5.70+7	2.85+7	0.
Xe-139	6.62+4	1.97+5	4.44+6	4.88+5	7.60+6	3.12+1	1.63+1	7.09+1	1.05+2	1.22+1	6.09	0.
Cs-139	1.23+1	1.84+2	8.20+4	1.10+3	2.22+6	1.57+4	9.14+3	1.53+6	1.05+2	1.22+1	6.09	0.
Ba-139	1.71-4	1.07-2	1.05+2	1.84-1	9.16+4	1.63+3	9.61+2	2.97+6	1.05+2	1.22+1	6.09	0.
Xe-140	4.58+5	1.34+5	2.10+6	1.39+5	7.19+5	0.	0.	0.	0.	0.	0.	0.
Cs-140	7.50+1	1.10+3	3.59+5	2.76+3	4.30+5	4.57+1	2.49+1	4.63+2	0.	0.	0.	0.
Ba-140	4.71-6	2.93-4	2.25	2.12-3	1.32+2	1.47	8.63-1	2.87+5	0.	0.	0.	0.
La-140	0.	0.	7.69-5	0.	1.60-1	3.48-3	2.06-3	2.87+5	0.	0.	0.	0.
Xe-141	2.97+2	7.04+2	1.61+3	4.60-2	1.41-2	0.	0.	0.	0.	0.	0.	0.
Cs-141	1.27	1.67+1	1.26+3	2.77-3	8.45-3	0.	0.	0.	0.	0.	0.	0.
Ba-141	8.13-5	4.66-3	1.08+1	2.34-6	2.52-3	2.04-5	1.19-5	3.92-3	0.	0.	0.	0.
La-141	0.	0.	4.62-3	0.	3.71-5	0.	0.	5.61-3	0.	0.	0.	0.
Ce-141	0.	0.	0.	0.	0.	0.	0.	5.61-3	0.	0.	0.	0.
Xe-142	9.44	2.03+1	3.05+1	1.52-5	2.26-6	0.	0.	0.	0.	0.	0.	0.
Cs-142	5.72-1	6.32	5.34+1	8.98-6	1.36-6	0.	0.	0.	0.	0.	0.	0.
Ba-142	6.32-5	3.21-3	1.43	0.	0.	0.	0.	0.	0.	0.	0.	0.
La-142	0.	0.	2.04-3	0.	0.	0.	0.	0.	0.	0.	0.	0.

TABLE 11.3-4: INVENTORY ACTIVITIES FOR OFFGAS RECHAR EQUIPMENT (LOW-TEMPERATURE) (MICROCURIES)* (CONTINUED)

	Pre-heater	Recomb	Offgas Cond	Water Sep	Holdup Pipe	Cooler Cond	Moist Sep	Pre-Filter	Dryer	Charcoal Vessels (Train)	Charcoal Vessels (First)	After-Filter
Xe-143	1.85-1	3.66-1	4.00-1	0.	0.	0.	0.	0.	0.	0.	0.	0.
Cs-143	1.13-2	1.19-1	8.20-1	0.	0.	0.	0.	0.	0.	0.	0.	0.
Ba-143	6.67-5	3.24-3	6.87-1	0.	0.	0.	0.	0.	0.	0.	0.	0.
La-143	0.	0.	7.86-3	0.	0.	0.	0.	0.	0.	0.	0.	0.
Ce-143	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Pr-143	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
Xe-144	5.92+1	1.70+2	2.03+3	8.15+1	2.55+2	0.	0.	0.	0.	0.	0.	0.
Nd-144	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
I-131										3.30+6	3.30+6	
I-132										3.50+5	3.50+5	
I-133										2.40+6	2.40+6	
I-134										2.60+5	2.60+5	
I-135										2.10+6	2.10+6	
Gas (Kr+Xe)	3.48+5	1.03+6	2.31+7	2.66+6	1.78+8	1.48+6	8.61+5	4.83+6	2.17+7	7.30+9	2.93+9	1.92+3
S.O	2.14+2	3.12+3	9.80+5	8.87+3	1.36+7	1.39+5	8.20+4	5.79+7	1.31+7	3.41+8	1.63+8	6.11
Kr Gas	1.48+5	4.36+5	9.27+6	1.03+6	6.05+7	4.80+5	2.79+5	1.57+6	7.13+6	5.63+8	2.61+8	8.58+2
Xe Gas	2.01+5	5.95+5	1.38+7	1.63+6	1.18+8	1.00+6	5.82+5	3.26+6	1.45+7	6.74+9	2.67+9	1.07+3

TABLE 11.3-5: EQUIPMENT MALFUNCTION ANALYSIS

Equipment Item	Malfunction	Consequences	Design Precautions
Steam Jet Air Ejectors	Low flow of motive high-pressure steam	When the hydrogen and oxygen concentrations exceed 4 and 5 vol %, respectively, the process gas becomes flammable.	Alarm provided on steam for low steam flow. Recombiner temperure alarm.
		Inadequate steam flow will cause overheating and deterioration of the catalyst.	Steam flow to be held at constant maximum flow regardless of plant level. Recombiner temperature alarm.
	Wear of steam supply nozzle of ejector	Increased steam flow to recombiner. This could reduce degree of recombination at low power levels.	Low temperature alarms on preheater exit (recombiner inlet). Recombiner outlet H_2 analyzers.
Preheaters	Steam leak	Would further dilute process off-gas. Steam consumption would increase.	Spare preheater.
	Low pressure steam supply	Recombiner performance would fail off at low power level, and hydrogen content of recombiner gas discharge may increase, eventually to a combustible mixture.	Low-temperature alarms on preheater exit (recombiner inlet). Recombiner outlet H_2 analyzers.
Recombiners	Catalyst gradually deactivates	Temperature profile changes through catalyst. Eventually excess H_2 would be detected by H_2 analyzer or by gas flowmeter. Eventually the stripped gas could become combustible.	Temperature probes in recombiner H_2 analyzer provided. Spare recombiner.

TABLE 11.3-5: EQUIPMENT MALFUNCTION ANALYSIS (CONTINUED)

Equipment Item	Malfunction	Consequences	Design Precautions
	Catalyst gets wet at start	H_2 conversion falls off and H_2 is detected by downstream analyzers. Eventually the gas could become combustible.	Condensate drains, temperature probes in recombiner. Air bleed system at startup. Recombiner thermal blanket, spare recombiner, and heater. Hydrogen analyzer.
Offgas Condenser	Cooling water leak	The coolant (reactor condensate) would leak to the process gas (shell) side. This would be detected if drain well liquid level increases. Moderate leakage would be of no concern from a process standpoint. (The process condensate drains to the hotwell.)	None
	Liquid level instruments fail	If both drain valves fail to open water will build up in the condenser and pressure drop will increase. The high ΔP, if not detected by instrumentation, could cause pressure buildup in the main condenser and eventually initiate a reactor scram. If a drain valve fails to close, gas will recycle to the main condenser, increase the load on the SJAE, and increase operating pressure of the main condenser.	Two independent drain systems, each, provided with high- and low-level alarms.
Water Separator	Corrosion of wire mesh element	Higher quantity of water collected in holdup line and routed to radwaste.	Stainless steel mesh specified.

TABLE 11.3-5: EQUIPMENT MALFUNCTION ANALYSIS (CONTINUED)

Equipment Item	Malfunction	Consequences	Design Precautions
Holdup Line	Corrosion of line	Leakage to soil of gaseous and liquid fission products	Outside of pipe dipped and wrapped. 1/4-in. corrosion allowance.
Cooler-Condensers	Corrosion of tubes	Glycol-water solution would leak into process (shell) side and be discharged to clean radwaste. If not detected at radwaste, the glycol solution would discharge to the reactor condensate system.	Stainless-steel tubes specified. Low level alarm glycol tank level. Spare cooler condenser provided.
	Icing up of tubes	Shell side of cooler could plug up with ice, gradually building up pressure drop. If this happens, the spare unit could be activated. Complete blockage of both units would increase ΔP and lead to a reactor scram.	Design glycol-H_2O solution temperature well above freezing point. Spare unit provided. Temperature indication and low alarms on glycol temperature and process gas temperature.
Glycol Refrigeration Machines	Mechanical failure	If both spare units fail to operate, the glycol solution temperature will rise and the dehumidification system performance will deteriorate. This will require rapid regeneration cycles for the desiccant beds and may raise the gas dewpoint as it is discharged from the drier.	Two spare refrigerators during normal operation are provided. Glycol solution temperature alarms provided. Gas moisture detectors provided downstream of gas driers.

TABLE 11.3-5: EQUIPMENT MALFUNCTION ANALYSIS (CONTINUED)

Equipment Item	Malfunction	Consequences	Design Precautions
Moisture Separators	Corrosion wire mesh element	Increased moisture would be retained in process gas routed to gas driers. Over a long period, the desiccant drier cycle period would deteriorate as a result of moisture pickup. Pressure drop across prefilter may increase if filter media is wetted.	Stainless steel mesh specified. Spare unit provided. High ΔP alarm on prefilter.
Prefilters	Loss of integrity of filter media	More radioactivity would deposit the drier desiccant. This would increase the radiation level in the drier vault and make maintenance more difficult, but would not affect releases to the environment.	Spare unit provided in separate vault. ΔP instrumentation provided.
Desiccant Drier	Moisture breakthrough	Moisture would freezeout in Gas Cooler and would result in increased system pressure drop. 0° F dewpoint gas would reach charcoal bed.	Drier cycled on timer. Redundant gas humidity analyzers and alarms supplied. Redundant drier systems supplied. Gas drier and first charcoal bed can be bypassed through alternate drier to second charcoal bed.
Desiccant Regeneration Equipment	Mechanical Failure	Inability to regenerate desiccant.	Redundant, shielded desiccant beds and drier equipment supplied.
Charcoal Adsorbers	Charcoal accumulates moisture	Charcoal performance will deteriorate gradually as moisture deposits. Holdup times for krypton and xenon would decrease, and plant emissions would increase. Provisions made for drying charcoal as required.	Highly instrumented, mechanically simple gas dehumidification system with redundant equipment.

TABLE 11.3-5: EQUIPMENT MALFUNCTION ANALYSIS (CONTINUED)

Equipment Item	Malfunction	Consequences	Design Precautions
Vault Refrigeration Units	Mechanical failure	If temperature exceeds approximately 0 F, increased emission could occur.	Spare refrigeration unit provided. Vault and charcoal adsorber temperature alarms provided.
After Filters	Loss of integrity of filter media	Probably of no real consequence. The charcoal media itself should be a good filter at the low air velocity.	ΔP instrumentation provided. Spare unit provided.
System	Internal detonation	Release of radioactivity if pressure boundary fails.	Main process equipment and piping are designed to contain a detonation.
System	Earthquake damage	Release of radioactivity.	Dose consequences are within 10CFR20 limits. Analysis is included in Reference 6.

TABLE 11.3-6: RADWASTE EQUIPMENT DESIGN REQUIREMENTS

Equipment	Codes			
	Design and Fabrication	**Materials**[2]	**Welder Qualification and Procedure**	**Inspection and Testing**
Pressure Vessels	ASME Code Section VIII, Div 1	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div 1
Atmospheric or 0-15 psig tanks	ASME Code[3] Section III, Class 3, API 620; 650, AWWA D-100	ASME Code Section II	ASME Code[3] Section IX	ASME Code Section III, Class 3, API 620; 650, AWWA D-100
Heat Exchangers	ASME Code Section VIII, Div 1; and TEMA	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div 1
Piping and Valves	ANSI B 31.1	ASTM or ASME Code Section II	ASME Code Section IX	ANSI B 31.1
Pumps	Manufacturers[1] Standards	ASME Code Section II or Manufacturer’s Standard	ASME Code Section IX (as required)	ASME Code[3] Section III Class 3; and Hydraulic Institute

Notes: (1) Manufacturer's standard for the intended service. Hydrotesting should be 1.5 times the design pressure.

(2) Material Manufacturer's certified test reports should be obtained whenever possible.

(3) ASME Code stamp and material traceability not required.

TABLE 11.3-7: DELETED

TABLE 11.3-8: PARAMETERS INPUT TO BWR-GALE CODE

[This Table is historical]

Item, Description	Input
Main Condenser and Turbine Gland Seal Air Removal System:	
Gland seal steam flow (10^3 lbm/hr)	0.0
Gland seal hold up time (hours)	0.0
Holdup time (hr) for offgases from the main condenser air ejector prior to processing by the offgas treatment system	0.167
Treatment system for offgases from condenser air ejector	Charcoal delay system
Offgases from the mechanical vacuum pump	No treatment prior to release
Air inleakage per condenser shell(cfm)	10 cfm (Built into GALE Code)
Mass of Charcoal in the charcoal delay systems (10^3 lbs)	48
Operating temperature of the delay system (F)	0
Dewpoint temperature of the delay system (F)	-90
Dynamic adsorption coefficient for xenon (cm^3/g)	2410
Dynamic adsorption coefficient for Krypton (cm^3/g)	105
Cryogenic distillation system	Not used
Steam flow to turbine gland seal (lb/hr) [Clean steam is used]	0.0
Source of steam to the turbine gland seal	Seal steam generator

TABLE 11.3-8: PARAMETERS INPUT TO BWR-GALE CODE (CONTINUED)

[This table is historical]

Item, Description	Input
Iodine released from gland seal system [Clean steam is used]	0
Fraction of radioiodine released from Turbine Gland Seal Condenser Vent	0
Fraction of radioiodine released from the Condenser Air Ejector Offgas Treatment System	1
<u>Ventilation and Exhaust Systems:</u>	
Provisions incorporated to reduce radioactivity releases through ventilation exhaust systems:	
Containment building	Release through charcoal and HEPA filters
Drywell purge	Same as for containment
Auxiliary building	No treatment of releases
Turbine building	No treatment of releases
Radwaste building	Release through HEPA filters. No credit is taken for charcoal filters for tank vents

TABLE 11.3-8: PARAMETERS INPUT TO BWR-GALE CODE (CONTINUED)

[This table is historical]

Filter Removal Efficiency	Iodine	Particulates
Containment building releases	99	99
Auxiliary building releases	0	0
Radwaste building releases	0	99
Turbine building releases	0	0

Table 11.3-9: EXPECTED ANNUAL RELEASE OF GASEOUS EFFLUENTS (Ci/yr)

[This table is historical]

Grand Gulf	BWR
Thermal Power Level (megawatts)	4496.00000
Plant Capacity Factor	1.00000
Total Steam Flow (million lbs/hr)	19.42800
Mass of Water in Reactor Vessel (million lbs)	.58870
Clean-up Demineralizer Flow (million lbs/hr)	.17800
Condensate Demineralizer Regeneration Time (days)	720.00000
Fission Product Carry-Over Fraction	.00100
Halogen Carry-Over Fraction	.02000
Fraction Feed Water Through Condensate Demin	.64700
Reactor Vessel Halogen Carryover Factor	.02000

TABLE 11.3-9: EXPECTED ANNUAL RELEASE OF GASEOUS EFFLUENTS (Continued)

[This table is historical]

LIQUID WASTE INPUTS

STEAM	FLOW RATE (GAL/DAY)	FRACTION OF PCA	FRACTION DISCHARGED	COLLECTION TIME(DAYS)	DECAY TIME(DAYS)	DECONTAMINATION FACTORS I	CS	OTHERS
HIGH PURITY WASTE	2.03E+04	.243	.100	1.708	.102	1.00E+02	2.00E+01	1.00E+02
LOW PURITY WASTE	1.18E+04	.001	.600	.939	.050	1.00E+02	2.00E+01	1.00E+02
CHEMICAL WASTE	0.00E+00	.000	.000	.000	.000	1.00E+00	1.00E+00	1.00E+00
REGENERANT SOLS	0.00E+00		.000	.000	.000	1.00E+00	1.00E+00	1.00E+00

GASOUS WASTE INPUTS

GLAND SEAL STEAM FLOW (THOUSAND LBS/HR)	.00000
GLAND SEAL HOLUP TIME (HOURS)	.00000
AIR EJECTOR OFFGASS HOLDUP TIME (HOURS)	.16700
CONTAINMENT BLDG IODINE RELEASE FRACTION	.01000
PARTICULATE RELEASE FRACTION	.01000
TURBINE BLDG IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	1.00000
GLAND SEAL VENT, IODINE PF	1.00000
AIR EJECTOR OFFGASS IODINE PF	.00000
AUXILIARY BLDG IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	1.00000
RADWASTE BLDG IODINE RELEASE FRACTION	1.00000
PARTICULATE RELEASE FRACTION	.01000
THERE IS A CHARCOAL DELAY SYSTEM:	
KRYPTON HOLDUP TIME (DAYS)	2.0179
XENON HOLDUP TIME (DAYS)	46.3137
KRYPTON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	105.00000
XENON DYNAMIC ADSORPTION COEFFICIENT (CM3/GM)	2410.00000
MASS OF CHARCOAL (THOUDANS LBS)	48.00000
THERE IS NOT A PERMANENT ON-SITE LAUDRY	

TABLE 11.3-9: EXPECTED ANNUAL RELEASE OF GASEOUS EFFLUENTS (Continued)

[This table is historical]

GASOUS RELEASE RATE (CURIES PER YEAR)

NUCLIDE	COOLANT CONC (MICROCURIES/G)	CONTAINMENT BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	GLAND SEAL	AIR EJECTOR	MECH VAC PUMP	TOTAL
I-131	3.362E-03	2.0E-04	2.8E-01	3.9E-02	2.0E-02	0.0E+00	0.0E+00	2.1E-01	5.5E-01
I-133	4.524E-02	2.7E-03	3.8E+00	5.2E-01	2.7E-01	0.0E+00	0.0E+00	2.2E+00	6.8E+00

H-3 RELEASED FROM TURBINE BUILDING VENTILATION SYSTEM	4.2E+01
H-3 RELEASED FROM CONTAINMENT BUILDING VENTILATION SYSTEM	4.2E+01
TOTAL H-3 RELEASED VIA GASEOUS PATHWAY	8.5E+01
C-14 RELEASED VIA MAIN CONDENSER OFFGAS SYSTEM =	9.5 CI/YR

NUCLIDE	COOLANT CONC (MICROCURIES/G)	CONTAINMENT BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	GLAND SEAL	AIR EJECTOR	MECH VAC PUMP	TOTAL
AR-41	0.000E+00	1.5E+01	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.7E+01	0.0E+00	7.2E+01
KR-83M	9.100E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
KR-85M	1.600E-03	1.0E+00	2.5E+01	3.0E+00	0.0E+00	0.0E+00	5.9E+01	0.0E+00	8.8E+01
KR-85	5.000E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.9E+02	0.0E+00	3.9E+02
KR-87	5.500E-03	0.0E+00	6.1E+01	2.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.3E+01
KR-88	5.500E-03	1.0E+00	9.1E+01	3.0E+00	0.0E+00	0.0E+00	3.0E+00	0.0E+00	9.8E+01
KR-89	3.400E-02	0.0E+00	5.8E+02	2.0E+00	2.9E+01	0.0E+00	0.0E+00	0.0E+00	6.1E+02
XE-131M	3.900E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E+01	0.0E+00	2.0E+01
XE-133M	7.500E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
XE-133	2.100E-03	2.7E+01	1.5E+02	8.3E+01	2.2E+02	0.0E+00	3.7E+02	1.3E+03	2.2E+03
XE-135M	7.000E-03	1.5E+01	4.0E+02	4.5E+01	5.3E+02	0.0E+00	0.0E+00	0.0E+00	9.9E+02
XE-135	6.000E-03	3.3E+01	3.3E+02	9.4E+01	2.8E+02	0.0E+00	0.0E+00	5.0E+02	1.2E+03
XE-137	3.900E-02	4.5E+01	1.0E+03	1.4E+02	8.3E+01	0.0E+00	0.0E+00	0.0E+00	1.3E+03
XE-138	2.300E-02	2.0E+00	1.0E+03	6.0E+00	2.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E+03
TOTAL NOBLE GASES									8.0E+03

0.0 APPEARING IN THE TABLE INDICATES RELEASE IS LESS THAN 1.0 CI/YR FOR NOBLE GAS

TABLE 11.3-9: EXPECTED ANNUAL RELEASE OF GASEOUS EFFLUENTS (Continued)

[This table is historical]

AIRBORNE PARTICULATE RELEASE RATE (CURIES PER YEAR)

NUCLIDE	CONTAINMENT BUILDING	TURBINE BUILDING	AUXILIARY BUILDING	RADWASTE BUILDING	MECH VAC PUMP	TOTAL
CR-51	2.0E-06	9.0E-04	9.0E-04	7.0E-06	1.0E-06	1.8E-03
MN-54	4.0E-06	6.0E-04	1.0E-03	4.0E-05	0.0E+00	1.6E-03
CO-58	1.0E-06	1.0E-03	2.0E-04	2.0E-06	0.0E+00	1.2E-03
FE-59	9.0E-07	1.0E-04	3.0E-04	3.0E-06	0.0E+00	4.0E-04
CO-60	1.0E-05	1.0E-03	4.0E-03	7.0E-05	5.6E-07	5.1E-03
ZN-65	1.0E-05	6.0E-03	4.0E-03	3.0E-06	3.4E-07	1.0E-02
SR-89	3.0E-07	6.0E-03	2.0E-05	0.0E+00	0.0E+00	6.0E-03
SR-90	3.0E-08	2.0E-05	7.0E-06	0.0E+00	0.0E+00	2.7E-05
NB-95	1.0E-05	6.0E-06	9.0E-03	4.0E-08	0.0E+00	9.0E-03
ZR-95	3.0E-06	4.0E-05	7.0E-04	8.0E-06	0.0E+00	7.5E-04
MO-99	6.0E-05	2.0E-03	6.0E-02	3.0E-08	0.0E+00	6.2E-02
RU-103	2.0E-06	5.0E-05	4.0E-03	1.0E-08	0.0E+00	4.1E-03
AG-110M	4.0E-09	0.0E+00	2.0E-06	0.0E+00	0.0E+00	2.0E-06
SB-124	2.0E-07	1.0E-04	3.0E-05	7.0E-07	0.0E+00	1.3E-04
CS-134	7.0E-06	2.0E-04	4.0E-03	2.4E-05	3.2E-06	4.2E-03
CS-136	1.0E-06	1.0E-04	4.0E-04	0.0E+00	1.9E-06	5.0E-04
CS-137	1.0E-05	1.0E-03	5.0E-03	4.0E-05	8.9E-06	6.1E-03
BA-140	2.0E-05	1.0E-02	2.0E-02	4.0E-08	1.1E-05	3.0E-02
CE-141	2.0E-06	1.0E-02	7.0E-04	7.0E-08	0.0E+00	1.1E-02

* Containment iodine releases include a reduction factor of 100 to account for provision of 8-in deep-bed charcoal adsorbers on the containment exhaust line.

** 0 appearing in the table indicates release is less than 1.0 Ci/yr for noble gas, 0.0001 Ci/yr foriodine

TABLE 11.3-10: DESCRIPTION OF RELEASE POINTS

Release point	Ht. above grade (ft.)	Ht.above adjacent structure (ft)	Location relative to adjacent structure	ΔT (F) between gaseous effluent and ambient air and normal condition (assume ambient Temp. 95 F)	Flow rate (cfm) normal condition	Exit Velocity Normal condition approx. fpm	Discharge Point
Radwaste bldg	31.5	See Figure 2.1-2	See Figure 2.1-2	25	52,495	2,500	(1)
SGTS	139.5	See Figure 2.1-2	See Figure 2.1-2	67	4,000	1,273	(1)
Auxiliary bldg	139.5	See Figure 2.1-2	See Figure 2.1-2	3	25,075	3,134	(2)
Containment	60.5	See Figure 2.1-2	See Figure 2.1-2	15	6,000	2,700	(1)
Turbine bldg:							
a. Smoke exhaust	54.5	See Figure 2.1-2	See Figure 2.1-2	10	19,000	422	(2)
b. Battery room exh.	36.5	See Figure 2.1-2	See Figure 2.1-2	10	2,000	500	(2)
c. Lube oil room exh.	10	See Figure 2.1-2	See Figure 2.1-2	10	1,500	400	(2)

TABLE 11.3-10: DESCRIPTION OF RELEASE POINTS (CONTINUED)

Release point	Ht. above grade (ft.)	Ht.above adjacent structure (ft)	Location relative to adjacent structure	ΔT (F) between gaseous effluent and ambient air and normal condition (assume ambient Temp. 95 F)	Flow rate (cfm) normal condition	Exit Velocity Normal condition approx. fpm	Discharge Point
d. Turbine bldg. vent. system	99.5	See Figure 2.1-2	See Figure 2.1-2	10	7,205 (8,921)(3)	1,297 (1,611)(3)	(1)
e. Occasional release point	100+	See Figure 2.1-2	See Figure 2.1-2	25	Varies(4)	Varies(4)	(5), (6)

NOTES:

1. Discharge point is a penthouse on the building roof with louvered sides.
2. Discharge point is at the side of the building with louvers.
3. During operation of the mechanical vacuum pumps, an additional 1716 cfm flow will occur and the velocity will increase to 1611 fpm.
4. Varies based on the temperature difference between the turbine building air and outdoor air. Also affected by duct size and configuration.
5. Occasional use hatch located in the southeast corner of the Turbine Building roof in modes 1, 2, and 3.
6. Up to four hatches on the Turbine Building roof during mode 4 and 5 only.

TABLE 11.3-11: χ/Q AND D/QS FOR THE VEGETABLE GARDENS, RESIDENCES AND COWS WITHIN 5 MILES

Item	Sector	Distance (meters)	χ/Q (Sec/meter^3)	D/Q (1 meter^2)
Vegetable Garden	NNE	2414	1.195E-06	1.893E-09
	ENE	4828	2.098E-07	3.958E-10
	E	2414	4.615E-07	9.058E-10
	ESE	4426	1.931E-07	3.721E-10
	N	2816	1.453E-06	2.100E-09
Residence	NNE	1448	2.534E-06	4.543E-09
	NE	1062	2.563E-06	6.142E-09
	ENE	4297	2.493E-07	4.863E-10
	E	982	1.796E-06	4.162E-09
	ESE	4007	2.239E-07	4.434E-10
	SE	3299	3.738E-07	7.693E-10
	SSE	1690	1.763E-06	4.065E-09
	S	1770	2.669E-06	4.389E-09
	SSW	3734	1.541E-06	1.154E-09
	SW	1432	9.416E-06	6.669E-09
	WNW	6437	7.276E-07	2.842E-10
	NNW	1738	2.964E-06	3.622E-09
	N	1481	3.710E-06	6.337E-09
Cow	E	8047	7.809E-08	1.080E-10

Note: Updates to χ/Q's and D/Q's used to calculate dose to the public are located in and controlled by the Offsite Dose Calculation Manual.

TABLE 11.3-12: MAXIMUM INDIVIDUAL DOSES FROM GASEOUS EFFLUENTS

Noble Gases

[HISTORICAL INFORMATION]

Pathway	Location	Annual Dose	10 CFR 50 Appendix I Limits
Cloud Submersion			
- total body	SSW sector-site boundary - 1046 meters	0.88 mrem	5 mrem
- skin	SSW sector-site boundary - 1046 meters	2.16 mrem	15 mrem
Air dose			
- gamma	SSW sector-site boundary - 1046 meters	1.35 mrad	10 mrad
- beta	SW sector-site boundary - 1368 meters	1.83 mrad	20 mrad

TABLE 11.3-12: MAXIMUM INDIVIDUAL DOSES FROM GASEOUS EFFLUENTS (CONTINUED)

Radioiodines and Particulates
(Thyroid)*

Location and Pathway	Age Group	Annual Dose (mrem)	10 CFR 50 Appendix I Annual Limits (mrem)
SW sector - site boundary - 1368 meters	Child		
- inhalation		8.91	15 from all pathways
- ground contamination		0.06	
SW sector - residence - 1432 meters	Child		
- inhalation		8.31	15 from all pathways
- meat ingestion		0.59	
- ground contamination		0.05	
N sector - vegetable garden - 2816 meters	Child		
- inhalation		1.23	15 from all pathways
- vegetable ingestion		0.95	
- ground contamination		0.02	
E sector - pasture - 8047 meters	Infant		
- inhalation		0.05	15 from all pathways
- cow’s milk ingestion		0.96	
- ground contamination		0.001	

* Doses to other organs are less than the dose to the thyroid.

TABLE 11.3-13: POPULATION DOSES FROM GASEOUS RELEASES

[HISTORICAL INFORMATION]

Pathway	Total Body Dose (person-rem)	Thyroid Dose (person-rem)
	Noble Gases	
Cloud submersion	0.143	0.143
	Radioiodine and Particulates	
Ground contamination	0.032	0.032
Inhalation	0.046	3.03
Vegetable consumption	0.915	3.07
Milk consumption	0.149	1.35
Meat consumption	0.183	0.303
	1.325	7.785

TABLE 11.3-14: ANNUAL AIRBORNE RELEASES OF ELEMENTAL IODINE-131 ACCORDING TO PLANT OPERATING MODE FOR ENVIRONMENTAL IMPACT EVALUATION MILLICURIES PER YEAR

[HISTORICAL INFORMATION]

Source	Plant Operating Mode	
Building or Exhaust	Power Generation	Refueling/Maintenance
Reactor building*	30.0	3.5
Turbine building	59.0	3.2
Radwaste building	11.0	0.34
Gland seal steam and mechanical vacuum pump	0.0036	0.020
Total	100.	7.1

Total Elemental I-131 = 107.1 millicuries/year

*Use 50% of reactor building release for the auxiliary building and 50% for the containment building.

TABLE 11.3-15: ANNUAL AIRBORNE RELEASES OF NON-ELEMENTAL IODINE-131 SPECIES ACCORDING TO PLANT OPERATING MODE FOR ENVIRONMENTAL IMPACT EVALUATIONS MILLICURIES PER YEAR

[HISTORICAL INFORMATION]

Source	Plant Operating Mode					
	Power Operation			Refueling/Maintenance		
	Species					
Building or Exhaust	Particulate	HOI	CH_3I	Particulate	HOI	CH_3I
Reactor building*	8.8	13.0	28.0	0.69	5.7	4.0
Turbine building	21.0	16.0	9.8	0.56	4.6	3.3
Radwaste building	1.6	4.2	30.0	0.044	0.58	6.0
Gland seal steam and mechanical vacuum pump	0.0029	0.013	0.043	0.039	0.020	20.0
Total	31.4	33.2	67.8	1.33	10.9	33.3

Particulate 31.4 + 1.33 = 32.7 millicuries/year

TABLE 11.3-15: ANNUAL AIRBORNE RELEASES OF NON-ELEMENTAL IODINE-131 SPECIES ACCORDING TO PLANT OPERATING MODE FOR ENVIRONMENTAL IMPACT EVALUATIONS MILLICURIES PER YEAR

This information is evaluated in PUSAR Sections 2.10.1.2.4,
Sections 2.5.5.1.1 and ODCM

Source	Plant Operating Mode					
	Power Operation			Refueling/Maintenance		
	Species					
Building or Exhaust	Particulate	HOI	CH_3I	Particulate	HOI	CH_3I
HOI	33.2	+ 10.9	= 44.1 millicuries/year			
CHI	67.8	+ 33.3	= 101.1 millicures/year			

Total Non-elemental I-131 = 177.9 millicuries/year

*Use 50% of reactor building release for the auxiliary building and 50% for the containment building.

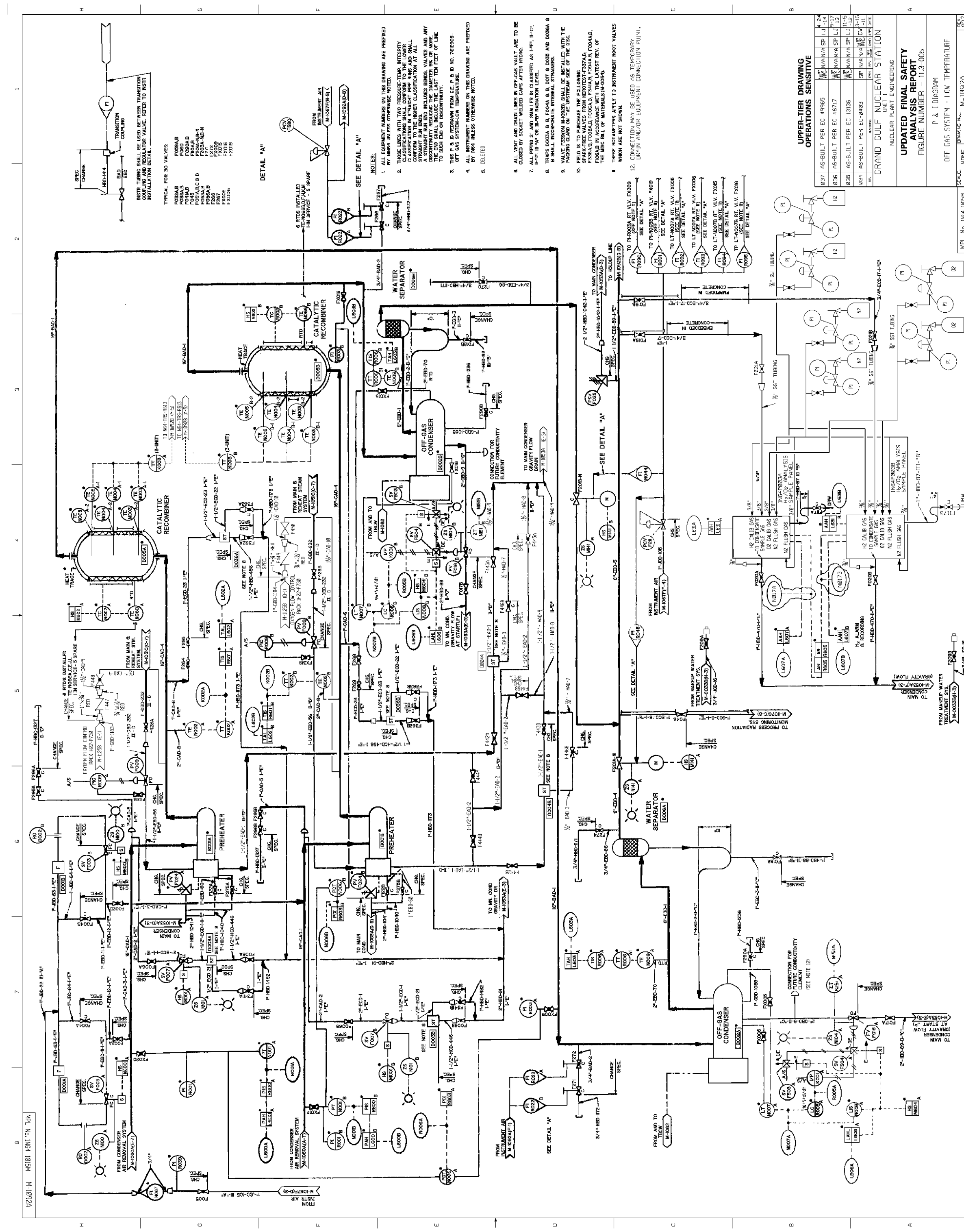
FIGURES 11.3-1, 11.3-2, 11-3-3, 11.3-4, AND 11.3-6

ARE

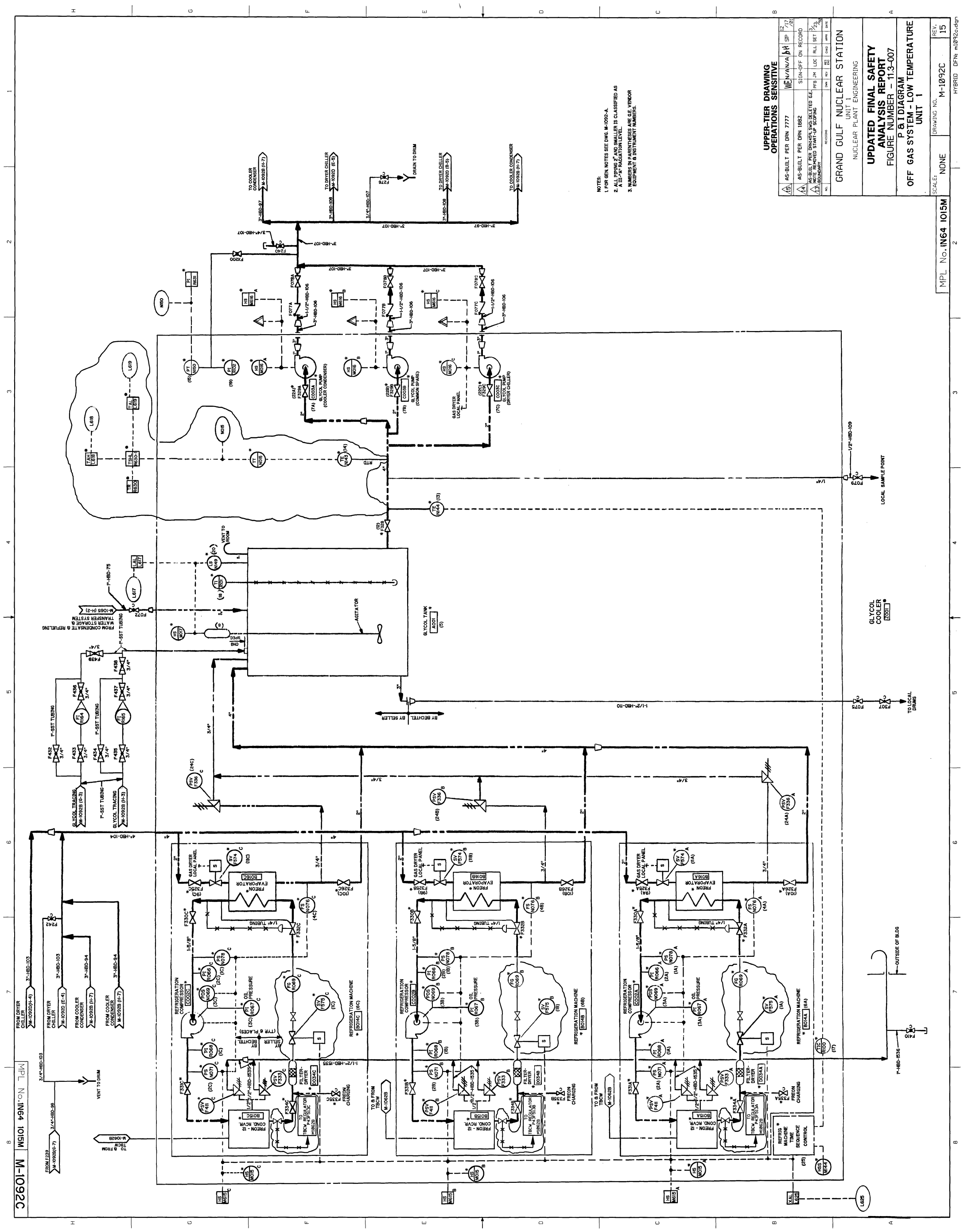
P R O P R I E T A R Y

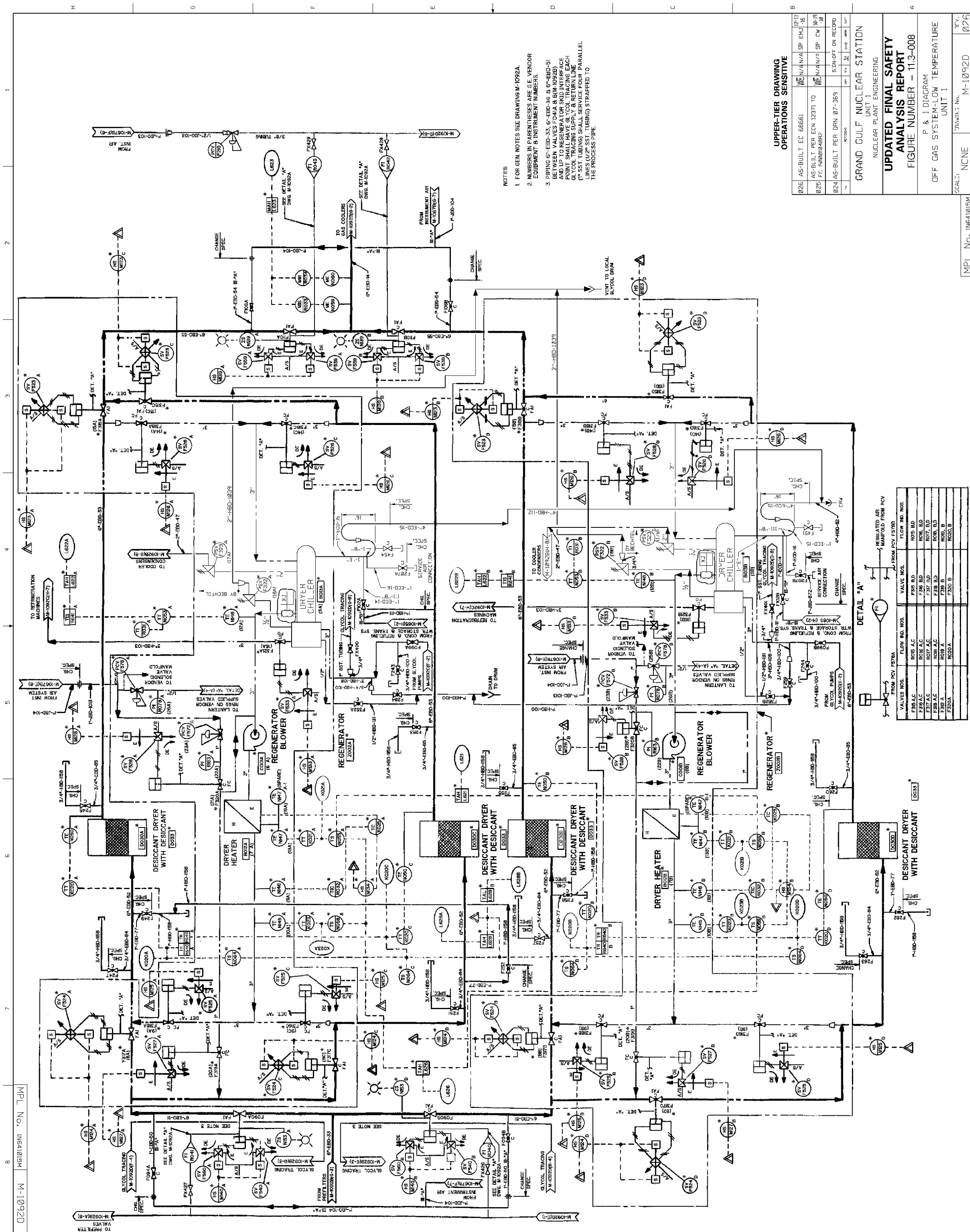
GENERAL TITLES:

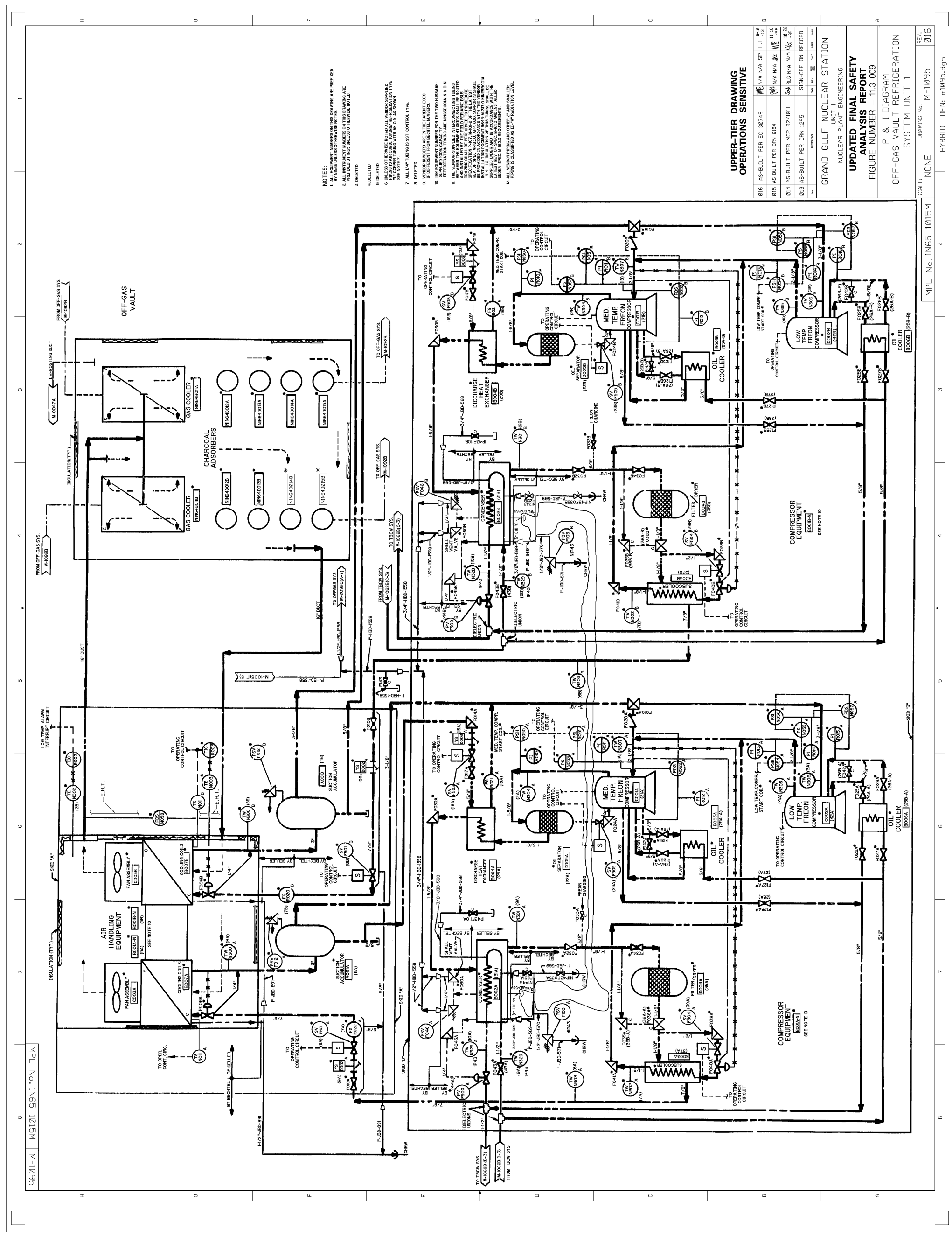
System Flow Diagrams
Offgas System Drawings
P & I Diagrams

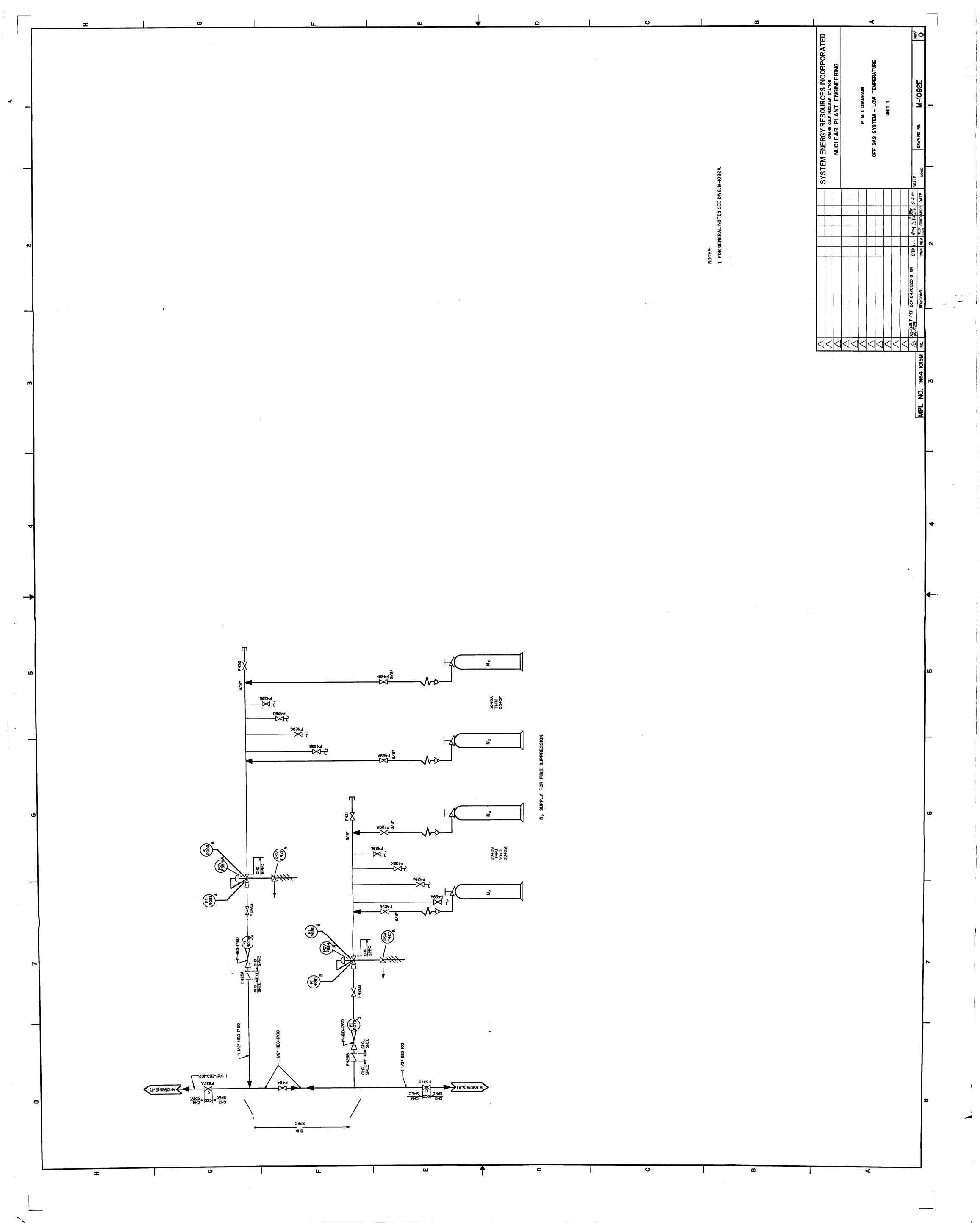

UPPER-TIER DRAWING
OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.3-005

This page intentionally left blank


UPPER-TIER DRAWING
OPERATIONS SENSITIVE
AS-BUILT PER DRN 7777
AS-BUILT PER DRN 1882
SIGN-OFF ON RECORD
AS-BUILT PER DRN1459, SWO: DELETED G.E. NOTE REMOVED START-UP SCOPING BOUNDARY
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY
ANALYSIS REPORT
FIGURE NUMBER - 11.3-007
P & I DIAGRAM
OFF GAS SYSTEM - LOW TEMPERATURE
UNIT 1
SCALE: NONE
DRAWING NO. M-1092C
REV. 15
HYBRID DFN: m1092c.dgn
MPL No. IN64 IO15M


GRAND GULF NUCLEAR STATION
UNIT 1
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.3-008
P & I DIAGRAM
OFF GAS SYSTEM-LOW TEMPERATURE
UNIT 1
M-1092D


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.3-009
P & I DIAGRAM
OFF-GAS VAULT REFRIGERATION
SYSTEM UNIT 1
UPPER-TIER DRAWING
OPERATIONS SENSITIVE
COMPRESSOR EQUIPMENT
AIR HANDLING EQUIPMENT
CHARCOAL ADSORBERS
OFF-GAS VAULT


SYSTEM ENERGY RESOURCES INCORPORATED
NUCLEAR PLANT ENGINEERING
P & I DIAGRAM
OFF GAS SYSTEM - LOW TEMPERATURE
UNIT 1
M-1092E
MPL NO. N64 1015M
NOTES:
1. FOR GENERAL NOTES SEE DWG M-1092A.
N2 SUPPLY FOR FIRE SUPPRESSION

11.4 SOLID RADWASTE SYSTEM

The solid radwaste system is designed to provide solidification and packaging for radioactive wastes that are produced during shutdown, startup, and normal plant operation, and to store these wastes until they are shipped offsite for burial. The system is located in the radwaste building. Plant operating procedures will be written covering Radioactive Waste Management and Materials Control Procedures.

11.4.1 Design Bases

11.4.1.1 Power Generation Design Bases

a. The solid radwaste system provides the capability for processing and packaging wastes from the reactor water cleanup system, fuel pool cooling and cleanup system, liquid radwaste system, and resins, and particulate wastes from the condensate cleanup system. Wastes from the above systems may consist of spent resin, or other filtering media.

b. The solid radwaste system provides a means of compacting and packaging miscellaneous dry radioactive materials, such as paper, rags, contaminated clothing, gloves, and shoe coverings, and for packaging contaminated metallic materials and incompressible solid objects, such as small tools and equipment parts.

c. The solid radwaste system is designed so that failure or maintenance of any frequently used component shall not impair system or plant operation. Redundancy of some components is provided to allow continued operation when one piece of equipment is out of service due to either failure or maintenance. Equipment which is not redundant is cross-tied, where feasible, with similar components for backup service. Additionally, a mobile solidification station is provided to accommodate processing of wastes with mobile, or portable waste processing equipment.

d. Redundant and backup equipment are shielded from each other, where possible, to allow access to nonfunctioning components for maintenance and repair. Areas of the solid radwaste system for which access is required under all operating conditions are shielded from radioactive, and potentially radioactive, components.

e. System piping and components were hydrostatically tested prior to initial startup.

f. The primary operating station for the solid radwaste system is the water inventory control station located at El. 118-0 in the radwaste building; container capping and swipe sample retrieval are performed locally. The operating philosophy of the solid radwaste control system is manual start and stop, with all functions interlocked to provide a fail-safe mode of operation.

11.4.1.2 Codes and Standards

Codes and standards applicable to the solid radwaste system are listed in Table 3.2-1 item XVIII. The solid radwaste system is designed and constructed in accordance with quality group D and the additional requirements of Branch Technical Position ETSB 11-1 (Revision 1, 4/75), "Design Guidance for Radioactive Waste Management Systems Installed In Light-Water-Cooled Nuclear Power Reactor Plants." The solid radwaste system components and the structure housing the components are designed to the seismic criteria of ETSB 11-1.

Collection, processing, packaging, and storage of radioactive wastes will be performed so as to maintain any potential radiation exposure to plant personnel to "as low as is reasonably achievable" levels, in accordance with Regulatory Guide 8.8 (Rev. 2 March, 1977) guidelines (see Section 12.1), and within the dose limits of 10 CFR 20. Some of the design features incorporated to maintain ALARA criteria include remote system operation, remotely actuated flushing, and equipment layout that permits shielding of components containing radioactive materials.

Packaging and transporting radioactive wastes will be in conformance with 10 CFR 71. Packaged wastes will be shipped in conformance with 49 CFR 173 dose limits.

11.4.2 System Description

11.4.2.1 General Description

The solid radwaste system consists of the following:

a. Three waste holding tanks, capable of dewatering slurries and complete with level detection devices and mixing and flushing equipment

b. Three waste transfer pumps

c. One indoor, electric, overhead, double-trolley bridge crane

d. A decontamination area

e. Disposable shipping containers

f. Optical surveillance facilities

g. One hot water heater

h. One waste compactor

i. One mobile solidification station

Detailed piping and instrumentation diagrams are provided in Figure 11.4-1. A process flow diagram indicating the process route, expected flows, and equipment capacities is shown in Figure 11.4-2. A physical layout drawing illustrating the packaging, storage, and shipping areas of the radwaste building is presented in Figures 1.2-10, 1.2-13, 12.3-6, and 12.3-7.

Table 11.4-1 lists the expected volumes of wastes to be processed on an annual basis.

11.4.2.2 Component Description

A description of the solid radwaste system components, (including materials of construction) as shown in the process flow diagram, is given in Table 11.4-4.

The following is a functional description of the major system components:

a. Waste Holding Tanks - These tanks function as batch tanks to provide a starting point for the solids waste process. They also provide capability for dewatering resins and high-solid-content wastes, and for mixing these wastes. The agitator provides a homogeneous waste slurry. These tanks are vented to the radwaste building ventilation system. Overflows from the waste holding tanks are directed to the radwaste building floor drain sump for reprocessing through the liquid radwaste system. The holding tanks have the provisions to obtain representative waste samples which may be removed for chemical lab

analysis if necessary. From samples, the batch parameters for packaging are determined as described in subsection 11.4.5.

b. Waste Transfer Pumps - These pumps transfer the homogeneous waste stream from the waste holding tanks and may also function as transfer pumps for recycling wastes back to the liquid radwaste system for additional waste processing or storage.

c. Bridge Crane - This crane is locally controlled and provides a means of moving containers from the fill area to the solid waste storage area, and from the waste storage area to the shipping area. The crane is also used for moving empty containers to the fill area. The crane is equipped with television cameras to facilitate remote handling. However, the television equipment is not used and is abandoned in place.

d. Decontamination Station - The decontamination station is not used and is abandoned in place. This station provides for container washdown if they become contaminated during the filling sequence. Drain hubs in the floor are provided to route flushing water from this process to the radwaste building floor drain sump for processing through the liquid radwaste system. Since this method of decontamination is not a normal occurrence, the small amount of solids associated with the washdown is not expected to cause drain clogging.

e. Disposable Shipping Containers - For storage and transporting solid wastes, 55-gallon, DOT standard drums and other containers approved by DOT and the waste disposal facility are used.

f. Optical Surveillance Facilities - A closed circuit television viewing system provides for remote monitoring of container filling, storage, and transport loading operations. This system is inoperative and is abandoned in place.

g. Hot Water Heater - This unit provides hot water for suitable flushing and decontamination of the waste holding tanks and associated equipment. The water heater is not used and is abandoned in place.

h. Waste Compactor - This unit is a powered, mechanical ram and is used to reduce the volume of compressible dry wastes. The compactor is complete with a hooded exhaust fan and filter to control airborne particles during dry waste compaction.

i. Mobile Solidification Station - This station, located in the radwaste building railroad bay, provides interfaces with all liquid radwaste system tanks, which normally input to the solid radwaste system, and with necessary plant auxiliaries to accommodate the use of mobile, or portable, waste processing systems.

None of the above tanks use compressed gases for transport or drying of resins or filter sludge.

11.4.2.3 Component Integration

The following description shows how the major system components described in subsection 11.4.2.2 function as an integrated system:

a. Equipment Drain Filter Discharge, Floor Drain Filter Discharge, and High Solids Content Waste

   When either of the two liquid radwaste filters reaches the end of its filtering cycle, the flow through the filter will be terminated. The filter will be drained of excess water and the solid radioactive wastes will be centrifugally discharged from the precoat filter. The filter will be capable of discharging a maximum of approximately 26.5 cubic feet, at one time, either as a wet sludge or as a dry cake (approximately 50 percent by weight moisture). The filter wastes will be collected in the waste holding tank located directly below the filter. Once the filter waste has been collected in this tank, it will be pumped by the tank-associated waste transfer pump to the waste processing station. The wastes will normally be pumped into liners and dewatered. If solidification is required it will be performed by a vendor, using their own operating procedures and process control program accepted by the NRC or the On-Site Safety Review Committee. High solids content wastes (described in subsection 11.4.2.4), which are not filtered, will be sluiced directly to the waste processing station. After sufficient time for the

solids to settle is allowed, excess water will be decanted. Processing shall then proceed as described above.

b. Solid Radwaste Handling Crane

After capping, smear swipe sampling, and decontamination (if required), the container will be moved, by the solid radwaste handling crane, to the appropriate storage area.

When it is time to ship the container offsite for burial, or further processing, the solid radwaste handling crane will pick up the container and move it onto the waiting truck.

c. Decontamination Station

The decontamination station is not used and is abandoned in place. The decontamination station is used for cleaning and inspection of the filled shipping containers. After decontamination, a smear swipe is taken of the side of the container and analyzed for gross beta-gamma surface contamination. The container is also classified as to its dose rate at a specified distance; this will determine its storage location in the decay area and shielding requirements for shipment.

11.4.2.4 System Operation

11.4.2.4.1 High Solids Content Waste

The slurry wastes normally will be processed as described below. Solidification of these wastes will be accomplished as described in subsection 11.4.2.4.2.

a. Reactor Water Cleanup (RWCU) Backwash - The RWCU discharge pump (liquid radwaste system) is used to produce a homogeneous slurry of resin and water in the RWCU phase separator decay tank. The discharge valve is then opened, allowing a portion of the recycle flow to be directed to the container. If it is determined that excess water is present after the solids have settled, the excess will be removed. Water removed in this manner will be returned to the Liquid Radwaste System.

b. Fuel Pool Cooling and Cleanup Wastes - Fuel pool cooling and cleanup (FPC & CU) wastes will be collected in the RWCU phase separator decay tank and processed as described in a. above.

c. Spent Resins - Spent resins from the spent resin tank are also slurried to the shipping container. Excess water will be decanted and routed to the Liquid Radwaste System, or Solid Radwaste System.

d. Condensate resin cleaning - Overflow from resin cleaning activities (condensate clean-up system) is directed to the condensate clean waste tank (floor and equipment drains system). These wastes may then be transferred to the spent resin tank or the condensate phase separator decay tank and processed with the spent resins as described in c. above. Liquid wastes discharged through the spent resin tank overflow are collected in the floor drain collection tank for processing.

e. Condensate Precoat Filter Backwash - Condensate precoat filter wastes will be collected in one of the two condensate phase separator tanks (liquid radwaste system). Because it is expected that sufficient volumes of particulate waste will make direct processing feasible, the wastes will be transferred directly to the shipping container, and handled as described in the latter portion of a. above, with decant effluent being routed to the Liquid Radwaste System for processing.

11.4.2.4.2 Equipment Drain Filter Discharge, Floor Drain Filter Discharge, and High Solids Content Waste Handling

As dirt, crud, and filter-aid material (if required) are built up on the equipment drain or floor drain filter, the pressure drop across the filter increases until a preset limit is reached. At this time, processing through the filter is stopped manually. The unit is either drained back to the tank from which the waste water originated or to a sump; if desired, the cake built up on the filter elements may be dried, with air, to a predetermined moisture content (refer to liquid radwaste system, Section 11.2). The filter nest is then mechanically rotated, throwing the cake off. As the cake drops to the bottom of the filter, high pressure air is used to force the cake out the discharge port and into the waste holding tank. Once the filter cake has been collected in the

waste holding tank, the waste may be transferred to shipping containers for dewatering or returned to the condensate phase separator for further processing.

Radioactive waste packaging and processing will be accomplished by using the appropriate waste transfer pump to transfer predetermined amounts of filter waste (or high solids content waste) into the shipping container.

Level detectors will be provided at the shipping container as part of the vendor's equipment. On high level in the shipping container, the detector will alarm and automatically stop the container fill process.

The vendor's mobile/portable processing unit will provide waste and level detection connections to the containers. The unit will allow for level detection and addition of the waste. Connection of the unit to the container will be made manually.

11.4.2.4.3 Capping

After filling has been completed, the shipping container will be capped.

11.4.2.4.4 Decontamination Station

The decontamination station is not used and is abandoned in place.

11.4.2.4.5 Solid Radwaste Handling Crane

After sufficient decontamination, if required, and dose rate classification, the solid radwaste handling crane will be used to move the container to its storage area. The solid radwaste handling crane may also be used for maintenance on the liquid waste filters.

When it is time to ship the containers offsite for burial or further processing, the solid radwaste handling crane will be used to pick the containers up, and move them onto the waiting truck.

Prior to shipment a final radiological survey of the loaded transport vehicle will be performed.

11.4.2.4.6 Remote Viewing Television

This system is inoperative and is abandoned in place.

11.4.2.4.7 Process Pump Cleaning Upon Loss of Power

The loss of electrical control power to the waste processing system will result in the immediate shutdown of the system. The waste holding tank power-operated outlet valves will close upon loss of air pressure or electrical power and all pumps will cease to operate. Other waste transfer power-operated valves will fail-as-is, permitting the pumps and associated piping to be drained and flushed.

The short term corrective action in this situation is the cleaning of the waste transfer pumps of liquid wastes by flushing with condensate supplied to the inlet piping of the pumps.

If the power outage is not sufficiently long, no action is required. However, if the operator determines that the outage will be sufficiently long, the waste holding tanks and associated piping could be drained and flushed. The necessary valve openings can be achieved by applying bottled gas pressure or plant air to the appropriate valve operators. This is done through valve rack manifolds located in the access and operating galleries. Tubing connections from these manifolds extend to the various valves which must be operated for system draining, return of waste to the liquid radwaste system, or dumping into waste containers. Another flush valve provides a source of flush water to the inlet of the waste transfer pump to assist in cleaning this portion of the system and the waste holding tank spray nozzles. The expected length of the power outage will determine if cleaning this portion of the system is necessary.

11.4.2.4.8 Hydraulic Press

The solid radwaste system will also dispose of dry waste consisting of small tools, air filters, miscellaneous paper, rags, equipment parts which cannot be effectively decontaminated, wood, and solid laboratory waste. Compressible wastes can be compacted to reduce their volume. Ventilation is provided to maintain control of contaminated particles when operating this equipment. Noncompressible wastes are packaged manually in appropriate containers. Because of its low activity, this waste can be stored until enough is accumulated to permit economic transportation offsite for final disposal or further processing.

Storage areas for dry waste are provided in various locations throughout the plant. These areas are posted in accordance with the requirements of 10CFR20 and are arranged to maintain personnel exposures ALARA.

11.4.2.4.9 Mobile Solidification Station/Waste Processing Equipment

To provide system flexibility, a mobile solidification station is provided to accommodate processing of influents to the solid radwaste system with a mobile or portable system. The associated system piping, as shown in Figure 11.4-1b, provides interfaces from the RWCU phase separator decay tank, spent resin tank, waste holding tanks, and the condensate phase separator tanks to a valve station located within the radwaste building railroad bay. Condensate and service air connections to this piping are provided to permit backflushing of these lines after completion of transfer operations, and a dewatering return line is provided to the RWCU phase separator decay tanks. Additional condensate, service air, radwaste building ventilation, and electrical power interfaces are provided in this area for use with this mobile/ portable equipment.

11.4.3 Malfunction Analysis

The radwaste solidification system is equipped with a numa logic control system.

The process system is protected from component malfunction and operator error through a series of safety interlocks.

If a parameter is violated, an alarm will sound and the annunciator will identify the problem.

Once operating, pressure sensing switches will automatically stop the system if the valves fail to open.

On loss of power, supply valves close.

11.4.4 Expected Volumes

The quantities of waste and specific activities shipped per year are given in Table 11.4-1. The total activity is directly related to the activity in the liquids from each source and the

decontamination factors (DF) assumed in the respective system. Additionally, it is conservatively assumed that both soluble and particulate nuclides are deposited in the demineralizers. Decay, prior to shipment is also considered. It is expected that intervals of 30 days or longer will occur prior to shipment.

11.4.5 Packaging

All wastes collected in the solid radwaste system for disposal will be processed as described in subsection 11.4.2.4. If solidification is required, it will be completed as specified in the process control program. If other waste processing methods are used, the alternative methods will be reviewed and approved in accordance with the GGNS Process Control Program.

The administrative control requirements contained in Regulatory Guide 1.33, Revision 2, and ANSI N18.7-1976 shall be implemented in the Operation Procedures. In addition, Quality Programs (see Section 17.2) will perform periodic monitoring, review, and inspection activities to establish adequate confidence levels that operating procedures are being adhered to.

The estimated curie content of solid radwaste to be stored onsite is given in Table 11.4-2.

11.4.6 Storage Facilities

11.4.6.1 Radwaste Building

Packaged high activity solid radwaste is stored in a shielded storage area in the radwaste building, as shown in Figure 12.3-7. The storage area shield walls are sufficiently high to provide additional storage flexibility. Approximately 384 filled drums or 29 filled 120 ft^3 containers can be stored in this area at one time. Filled 120 ft^3 containers are not stacked. Based on generation of two hundred 120 ft^3 containers (approximately 22,036 ft^3) of waste per year, the solid radwaste storage area can provide storage capabilities of more than 30 days. The quantity of solidified/processed waste generated is given in Figures 11.2-6 through 11.2-10, and 11.4-2.

11.4.6.2 Large Component Storage Building

The Large Component Storage Building (LCSB) is a radioactive materials storage area located in the Northwest laydown area as shown in Figure 2.1-001. The approximate internal dimensions of the LCSB are 106 ft x 108 ft x 20 ft. Several components were replaced during the Extended Power Uprate (EPU) at GGNS. This building serves as permanent storage for these components until decommissioning. They include the steam dryer, both moisture separator reheaters, 9 feedwater heaters, both reactor feedpump turbines and their inner casings and the high pressure turbine rotor. The total expected volume of the major components contributing to offsite dose is approximately 39,000 cubic feet. The principal sources of radioactivity are from solid activated corrosion product buildup on the steam dryer, moisture separator reheaters, and the feedwater heaters. The maximum total quantity of stored radioactivity in the LCSB contributing to offsite dose is 960 curies. The LCSB is designed to limit calculated dose rates to within the limits of 10CFR20 and 40CFR190. The calculated dose rate at the site area boundary, approximately 400 feet north of the LCSB, is less than 0.5 mrem/yr.

11.4.6.3 GGNS Independent Spent Fuel Storage Installation Cask Storage Pad

The GGNS ISFSI storage pad is located at the north end of the GGNS plant site and at a location north of the canceled Unit 2 Containment and Turbine Building (see UFSAR Figure 1.2-001 and 3.4-001). The pad stores spent nuclear fuel. Detailed design and radiological information is provided in the NRC Certificate of Compliance (CoC) 72-1014, HI-STORM 100 FSAR HI-2002444, and the GGNS HI-STORM 100 10CFCFR72.212 Evaluation Report. Additional discussions are also provided UFSAR Chapters 1.2, 3.4, and 9.1. The ISFSI FSAR is maintained in accordance with 10CFR72.

11.4.7 Shipment

Containers normally can be shipped immediately after filling, provided the proper shielding is available, without exceeding Department of Transportation radiation limits. If 49 CFR 173 dose limitations cannot be met with the available shielding, however, the containers are stored until the appropriate shielding is available, or until dose rates have decreased.

All contaminated shipping containers and vehicles used for solid waste handling will be stored inside the power block or within designated areas within the Restricted Area in accordance with 10 CFR 20. Uncontaminated shipping containers and vehicles may be stored outside.

The expected annual volumes of solid radwaste to be shipped offsite are estimated in Table 11.4-1. The corresponding isotopic curie contents of solidified wastes are estimated in Tables 11.4-3a and 11.4-3b assuming 30-day decay.

11.4.8 Test and Inspection

The solid radwaste system is proved operable by its use during normal plant operation.* During the startup test phase, the operation and surveillance of the solid radwaste system processing will be in accordance with approved plant operating procedures.

11.4.9 Quality Control

The quality control program for the solid radwaste system is the same as described in subsection 11.3.2.2.1.3. This program is in accordance with BTP-ETSB-11-1 (Rev. 1).

*The solid radwaste system process components are inspected for conformance with design specifications and particular installation requirements set forth in Table 3.2-1.

TABLE 11.4-1: EXPECTED SOLID RADWASTE VOLUMES AND SPECIFIC ACTIVITY

Component Identification	Backwash Volume, in ft^3 in days	Backwash, Frequency, in days	Annual Waste, Volume, in ft^3	Specific Activity, in µCi/cc
		(Note 1)	(Note 1)	(Note 2)
Equipment Drain Filter	22.4	7.6	1076	1.66E+00
Equipment Drain Demin	141.5	99.7	518	2.53E-01
Floor Drain Filter	22.4	17.04	480	8.12E-03
Floor Drain Demin	141.5	28.5	1812	2.35E-04
Condensate Demin Beds	290	730	1160	2.86E-01
Condensate Precoat Filters	24	See Note 4	145	8.20E+00
RWCU Filter/Demins	5	75	49	3.75E+03
FPCU & CU Filter/Demins	13	30	156	3.39E+01
Total Waste Volume, ft^3/year			5396	

Note 1: Where multiple components exist, the backwash volume and backwash frequency are "per unit" while the annual waste volume represents the waste stream.

Note 2: The expressed specific activity incorporates a 30 day storage period for decay.

Note 3: The volume of solid waste presented above reflects wet, unprocessed waste volume.

Note 4: The backwash frequency for Condensate Precoat Filters is assumed to be 1 backwash every 90 days when these filters are used in the Suppression Pool clean-up mode and two backwashes per year when used in the Condensate System clean-up mode.

TABLE 11.4-2: EXPECTED SOLID RADWASTE CURIE CONTENT AFTER 30 DAYS OF STORAGE

Waste Stream Identification	Waste Volume, in ft3/yr	Specific Activity, in µCi/cc	Total Activity, in Ci/yr	Notes
Flood Drain Filter Solids	480	8.12E-03	0.11	1
Equipment Drain Filter Solids	1076	1.66E+00	50.5	1
Spent Resin Tank	2330	5.64E-02	3.72	1,2
RWCU Phase Separator Tank	205	9.21E+02	5346	1,3
Condensate Demineralizer	1160	2.86E-01	9.39	1
Condensate Precoat Filters	145	8.20E+00	33.8	1,4

Note 1: Specific and Total activity decay corrected for 30 days of storage.

Note 2: Mixture of Floor Drain and Equipment Drain demineralizer resins.

Note 3: Mixture of RWCU and FPC&CU filter/demineralizer resins.

Note 4: Mixture of Condensate Precoat filter/demineralizer resins from Suppression Pool and Condensate System usage.

TABLE 11.4-3A: EXPECTED ISOTOPIC COMPOSITION OF SOLID RADWATE (IN µCI/cc)

Isotope	Floor Drain Filter Solids	Equipment Drain Filter Solids	Spent Resin Tank	RWCU Phase Separator Tank	Condensate Demineralizer	Condensate Precoat Filters
	(Note 1)	(Note 1)	(Note 1, 2)	(Note 1, 3)	(Note 1, 4)	(Note 1, 5)
F-18	N	N	N	N	N	N
Na-24	N	N	N	N	N	N
P-32	3.43E-06	7.87E-04	8.98E-06	1.68E-01	2.24E-05	2.56E-03
Cr-51	2.08E-04	4.35E-02	8.16E-04	1.56E+01	2.21E-03	1.81E-01
Mn-54	3.96E-05	7.46E-03	3.12E-04	6.62E+00	3.08E-03	4.68E-02
Mn-56	N	N	N	N	N	N
Fe-59	4.83E-05	9.66E-03	2.44E-04	4.78E+00	7.75E-04	4.66E-02
Co-58	3.72E-03	7.27E-01	2.23E-02	4.50E+02	8.92E-02	3.87E+00
Co-60	5.32E-04	9.97E-02	4.53E-03	9.80E+01	7.37E-02	6.54E-01
Zn-65	1.94E-06	3.66E-04	1.49E-05	3.16E-01	1.32E-04	2.27E-03
Zn-69M	N	N	N	N	N	N
Ni-65	N	N	N	N	N	N
Br-83	N	N	N	N	N	N
Br-84	N	N	N	N	N	N
Br-85	N	N	N	N	N	N
Sr-89	1.50E-03	2.98E-01	8.08E-03	1.60E+02	2.75E-02	1.49E+00
Sr-90	1.83E-04	3.41E-02	1.58E-03	3.42E+01	2.81E-02	2.26E-01
Sr-91	N	N	N	N	N	N
Sr-92	N	N	N	N	N	N
Zr-95	2.16E-05	4.23E-03	1.26E-04	2.52E+00	4.78E-04	2.22E-02

TABLE 11.4-3A: EXPECTED ISOTOPIC COMPOSITION OF SOLID RADWATE (IN µCI/cc) (Continued)

Isotope	Floor Drain Filter Solids	Equipment Drain Filter Solids	Spent Resin Tank	RWCU Phase Separator Tank	Condensate Demineralizer	Condensate Precoat Filters
Nb-95	1.57E-05	3.20E-03	6.98E-05	1.35E+00	2.01E-04	1.44E-02
Zr-97	N	N	N	N	N	N
Mo-99	2.43E-06	8.76E-04	3.67E-06	6.93E-02	9.04E-06	1.44E-03
Tc-99m	N	N	N	N	N	N
Tc-101	N	N	N	N	N	N
Ru-103	8.28E-06	1.68E-03	3.92E-05	7.63E-01	1.18E-04	7.78E-03
Ru-106	1.91E-06	3.59E-04	1.53E-05	3.26E-01	1.66E-04	2.28E-03
Ag-110M	5.84E-05	1.10E-02	4.52E-04	9.57E+00	4.07E-03	6.84E-02
Te-129M	1.29E-04	2.64E-02	5.67E-04	1.09E+01	1.62E-03	1.18E-01
Te-132	5.16E-06	1.78E-03	7.88E-06	1.49E-01	1.94E-05	3.09E-03
I-131	4.70E-04	1.23E-01	9.08E-04	1.71E+01	2.24E-03	3.13E-01
I-132	N	N	N	N	N	N
I-133	N	N	N	N	N	N
I-134	N	N	N	N	N	N
I-135	N	N	N	N	N	N
Cs-134	6.95E-05	1.30E-02	5.20E-03	2.24E+01	1.44E-02	1.52E-01
	(Note 1)	(Note 1)	(Note 1, 2)	(Note 1, 3)	(Note 1, 4)	(Note 1, 5)
Cs-136	7.05E-06	1.63E-03	1.62E-04	6.06E-01	8.05E-05	9.37E-03
Cs-137	1.08E-04	2.01E-02	8.38E-03	3.62E+01	2.98E-02	2.40E-01
Cs-138	N	N	N	N	N	N
Ba-139	N	N	N	N	N	N
Ba-140	9.33E-04	2.19E-01	2.28E-03	4.28E+01	5.68E-03	6.79E-01
Ba-141	N	N	N	N	N	N

TABLE 11.4-3A: EXPECTED ISOTOPIC COMPOSITION OF SOLID RADWATE (IN µCI/cc) (Continued)

Isotope	Floor Drain Filter Solids	Equipment Drain Filter Solids	Spent Resin Tank	RWCU Phase Separator Tank	Condensate Demineralizer	Condensate Precoat Filters
Ba-142	N	N	N	N	N	N
Ce-141	1.43E-05	2.95E-03	6.15E-05	1.18E+00	1.73E-04	1.29E-02
Ce-143	N	N	N	N	N	N
Ce-144	2.55E-05	4.84E-03	2.00E-04	4.25E+00	1.91E-03	3.01E-02
Pr-143	4.54E-06	1.05E-03	1.15E-05	2.15E-01	2.86E-05	3.34E-03
Nd-147	1.11E-06	2.69E-04	2.51E-06	4.71E-02	6.21E-06	7.85E-04
W-187	N	N	N	N	N	N
Np-239	5.81E-06	2.19E-03	8.66E-06	1.64E-01	2.15E-05	3.43E-03
TOTAL	8.12E-03	1.66E+00	5.64E-02	9.21E+02	2.86E-01	8.20E+00

Note 1: The above data reflects specific activity decay corrected for 30 days of storage in the various waste tanks. "N" denotes those isotopic activities that are negligible due to decay during the storage period.

Note 2: The above data reflects a composite mixture of exhausted Floor Drain and Equipment Drain demineralizer resins.

Note 3: The above data reflects a composite mixture of exhausted RWCU and FPC&CU filter/demineralizer resins.

Note 4: The above data reflects estimated specific activity after a two year service life (with no regeneration or cleaning).

Note 5: The above data reflects a composite mixture of exhausted Condensate Precoat filter/demineralizer resins from Suppression Pool and Condensate System usage.

TABLE 11.4-3B: DELETED

TABLE 11.4-4: DESCRIPTION OF SOLID RADWASTE SYSTEM COMPONENTS

Tanks	Equipment Numbers	Quantity	Capacity (ft^3 ea.)	Design Pressure	Design Temp. (F)	Material
Waste holding tanks	A001A,B,C	3	100	Atm	150	Stainless steel

Pumps	Equipment Numbers	Quantity	Type	Discharge Pressure (psig)	Capacity (gpm, ea)	Material
Waste transfer pumps	C005A-N,B-N,C-N	3	Horiz. Cont.	39	50	Stainless steel
Dewatering pumps	C003A-N,B-N,C-N	3	Horiz. cent.	23	10	Stainless steel

Mixer Units	Equipment Numbers	Quantity	Type	Discharge Pressure (psig)	Capacity (gpm, ea)	Material
Static mixer unit(1)	D009A,B	2	Radial	0-2	9.7 max.	Stainless steel

TABLE 11.4-4: DESCRIPTION OF SOLID RADWASTE SYSTEM COMPONENTS (CONTINUED)

Electric Transfer Cart(1)

Equipment Number	D003A-N, B-N
Material	Stainless steel and carbon steel
Quantity	2
Type	Electric, with direct drive
Travel, ft.	26
Capacity, tons	7-1/2
Container diameter, ft. (max)	4
Velocity, fpm (max)	15

Fill Ports(1)

Equipment Number	D006A,B
Material	Stainless steel and carbon steel
Quantity	2
Type	Retractable with leaktight connection Remote positioning, attachment, and removal

Shipping Containers

Equipment Number	NA
Material	Steel, polyethylene, or other materials approved by DOT and burial site

TABLE 11.4-4: DESCRIPTION OF SOLID RADWASTE SYSTEM COMPONENTS (CONTINUED)

Quantity	As required
Type	Various
Capacity	Various

Swipe Test Sample Retrieval[1]

Equipment Number	D010A,B
Material	Stainless steel, carbon steel, and brass
Quantity	2
Type	Remote-manual manipulator

Drum Capper[1]

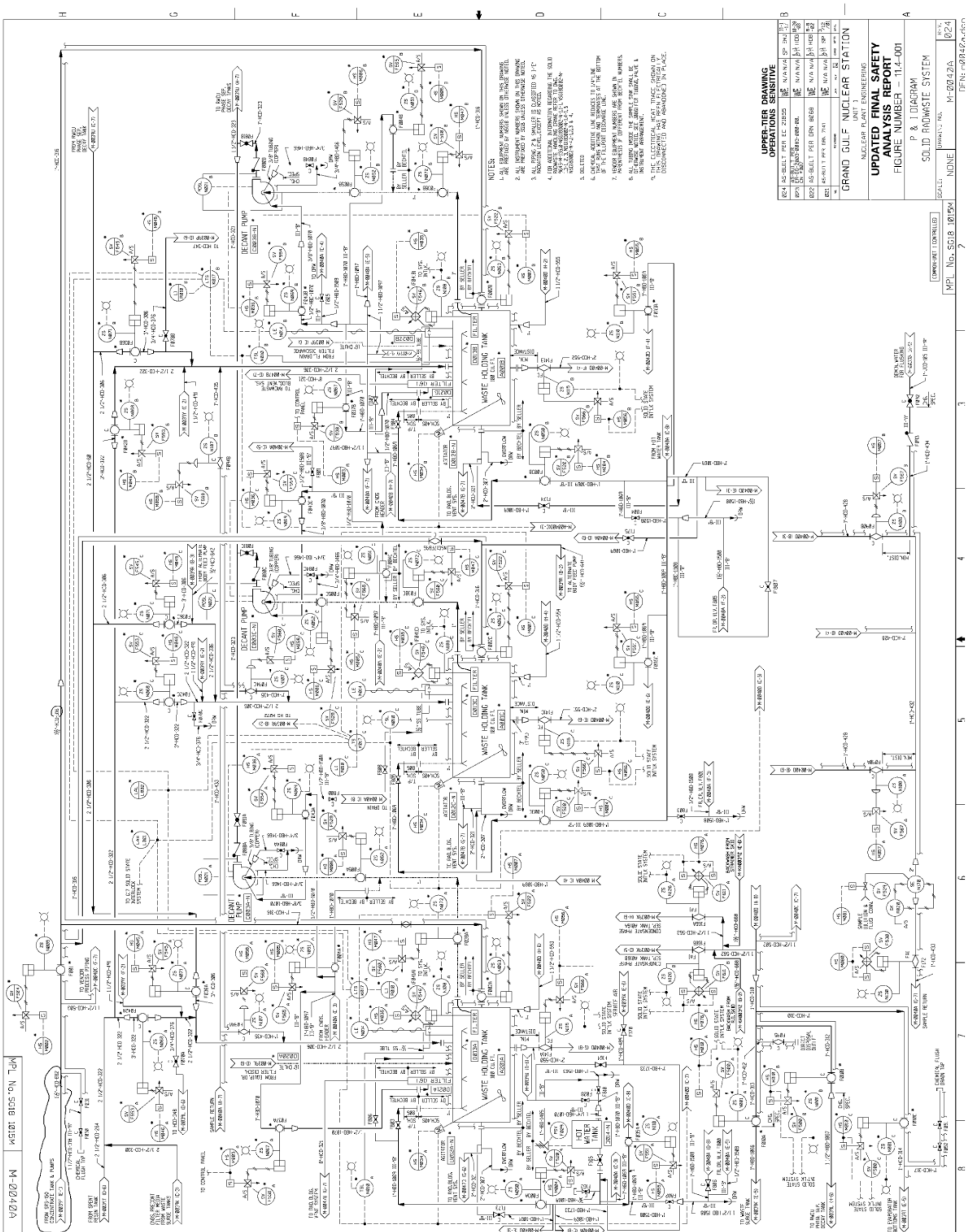
Equipment Number	D011A,B
Material	Carbon steel
Quantity	2
Type	Remote control; air operated

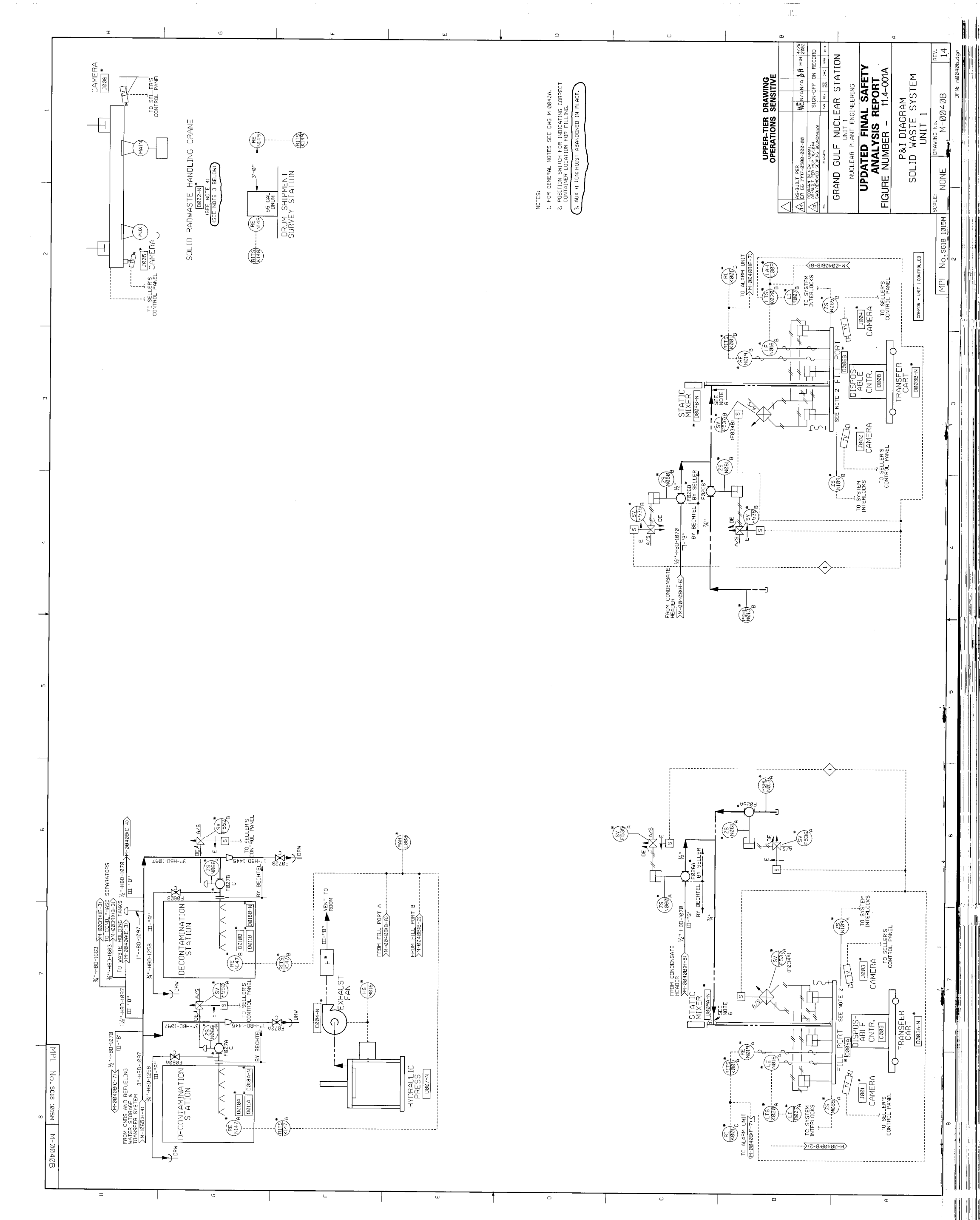
TABLE 11.4-4: DESCRIPTION OF SOLID RADWASTE SYSTEM COMPONENTS (CONTINUED)

Miscellaneous	**Equipment Numbers**	**Materials**	**Quantity**	**Type**
Waste holding tank agitator	D012A,B,C	Stainless steel	3	Electric
Waste holding tank decant filter	D012A,B,C	Stainless steel	3	Floating
Hot water heater[1] (100 gallon)	D014-N	Steel and fiberglass	1	Electric

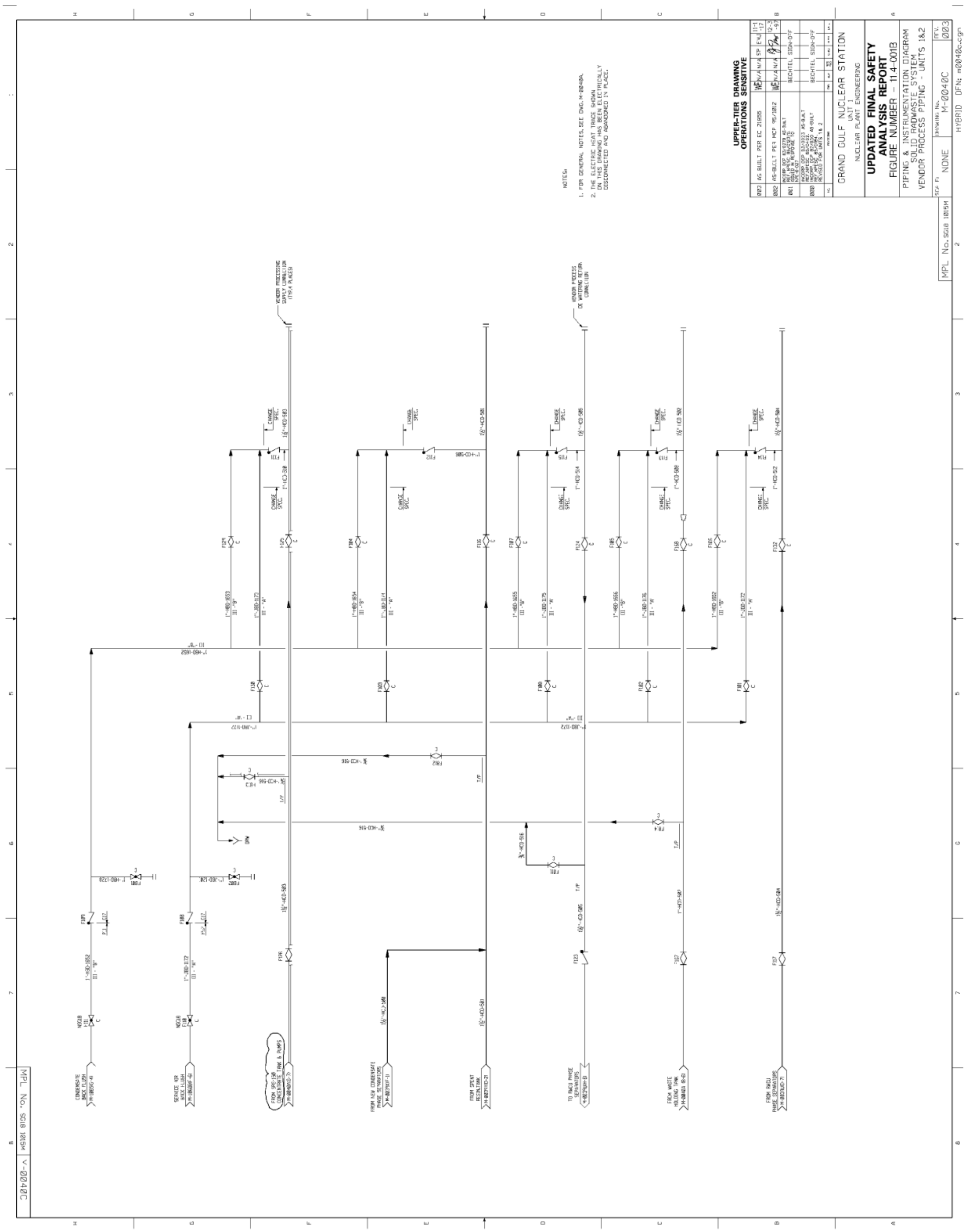
Note:

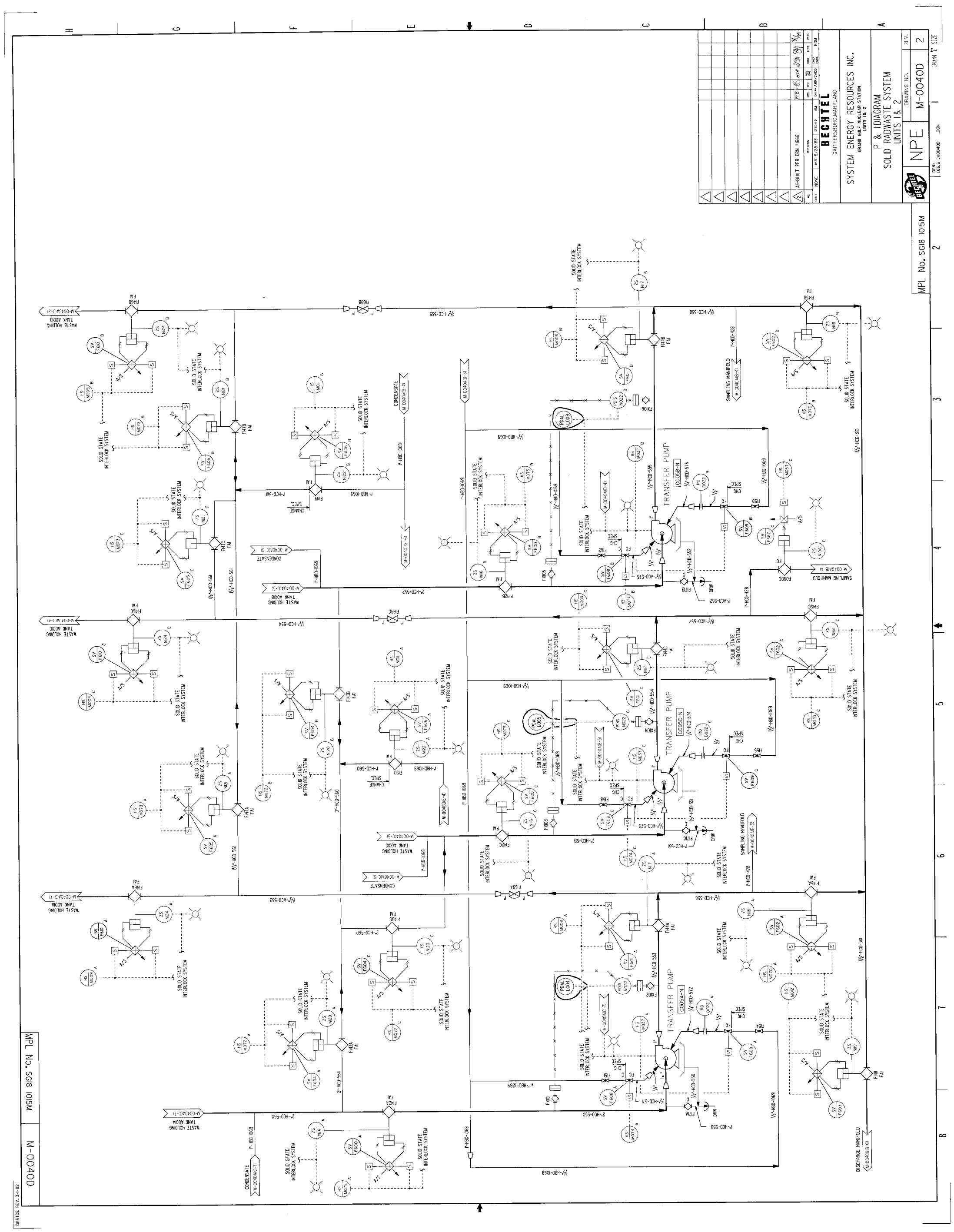
[1] Equipment is inoperative and has been abandoned in place.

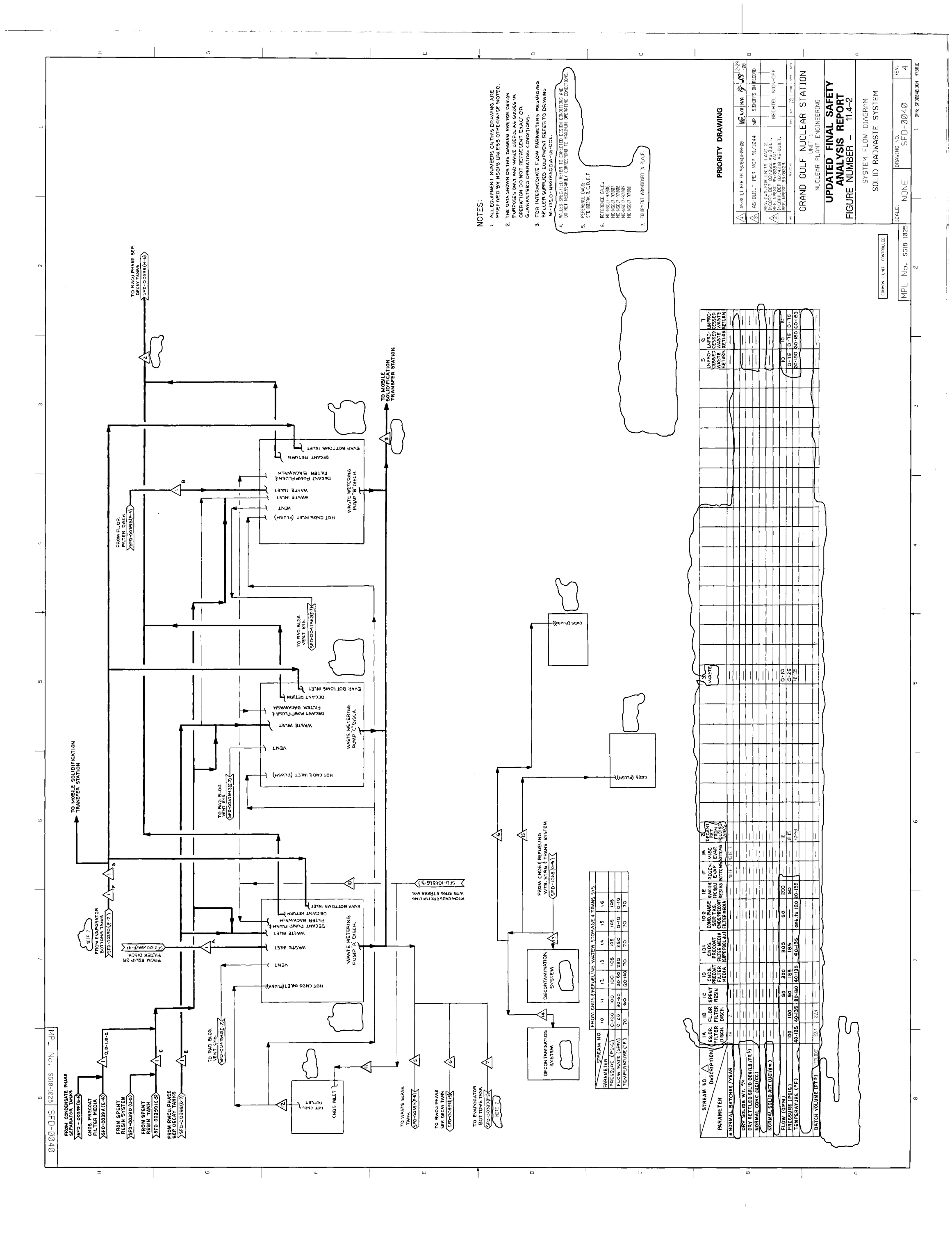

GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.4-001
P & I DIAGRAM
SOLID RADWASTE SYSTEM
M-0042A



UPPER-TIER DRAWING OPERATIONS SENSITIVE
GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.4-001A
P&I DIAGRAM
SOLID WASTE SYSTEM
UNIT 1
M-0040B
DECONTAMINATION STATION
HYDRAULIC PRESS
EXHAUST FAN
STATIC MIXER
TRANSFER CART
DRUM SHIPMENT SURVEY STATION
SOLID RADWASTE HANDLING CRANE


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.4-001B
PIPING & INSTRUMENTATION DIAGRAM
SOLID RADWASTE SYSTEM
VENDOR PROCESS PIPING - UNITS 1&2
M-0040C
UPPER-TIER DRAWING
OPERATIONS SENSITIVE


BECHTEL
SYSTEM ENERGY RESOURCES INC.
P & I DIAGRAM
SOLID RADWASTE SYSTEM
UNITS 1 & 2
NPE
M-0040D
TRANSFER PUMP
SOLID STATE INTERLOCK SYSTEM
WASTE HOLDING TANK A00A
WASTE HOLDING TANK A00B
WASTE HOLDING TANK A00C
WASTE HOLDING TANK A00D
CONDENSATE
SAMPLING MANIFOLD
MPL No. SG18 1015M


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.4-2
SYSTEM FLOW DIAGRAM
SOLID RADWASTE SYSTEM
PRIORITY DRAWING
SFD-0040

11.5 PROCESS AND EFFLUENT RADIOLOGICAL MONITORING AND SAMPLING SYSTEMS

The process and effluent radiological monitoring and sampling systems are provided to allow determination of the content of radioactive material in various gaseous and liquid process and effluent streams. The design objective and criteria are primarily determined by the system designation of either:

a. Instrumentation systems required for safety, or

b. Instrumentation systems required for plant operation.

11.5.1 Design Bases

11.5.1.1 Design Objectives

11.5.1.1.1 Systems Required for Safety

The main objective of radiation monitoring systems required for safety is to initiate appropriate protective action to limit the potential release of radioactive materials from the reactor vessel and primary and secondary containment if predetermined radiation levels are exceeded in major process/effluent streams. Additional objectives are to have these systems available under all operating conditions including accidents and to provide control room personnel with an indication of the radiation levels in the major process/effluent streams plus alarm annunciation if high radiation levels are detected.

The radiation monitoring systems (RMS) provided to meet these objectives are:

a. Main Steam Line RMS

b. Containment and Drywell Ventilation Exhaust PMS

c. Auxiliary Building Fuel Handling Area Ventilation Exhaust RMS

d. Auxiliary Building Fuel Handling Area Pool Sweep Exhaust RMS

11.5.1.1.2 Systems Required for Plant Operation

The main objective of radiation monitoring systems required for plant operation is to provide operating personnel with measurement of the content of radioactive material in all effluent and important process streams. This allows demonstration of compliance with plant normal operational Offsite Dose Calculation Manual/TRM specifications by providing gross radiation level monitoring and collection of halogens and particulates on filters (gaseous effluents) as required by Regulatory Guide 1.21. Additional objectives are to initiate discharge valve isolation on the offgas or liquid radwaste systems if predetermined release rates are exceeded and to provide for sampling at certain radiation monitor locations to allow determination of specific radionuclide content.

The radiation monitoring systems provided to meet these objectives are:

a. For gaseous effluent streams

   1. Containment Ventilation RMS

   2. Offgas and Radwaste Building Ventilation RMS

   3. Fuel Handling Area Ventilation RMS

   4. Turbine Building Ventilation RMS

   5. Standby Gas Treatment Exhaust Ventilation RMS

b. For liquid effluent streams

   1. Radwaste Effluent RMS

c. For gaseous process streams

   1. Offgas Pretreatment RMS

   2. Offgas Post-treatment RMS

   3. Carbon Bed Vault RMS

d. For liquid process streams

   1. Standby Service Water System RMS (Loops A and B)

2. Component Cooling Water RMS

3. Plant Service Water RMS (ADHRS effluent)

11.5.1.2 Design Criteria

11.5.1.2.1 Systems Required for Safety

The design criteria for the safety-related radioactivity monitoring systems are that the systems:

a. Withstand the effect of natural phenomena (e.g., earthquakes) without loss of capability to perform their functions.

b. Perform their intended safety function in the environment resulting from normal and postulated accident conditions.

c. Meet the reliability, testability, independence and failure mode requirements of engineered safety features.

d. Provide continuous outputs on control room panels.

e. Permit checking of the operational availability of each channel during reactor operation with provision for calibration function and instrument checks.

f. Assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.

g. Initiate prompt protective action prior to exceeding plant limits.

h. Provide warning of increasing radiation levels indicative of abnormal conditions by alarm annunciation.

i. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and channel trip.

j. Register full scale output if radiation detection exceeds full scale.

k. Have sensitivities and ranges compatible with anticipated radiation levels.

The applicable General Design Criteria of 10 CFR 50 Appendix A are 63 and 64. The systems meet the design requirements for Safety Class 2, Seismic Category I systems, along with the quality assurance requirements of 10 CFR 50, Appendix B.

11.5.1.2.2 Systems Required for Plant Operation

The design criteria for operational radiation monitoring systems are that the systems:

a. Provide continuous indication of radiation levels in the control room.

b. Provide warning of increasing radiation levels indicative of abnormal conditions by alarm annunciation.

c. Insofar as practical, provide self-monitoring of components to the extent that power failure or component malfunction causes annunciation and, for systems initiating discharge isolation, channel trip.

d. Monitor a sample representative of the bulk stream or volume. A description of provisions made to ensure that representative samples are made is contained in subsection 9.3.2.2.3.

e. Have provisions for calibration, function and instrumentation checks.

f. Have sensitivities and ranges compatible with anticipated radiation levels and ODCM/TRM limits.

g. Register full scale output if radiation detection exceeds full scale.

The RMS monitoring discharges from the gaseous and liquid radwaste treatment systems have provisions to alarm and to initiate automatic closure of the waste discharge valve on the affected treatment system prior to exceeding the normal operation limits specified in the ODCM/TRM, as required by Regulatory Guide 1.21.

The applicable General Design Criteria of 10 CFR 50, Appendix A are 60, 63, and 64.

11.5.2 System Description

11.5.2.1 Systems Required for Safety

Information on these systems is presented in Table 11.5-1 and the arrangements shown in Figure 7.6-1.

11.5.2.1.1 Main Steam Line Radiation Monitoring System

This system monitors the gamma radiation level exterior to the main steam lines. The normal radiation level is produced primarily by coolant activation gases plus smaller quantities of fission gases being transported with the steam. In the event of a gross release of fission products from the core, this monitoring system provides channel trip signals to the Rx water sample line drywell isolation valves and to the mechanical vacuum pump and valves to initiate protective action.

The system consists of four redundant instrument channels. Each channel consists of a local detector (gamma-sensitive ion chamber) and a control room radiation monitor with an auxiliary trip unit. Power for two channels (A and C) is supplied from ESF UPS bus division 1 and 3 and for the other two channels (B and D) from ESF UPS bus division 2 and 4. Channels A and C are physically and electrically independent of channels B and D.

The detectors are physically located near the main steam lines just downstream of the outboard main steam line isolation valves in the space between the containment and auxiliary building walls.

The detectors are geometrically arranged so that this system is capable of detecting significant increases in radiation level with any number of main steam lines in operation. Table 11.5-1 lists the range of the detectors.

Each radiation monitor has four trip circuits: two upscale (high-high and high), one downscale (low), and one inoperative. Each trip is visually displayed on the affected radiation monitor. A high-high or inoperative trip in the radiation monitor results in a channel trip in the auxiliary unit which is an input to the reactor protection system (RPS). These trip inputs result in initiation of mechanical vacuum pump shutdown, discharge valve closure and reactor water sample valve closure. A high trip actuates a MSL high radiation control room annunciator. A downscale trip actuates a MSL downscale control room annunciator

common to all channels. High and low trips do not result in a channel trip. Each radiation monitor visually displays the measured radiation level.

11.5.2.1.2 Containment and Drywell Ventilation Exhaust Radiation Monitoring System

This system monitors the radiation level exterior to the containment ventilation system exhaust duct. A high activity level in the ductwork could be due to fission gases from a leak or an accident.

The system consists of four redundant instrument channels. Each channel consists of a local detection assembly (a sensor and converter unit containing a GM tube and electronics) and a control room radiation monitor. Power for two channels (A and C) is supplied from ESF UPS bus division 1 and 3 and for the other two channels (B and D) from ESF UPS bus division 2 and 4. Channels A and C are physically and electrically independent of channels B and D. One recorder powered from the 125 V dc bus A allows the output of all channels to be recorded. The detection assemblies are physically located outside and adjacent to the exhaust ducting upstream of the containment discharge isolation valves.

Each radiation monitor provides both an analog output signal and contact which opens on upscale (high-high) radiation or an inoperative circuit. Two-out-of-two upscale/inoperative trips in channels A and C initiate closure of the containment ventilation outboard isolation valves and the drywell inboard isolation valves. The same condition for channels B and D initiates closure of the containment inboard valves and drywell outboard valves.

An upscale/inoperative trip is visually displayed on the affected radiation monitor and actuates a containment and drywell ventilation exhaust high-high radiation control room annunciator. A downscale trip is also visually displayed on the radiation monitor. Containment and drywell vent high radiation and downscale control room annunciators common to all channels are generated from the analog signal. Each radiation monitor visually displays the measured radiation level.

11.5.2.1.3 Auxiliary Building Fuel Handling Area Ventilation Exhaust Radiation Monitoring System

This system monitors the radiation level exterior to the auxiliary building fuel handling area ventilation exhaust duct. The system consists of four channels identical to the channels in the containment and drywell ventilation radiation monitoring system with the same arrangement and power sources, corresponding annunciators, and recorder.

Two-out-of-two upscale (high-high)/inoperative trips in channels A and C initiate closure of the inboard isolation valves of the auxiliary building and fuel handling area ventilation systems, and initiate startup of standby gas treatment system (SGTS) train A. The same condition for channels B and D initiates closure of the corresponding outboard isolation valves and initiates startup of SGTS train B.

11.5.2.1.4 Auxiliary Building Fuel Handling Area Pool Sweep Exhaust Radiation Monitoring System

This system monitors the radiation level exterior to the pool sweep exhaust duct. See Table 9.3-3 for liquid sampling provisions of the fuel pool cooling and cleanup system. The system is identical to the auxiliary building fuel handling area ventilation exhaust radiation monitoring system with the same channel trip logic and protective action initiation. The recorder is powered from 125 V dc bus B.

11.5.2.2 Systems Required for Plant Operation

Information on these systems is presented in Table 11.5-1 and the arrangements are shown in Figure 7.6-1.

11.5.2.2.1 Offgas Pretreatment Radiation Monitoring System

This system monitors radioactivity in the condenser offgas at the inlet to the holdup piping after it has passed through the offgas condenser and moisture separator. The monitor detects the radiation level which is attributable to the fission gases produced in the reactor and transported with steam through the turbine to the condenser.

A continuous sample is extracted from the offgas pipe via a sample line. It is then passed through a sample chamber and a sample panel before being returned to the suction side of the SJAE. The

sample chamber is a steel pipe which is internally polished to minimize plateout. It can be purged with room air to check detector response to background radiation by using a three-way solenoid operated valve. The valve is controlled by a switch located in the control room. The sample panel measures and indicates sample line flow. A sensor and converter (GM tube) is positioned adjacent to the vertical sample chamber and is connected to a radiation monitor in the control room. See Figure 11.5-1 for the system arrangement.

Power is supplied from channel A of the containment and drywell ventilation exhaust monitoring system for the radiation monitor and detector from the 120 V ac instrument bus for a recorder, and from a 120 V ac local bus for the sample and vial sampler panels.

The radiation monitor has three trip circuits: two upscale (high-high and high) and one downscale (low).

The trip outputs are used for alarm function only. Each trip is visually displayed on the radiation monitor and actuates a control room annunciator: offgas high-high, offgas high, and offgas downscale. High or low sample line flow measured at the sample panel actuates a control room offgas sample high-low flow annunciator.

The radiation level output by the monitor can be directly correlated to the concentration of the noble gases by using the semiautomatic vial sampler panel to obtain a grab sample. To draw a sample, a serum bottle is inserted into a sample chamber, the sample lines are evacuated and a solenoid-operated sample valve is opened to allow offgas to enter the bottle. The bottle is then removed and the sample is analyzed in the counting room with a multichannel gamma pulse height analyzer to determine the concentration of the various noble gas radionuclides. A correlation between the observed activity and the monitor reading permits calibration of the monitor.

11.5.2.2.2 Offgas Post Treatment Radiation Monitor

This system monitors radioactivity in the offgas piping downstream of the offgas system charcoal absorbers and upstream of the offgas system discharge valve. A continuous sample is extracted from the offgas system piping, passed through the offgas post-treatment sample panel for monitoring and sampling, and returned to the offgas system piping. The sample panel has a pair of filters (one for particulate collection and one for

halogen collection) in parallel (with respect to flow) with two identical continuous gross radiation detection assemblies. Each gross radiation assembly consists of a shielded chamber, a set of GM tubes, and a check source. Two radiation monitors in the control room analyze and visually display the measured gross radiation level.

The sample panel shielded chambers can be purged with room air to check detector response to background radiation by using a solenoid valve arrangement operated from the control room. The sample panel measures and indicates sample line flow. A solenoid operated check source for each detection assembly operated from the control room can be used to check operability of the gross radiation channel. See Figure 11.5-1 for the system arrangement.

Power is supplied from 125 V dc bus D for one radiation monitor, from 125 V dc bus E for the other radiation monitor, from the 120 V ac instrument bus for a common recorder, and from a 120 V ac local bus for the sample panel.

Each radiation monitor has three trip circuits: two upscale (high-high-high, and high) and one downscale (low). Each trip is visually displayed on the radiation monitor. These three trips actuate corresponding control room annunciators: offgas post treatment high-high-high radiation, offgas post treatment high radiation, and offgas post treatment downscale. A trip circuit on the recorder actuates an offgas post treatment high-high radiation annunciator. High or low sample flow measured at the sample panel actuates a control room offgas vent pipe sample high-low flow annunciator.

A trip auxiliary unit in the control room takes the high-high-high (HHH) and downscale trip outputs and, if its logic is satisfied, initiates closure of the offgas system discharge and drain valves. The logic is satisfied if two HHH, one HHH and one downscale, or two downscale trips occur. Any one high upscale trip initiates closure of offgas system bypass line valve and initiates opening of the treatment line valve.

A vial sampler panel similar to the pretreatment sampler panel is provided for grab sample collection to allow isotopic analysis and gross monitor calibration.

11.5.2.2.3 Carbon Bed Vault Radiation Monitoring System

The carbon vault is monitored for gross gamma radiation level with a single instrument channel. The channel includes a sensor and converter, an indicator and trip unit and a locally mounted auxiliary unit. The indicator and trip unit is located in the control room. The channel provides for sensing and readout, both local and remote, of gamma radiation over a range of six logarithmic decades (1 to 10 mR/hr).

The indicator and trip unit has one adjustable upscale trip circuit for alarm and one downscale trip circuit for instrument trouble. The trip circuits are capable of convenient operational verification by means of test signals or through the use of portable gamma sources. Power is supplied from channel A of the containment and drywell ventilation exhaust radiation monitoring system.

11.5.2.2.4 Containment Ventilation Radioactivity Monitoring System

The containment ventilation radioactivity monitoring system consists of a microprocessor-based system, utilizing a single flow monitoring and isokinetic sampling (FM&IS) unit located in the exhaust duct. In addition to the microprocessor based system, a GE radiation monitoring system utilizing a sample probe directly downstream of the FM&IS sample probes provides redundant radiation monitoring capabilities.

When the Containment Ventilation system is operated in the Low Volume Purge mode, the Containment Ventilation Exhaust Fans flow meter is used to monitor containment vent discharge flow.

11.5.2.2.4.1 Containment Ventilation Microprocessor-Based Radiation Monitoring System

This system monitors the containment ventilation discharge for noble gases, iodines, and particulates, and collects halogen and particulate samples. A representative sample is continuously extracted from the ventilation ducting through the FM&IS unit in accordance with ANSI N13.1-1969, passed through the containment ventilation sample panel for monitoring and sampling, and returned to the ventilation ducting.

The effluent radioactivity monitoring system consists of the FM&IS unit located in the exhaust duct, an isokinetic sample panel, a redundant stack flow monitoring panel, a microprocessor-based normal range radioactivity monitor, a particulate-iodine sample filter, a microprocessor-based accident range radioactivity monitor, a data acquisition module (DAM), and interface to Plant Data System (PDS) computer with report generating capability in the control room and Technical Support Center. During normal plant operation, the effluent sample is continuously delivered to the microprocessor-based normal range radioactivity monitor for particulate, iodine, and noble gas analysis. Should the radioactivity level exceed the normal range monitor's capacity (i.e., post-accident), a dedicated sample probe for the accident range monitor will provide monitoring of the gaseous effluent at the higher ranges. The operating ranges of the monitors overlap sufficiently to permit continuity of measurement upon changing from the normal to the accident range monitor. Should the radioactivity level return to normal (after the accident is over), the normal range monitor can be manually reset via access controlled PDS terminal to resume the radioactivity monitoring function.

The FM&IS unit consists of a velocity sensing (flow monitoring) section consisting of an array of total and static pressure sensors symmetrically connected to an averaging manifold to provide for the instantaneous and continuous monitoring of the stack flow rate. A minimum of one velocity sensor is provided for each half square foot of duct cross-sectional area.

The FM&IS unit also consists of a multi-probe isokinetic sampling section consisting of an array of sampling nozzles connected to a collection manifold for extracting a highly representative sample of the stack air from the airstream. The sampling nozzles are capable of simultaneously extracting an equal volume of stack gas and are located such that a minimum of one nozzle exists for each square foot of duct cross-sectional area. A redundant stack flow monitoring panel is provided in parallel with the isokinetic sample panel. Its function is to measure stack flow from the FM&IS unit to the isokinetic sample panel and provide a signal to the data acquisition module (DAM). This information is made available to the operator through the PDS Computer and serves as a backup to the sample flow signal from the isokinetic sample panel to the normal range monitor.

A redundant radioactivity monitoring system consisting of the GE constant volume radioactivity monitoring system is used to constantly monitor airborne radioactivity. This extends the overall system capabilities by providing additional indication of airborne radioactivity, or in the event of FM&IS unit failure, the redundant capability to monitor radioactivity. In the event of both FM&IS failure and failure of the GE radiation monitor, provisions have been made to obtain grab samples for laboratory analysis. See subsection 11.5.2.2.4.2 for a discussion of the GE system.

The radioactivity detection assembly for the normal range monitor consists of a shielded chamber, a sample filter of activated charcoal for iodine collection, a sodium iodide crystal gamma scintillation detector capable of monitoring the iodine 364 keV gamma peak with approximately 4 percent (4) efficiency, a sample filter of 0.009-inch-thick filter paper for particulate collection, a plastic beta scintillation detector to monitor the particulate Cs-137 beta particles with approximately 11 percent (4) efficiency, a beta scintillation detector and a GM tube to monitor gross radioactivity (i.e., noble gas activity) with an accuracy of approximately 15 percent of logarithmic scale down to 40 keV, and a check source mechanism.

The normal range monitor is also provided with a purge assembly which can be manually initiated from the data acquisition module or any access controlled PDS Computer terminal. In addition, upon receipt of a high radioactivity isolation signal, the normal range monitor will automatically isolate and the purge will automatically be initiated to purge the normal range monitor. The purge air is then exhausted back to the containment ventilation system exhaust duct.

The accident range monitor flow path is provided with a particulate-iodine sample filter assembly. The sample filter, constructed of silver zeolite, has a collection efficiency greater than 90 percent for 0.3-micron-diameter particles and for iodines. A bypass line is provided around the sample filter to permit filtered flow to continue to the high range monitor through the bulk filter. See Figure 11.5-2 for the system arrangement drawing. Sample filter removal is provided by means of quick disconnects. The sample filter is housed in a lead shield, mounted for ease of removal and replacement of filter media and capable of

being transported to the on-site analysis facility during normal and accident conditions without the operator receiving doses in excess of those specified in 10 CFR Part 20.

The radioactivity detection assembly for the accident range monitor consists of a shielded chamber, a GM tube to monitor gross radioactivity (i.e., noble gases) with an accuracy of approximately 15 percent of logarithmic scale down to 40 keV, and a check source mechanism.

The accident range monitor, particulate-iodine sample filter, and bulk filter are also provided with a purge assembly which can be manually initiated from the data acquisition module or any access controlled PDS Computer terminal after the accident range monitor, particulate-iodine sample filter, and bulk filter are isolated from the sample to permit purge air to flush the above equipment. The purge air is then exhausted back to the containment ventilation system exhaust duct.

In the event of failure of the accident range noble gas effluent monitoring system, there are provisions for alternate monitoring. The associated General Electric or Eberline micro-processor based normal range monitors are the pre-planned alternate method of monitoring, provided they are operable and on scale. If these monitors are inoperable, provisions have been made for collection of grab samples for laboratory analysis.

Area monitors are provided for the normal and accident range monitors and for the sample filter assembly to compensate for final and variable background radioactivity.

The data acquisition module (DAM) contains a microcomputer which performs background subtraction, applies conversion factors, and retains the data from each detector channel in history files consisting of the last 4 hours of 10-minute averages, the last 24 hours of 1-hour averages, and the last 24 days of 1-day averages. The DAM also receives a stack flow signal from the redundant stack flow monitoring panel. Each DAM is ac operated with 8 hours of battery backup. Bidirectional communication is provided between the DAM and the PDS Computer. Provisions exist to access each local DAM with a portable control terminal to conduct calibration and service functions at the DAM location. Each DAM, with its detectors, is optically isolated from the rest of the system. Failure of a DAM or its detector(s) will have no effect on any other portion of the system. Each DAM communicates with the PDS

Computer via communication interfaces. Because the local DAM is completely self-supporting for the performance of the tasks, even complete loss of PDS communication does not result in any loss of data accumulation or storage in the DAM.

The PDS Computer is the operator's interface with the rest of the system. The operator can perform routine operating functions, as well as changes to calibration parameters, alarm set points, and system status annunciator. The PDS Computer performs the functions of polling each local processor for operational status and data, logging any changes in status and associated data, logging history files automatically or upon manual request, performing calculations on data in the history files, and annunciating status conditions and communication error messages.

Changes in operating conditions are displayed within seconds of the occurrence. Data are presented only if the data are significant. History can be displayed in an interpretable, orderly manner, ensuring ease of operation. With a few manual entries any data, status, or parameters are presented. An interface is provided to connect the radioactivity monitoring system to a separate computer capable of determining off-site releases during both accident and recovery conditions.

The radioactivity monitors are provided with check source mechanisms. Radionuclides for each monitor are chosen which best represent the radioactive isotope of interest. The check source mechanism can be either actuated at the DAM or at any access controlled PDS terminal.

The effluent radiation monitoring system is powered from the same power source that powers the respective ventilation system exhaust fan.

The microprocessor-based radioactivity monitor alarms the annunciators on the DAM and the PDS Computer. A control room annunciator alarms to indicate system trouble.

There are no seismic requirements for the containment ventilation radioactivity monitoring system discussed herein. However ever, the system is designed to withstand local environmental conditions during and after an accident to ensure system operability.

11.5.2.2.4.2 Containment Ventilation GE Radiation Monitoring System

The GE radiation monitoring system receives its sample from sample probes directly downstream of the FM&IS probes.

The GE sample panel is provided with a pair of sample filters (one for particulate collection and one for halogen collection) in parallel (with respect to flow) with a continuous gross radiation detection assembly. The gross radiation detection assembly consists of a shielded chamber, a beta-sensitive GM tube, and a check source. A radiation monitor in the control room analyzes and visually displays the measured gross radiation level. See Figures 7.6-lb and 11.5-2 for the system arrangement drawings.

The sample panel shielded chambers can be purged with room air to check detector response to background radiation by using a three-way solenoid valve operated from the control room. The sample panel measures and indicates sample line flow. A solenoid operated check source operated from the control room can be used to check operability of the gross radiation channel.

Power is supplied from 125 V dc bus A for the radiation monitor and recorder, and from a 120 V ac local bus for the sample panel. The recorder has two inputs, one used by this system and the other used by the offgas and radwaste building ventilation radiation monitoring system.

The radiation monitor has three trip circuits: two upscale (high-high and high) and one downscale (low). Each trip is visually displayed on the radiation monitor. These three trips actuate corresponding control room annunciators: containment ventilation high-high radiation, containment ventilation high radiation, and containment ventilation downscale. High or low sample flow measured at the sample panel actuates a control room containment ventilation sample high-low flow annunciator.

11.5.2.2.5 Liquid Process and Effluent Monitoring Systems

These systems monitor the gamma radiation levels of liquid process and effluent streams. With the exception of the radwaste system effluent, the streams monitored normally contain only background levels of radioactive materials. Increases in radiation level may be indicative of heat exchanger leakage or equipment malfunction.

Radiation monitors are used to detect reactor coolant leakage into cooling water systems supplying the RHR heat exchangers and the RWCU heat exchangers. These monitoring channels are part of the process radiation monitoring system. The process radiation monitoring channels monitor for leakage into each common cooling water header downstream of the RHR heat exchangers and the RWCU nonregenerative heat exchangers. Each channel will alarm on high radiation conditions indicating process leakage into the cooling water. Set points of monitors are given in the TRM.

Power is supplied from 125 V dc non-divisional buses for the radiation monitors and recorders, and from a 110 V ac local bus for the sample panels.

Each radiation monitor has three trip circuits: two upscale (high-high and high) and one downscale (low). Each trip is visually displayed on the affected radiation monitor. Each of the trips actuate corresponding control room annunciators: one upscale (high radiation) and one upscale (high-high radiation)/ downscale for the affected liquid monitoring channel. High or low sample flow measured at the sample panel actuates a control room high-low flow annunciator for the affected liquid channel.

For each liquid monitoring location, a continuous sample is extracted from the liquid process pipe, passed through a liquid sample panel which contains a detection assembly for gross radiation monitoring, and returned to the process pipe. The detection assembly consists of a scintillation detector mounted in a shielded sample chamber equipped with a check source. A radiation monitor in the control room analyzes and visually displays the measured gross radiation level.

The sample panel chamber and lines can be drained to allow assessment of background buildup. The panel measures and indicates sample line flow. A solenoid operated check source operated from the control room can be used to check operability of the channel. See Figure 11.5-1 for the system arrangement.

11.5.2.2.5.1 Radwaste Effluent Radiation Monitoring System

This system monitors the radioactivity in the radwaste effluent prior to its discharge. See Figure 11.5-3 for the system arrangement.

Liquid waste can be discharged from several radwaste processed water tanks such as the floor drain sample tanks, equipment drain sample tanks or distillate sample tanks. These tanks contain liquids that have been processed through one or more treatment systems such as evaporation, filtration and ion exchange. Prior to discharge from any tank, the liquid in the appropriate tank is sampled and analyzed in the laboratory. Based upon this analysis, discharge is permitted at a specified release rate and dilution rate.

The downscale and high-high upscale trips on the radwaste effluent radiation monitor are used to initiate closure of the radwaste system discharge valve and actuate a control room annunciator. The high-high upscale trip point is set such that closure is initiated prior to exceeding limits for liquid effluents. The high upscale trip actuates an annunciator in the control room.

11.5.2.2.5.2 Standby Service Water Radiation Monitoring System

This system consists of two channels: one for monitoring downstream of equipment in standby service water system loop A and the other for loop B. If a high radiation level is detected, the affected standby service water line can be manually isolated. See Figure 11.5-1 for the system arrangement. The skids are required to maintain their pressure retaining capabilities before, during and after an SSE in order to maintain the required 30 day SSW basin inventory.

11.5.2.2.5.3 Component Cooling Water Radiation Monitoring System

This system has a single channel for monitoring downstream of equipment in the component cooling water system. See Figure 11.5-1 for the system arrangement.

11.5.2.2.5.4 Plant Service Water Radiation Monitoring System

This system has a single channel for monitoring downstream of ADHRS equipment in the plant service water system. See Figure 11.5.8 for the system arrangement.

11.5.2.2.6 Offgas and Radwaste Building Ventilation Radioactivity Monitoring System

11.5.2.2.6.1 Microprocessor-Based Offgas and Radwaste Building Ventilation Radioactivity Monitoring System

This system monitors the offgas and radwaste building ventilation discharge, including the radwaste storage tank vents, for noble gases, iodines, and particulates and collects halogen and particulate samples. This system is identical to the microprocessor-based containment ventilation radioactivity monitoring system discussed in subsection 11.5.2.2.4.1 with corresponding annunciators. See Figure 11.5-3 for the system arrangement.

11.5.2.2.6.2 GE Offgas and Radwaste Building Ventilation Radiation Monitoring System

This system monitors the offgas and radwaste building ventilation discharge, including radwaste storage tank vents, for gross radiation level and collects halogen and particulate samples. The system is identical to the GE containment ventilation radiation monitoring system with corresponding annunciators. See subsection 11.5.2.2.4.2 for a description of the GE system. See Figures 7.6-lb and 11.5-3 for the system arrangement.

11.5.2.2.7 Fuel Handling Area Ventilation Radioactivity Monitoring System

11.5.2.2.7.1 Microprocessor-Based Fuel Handling Area Ventilation Radioactivity Monitoring System

This system monitors the fuel handling area ventilation discharge, including auxiliary building and fuel pool sweep vents, for noble gases, iodines, and particulates and collects halogen and particulate samples. This system is identical to the microprocessor-based containment radioactivity monitoring system discussed in subsection 11.5.2.2.4.1 with corresponding annunciators. See Figure 11.5-4 for the system arrangement.

11.5.2.2.7.2 GE Fuel Handling Area ventilation Radiation Monitoring System

This system monitors the fuel handling area ventilation radiation monitoring system discharge, including auxiliary building and fuel pool sweep vents, for gross radiation level and collects

halogen and particulate samples. The system is identical to the GE containment ventilation radiation monitoring system with corresponding annunciators.

The fuel handling area ventilation system is powered from a 120V ac local bus for the sample panel and 125 V dc bus B for the GE radiation monitor and recorder. See subsection 11.5.2.2.4.2 for a description of the system. See Figures 7.6-1c and 11.5-4 for the system arrangement.

11.5.2.2.8 Turbine Building Ventilation Radioactivity Monitoring System

11.5.2.2.8.1 Microprocessor-Based Turbine Building Ventilation Radioactivity Monitoring System

This system monitors the turbine building ventilation discharge for noble gases, iodines, and particulates and collects halogen and particulate samples. This system is identical to the microprocessor-based containment radioactivity monitoring system discussed in subsection 11.5.2.2.4.1 with corresponding annunciators. See Figure 11.5-5 for the system arrangement.

11.5.2.2.8.2 GE Turbine Building Ventilation Radiation Monitoring System

This system monitors the turbine building ventilation discharge for gross radiation level and collects halogen and particulate samples. The system is identical to the GE containment ventilation radiation monitoring system with corresponding annunciators.

The turbine building ventilation system is powered from a 120V ac local bus for the sample panel and 125 V dc bus B for the GE radiation monitor. A recorder is shared between this system and the fuel handling area ventilation GE radiation monitoring system. See subsection 11.5.2.2.4.2 for a description of the system. See Figures 7.6-1c and 11.5-5 for the system arrangement.

11.5.2.2.8.3 Occasional Turbine Building Release Point Radioactive Monitoring System and Duct

This system consists of a duct with the required flow and radiation monitoring equipment. It is connected to the southeast most smoke hatch on the turbine building.

In modes 1, 2, and 3 the hatch is occasionally opened to vent noble gases or relieve heat conditions on the turbine deck. The radiation monitoring equipment monitors the release and alarms in the control room if equipment malfunctions or release rates are exceeded. The system also has a flow monitor to measure the total release. Release rates are viewable from the control room.

11.5.2.2.8.4 Modes 4 and 5 Turbine Building Hatches Release Point

In modes 4 and 5 up to four Turbine Building Hatches may be opened. The source term will be monitored by the Turbine Building exhaust fan flow rate bypassing the Filter Train. The radionuclide concentrations from the Turbine Building exhaust will be periodically monitored and limited to £ 30% of the ODCM 6.11.4 and 6.11.6 dose limit.

11.5.2.2.9 Standby Gas Treatment A and B Exhaust Ventilation Radioactivity Monitoring System

These systems monitor the standby gas treatment system (SGTS) A and B discharges for noble gases, iodines, and particulates, and collects halogen and particulate samples. (See Figures 11.5-6 and 11.5-7 for the system arrangement). These systems are identical to the containment ventilation microprocessor-based radioactivity monitoring system discussed in subsection 11.5.2.2.4.1 with the following exceptions:

a. The SGTS normally operates during accident conditions; therefore, the SGTS radioactivity monitoring system will operate during accident and recovery conditions. The SGTS A and B exhaust ventilation RMS are powered from a Class lE power supply.

b. Each of the SGTS effluent radioactivity monitoring systems will be manually initiated by the operator. Initiation of the radioactivity monitoring system will automatically start the isokinetic sampling portion of the system with the exception of the vacuum pump which may be started manually or automatically on initiation of SGTS. The SGTS B RMS had its isokinetic vacuum pump disabled. A sample pump is located on the Normal Range Monitor that provides the same functions, as long as the flowrates are maintained.

c. The SGTS radioactivity monitoring systems do not have an associated GE system.

d. Any portion of the SGTS effluent radioactivity monitoring systems which penetrates the boundary of the SGTS is designed to the seismic criteria of the exhaust duct.

e. The SGTS A radioactivity monitoring system annunciates at the data acquisition module and the PDS Computer. The SGTS B RMS annunciates at the local panels and Horizon, which sends it to PDS.

f. Grab sample points are located on plant elevation 139 feet in the auxiliary building that permit onsite analysis during normal and accident conditions.

g. The SGTS B RMS is composed of a Canberra Normal Range and High Range panels in addition with the Air Monitor FM&IS panel. The Horizon software console provides interface with the GGNS PDS network. No Data Acquisition Module (DAM) is present with the SGTS B RMS. The functions provided by the DAM are supplied by the Normal Range Ratemeter, High Range Ratemeter, and Horizon software console. The Horizon software console is located on the 148' Elevation, Computer Room and is interfaced with PDS.

h. Upon exit of accident/high range conditions, the SGTS B RMS will return to the Normal Range monitor for operation.

i. For the SGTS B RMS, the redundant stack flow monitoring panel provides a signal to the High Range Panel.

j. The SGTS B RMS uses 2.25 inch filter paper for particulate and iodine collection.

k. The purge feature can be initiated on either the Normal Range or High Range Panels or remotely via the Horizon software console in the 148' Elevation Control Building, Computer Room (for the SGTS B RMS).

l. The collection efficiency for the SGTS B RMS is 99% for particulates and 95% for iodines.

m. The High Range Panel for the SGTS B RMS does not have a particulate/iodine sample filter.

n. The check source feature can only be initiated at the Normal and High Range Panels for the SGTS B RMS.

o. The maximum reading for the SGTS B RMS is 9.9×10^4 µCi/cc versus the 10^5 µCi/cc stated in UFSAR Section 18.1.27.1. The overlap between the Normal Range Monitor and the High Range Monitor is 0.05 µCi/cc instead of a factor of 10 stated in UFSAR Section 18.1.27.1.

p. The SGTS B RMS normal range monitors the iodine 364 keV and 284 keV peaks at an efficiency of approximately 6.2%. The efficiency of the monitor is relative to both peaks summed and is defined for surface buildup of activity on the filter (not uniform buildup).

q. The SGTS B RMS normal range has the ability to monitor the particulate Cs-137 beta particles at an efficiency of approximately 18.8%.

r. The SGTS B RMS does not use a beta scintillation/GM tube to monitor gross radioactivity (i.e., noble gas activity), only a beta scintillation detector. Accuracy is approximately 10% under reference conditions with a simple multiplicative scalar to adjust for efficiency instead of a logarithmic scale down.

11.5.2.3 Inspection, Calibration and Maintenance

11.5.2.3.1 Inspection and Tests

During reactor operation and during times required by the ODCM/TRM, checks of system operability are made at the frequencies specified in ODCM/TRM by observing channel behavior. At periodic intervals during reactor operation, the detector response (of each monitor provided with a remotely positioned check source) will be recorded together with the instrument background count rate to ensure proper functioning of the monitors. Any detector whose response cannot be verified by observation during normal operation or by using the remotely positioned check source will have its response checked with a portable check source. A record will be maintained showing the background radiation level and the detector response.

The system has electronic testing and calibrating equipment which permits channel testing without relocating or dismounting channel components. An internal trip test circuit, adjustable over the full range of the readout meter, is used for testing. Each channel is functionally tested at least monthly except as identified in the Technical Specifications, Offsite Dose Calculation Manual or other TRM/UFSAR sections. Verification of valve operation,

ventilation diversion, or other trip function will be done at this time if it can be done without jeopardizing the plant safety. The tests will be documented.

11.5.2.3.1.1 Detailed Inspection and Tests

a. The following monitors have alarm trip circuits which can be tested by using test signals or portable gamma sources:

   1. Main steam line
   2. Containment and drywell ventilation exhaust
   3. Auxiliary building fuel handling area
   4. Auxiliary building fuel handling area pool sweep
   5. Offgas pretreatment
   6. Carbon bed fault

b. The following monitors include built-in check sources and purge systems which can be operated from the control room:

   1. Offgas post-treatment
   2. Containment ventilation
   3. Offgas and radwaste building
   4. Fuel handling area ventilation
   5. Turbine building ventilation
   6. Standby gas treatment system A

c. The following monitors include built-in check sources which can be operated from the control room:

   1. Radwaste effluent
   2. Standby service water
   3. Component cooling water
   4. Plant service water

d. The following monitor includes a built-in purge systems which can be operated remotely (148’ Elevation Control Room Computer Room):

1. Standby gas treatment system B

11.5.2.3.2 Calibration

The continuous radiation monitor's initial calibration is performed using one or more of the reference standards certified by the National Institute of Standards and Technology (NIST) or using standards that have been obtained from suppliers that participate in measurement assurance activities with NIST. These standards are to permit calibrating the system over its intended measurement range. For subsequent calibrations, sources that have been related to the initial calibration are to be used. Each continuous monitor is calibrated at times required by the ODCM/TRM.

11.5.2.3.2.1 Specific calibration criteria are as follows:

a. The following monitor shall have as a criterion for calibration response to a gross gamma signal with the calibration factor in mr/hr per µCi/sec being derived from periodic analyses of grab samples:

    1. Offgas pretreatment

b. The following monitors shall have as a criterion for calibration response to a gross gamma signal with the calibration factor in counts/min per µCi/sec being derived from periodic analyses of grab or filter samples:

    1. Offgas post-treatment
    2. Containment ventilation
    3. Offgas and radwaste building vent
    4. Fuel handling area vent
    5. Turbine building vent
    6. Standby gas treatment systems A and B
    7. Radwaste effluent
    8. Standby service water
    9. Component cooling water

c. The following monitors shall be calibrated to read the gross gamma rate in mr/hr:

    1. Main steam line
    2. Containment and drywell vent
    3. Auxiliary building fuel handling area
    4. Auxiliary building fuel handling area pool sweep
    5. Carbon bed vault

11.5.2.3.3 Maintenance

The channel detector, electronics and recorder are serviced and maintained on an annual basis or in accordance with manufacturers' recommendations to ensure reliable operations. Such maintenance includes cleaning, lubrication, and verification of recorder operation in addition to the replacement or adjustment of any components required after performing a test or calibration check. If any work is performed which would affect the calibration, a recalibration is performed at the completion of the work.

Maintenance, replacement, or decontamination of detectors for process and effluent monitors will not result in the opening of the process system or the loss of capability to isolate the effluent stream. Each detector is located external to the pipe or duct through which the process fluid flows or in wells inserted into the pipe, so that replacement of the sensor does not require opening of the process stream. Replacing a detector places that detector's channel in an inoperative status which causes a channel trip. Capability to isolate the effluent stream is maintained since tripping of the operative channel results directly in an isolation with the inoperative channel already tripped.

11.5.2.3.4 Audits and Verifications

Independent audits and verifications of test, calibration and maintenance records and procedures are conducted as described in Section 17.2.

11.5.3 Effluent Monitoring and Sampling

11.5.3.1 Implementation of General Design Criterion 64

All major and potentially significant radioactive effluent discharge paths are monitored for radioactivity; certain effluent streams are continuously monitored for gross radiation level. Liquid releases are monitored for gross gamma. Solid waste shipping containers are monitored with gamma sensitive portable survey instruments. Gaseous releases are monitored for gross gamma. The following gaseous effluent paths are sampled and monitored:

a. Containment Ventilation System

b. Offgas and Radwaste Building Ventilation System which includes the offgas system and the storage tank vents

c. Fuel Handling Area Ventilation System which includes the auxiliary building, fuel handling area, and fuel pool sweep ventilation systems

d. Turbine Building Ventilation System

e. Standby Gas Treatment System

The following liquid effluent path is sampled and monitored:

Liquid Radwaste System

All monitors have wide ranges and are listed in Table 11.5-1.

An isotopic analysis is performed periodically on samples obtained from each effluent release path in order to verify the adequacy of effluent processing to meet the discharge limits to unrestricted areas.

This effluent monitoring and sampling program is of such a comprehensive nature as to provide the information for the effluent measuring and reporting programs required by 10 CFR 50 Section 36A Appendix A General Design Criterion 64, and Appendix I and Regulatory Guide 1.21 in Annual reports to the NRC. The frequency of the periodic sampling and analysis described herein is a minimum and will be increased if effluent levels approach limits. Table 11.5-2 presents the sample schedules.

11.5.4 Process Monitoring and Sampling

11.5.4.1 Implementation of General Design Criterion 60

All potentially significant radioactive discharge paths are equipped with a control system to automatically isolate the discharge on indication of a high radiation level. All discharge valves or dampers which receive an automatic control signal to close from a process or effluent radiological monitor fail in the close position except for the mechanical vacuum pump suction which fails as-is (see Figure 10.4-2) and the offgas discharge valve which fails open (see Figure 11.3-6 PROPRIETARY). These include:

a. Offgas post-treatment

b. Containment and drywell ventilation exhaust

c. Liquid radwaste effluent

The effluent isolation functions for each monitor are given in Table 11.5-1.

11.5.4.2 Implementation of General Design Criterion 63

Radiation levels in radioactive and potentially radioactive process streams are monitored by the following process monitors:

a. Main Steam Line

b. Offgas Pretreatment

c. Offgas Post-treatment

d. Carbon Bed Vault

e. Component Cooling Water

f. Standby Service Water

g. Plant Service Water

Airborne radioactivity in the fuel handling area is detected by the auxiliary building fuel handling area vent exhaust monitor and the fuel pool sweep monitor which initiate the standby gas treatment system on high radioactivity. Airborne radioactivity in the containment is detected by the containment and drywell ventilation exhaust monitor which isolates the containment ventilation on high radioactivity. These monitors are also described in subsection 12.3.4 since they are used to monitor in plant airborne radioactivity to protect the workers. The area radiation monitors described in subsection 12.3.4 detect abnormal radiation levels in the various process equipment rooms.

Batch releases are sampled and analyzed prior to discharge in addition to the continuous effluent monitoring. The radwaste process monitoring systems are listed in Table 11.5-1. The gaseous and liquid process streams or effluent release points are monitored and sampled according to Table 11.5-3. Liquid sampling provisions are given in Table 9.3-3.

TABLE 11.5-1: PROCESS AND EFFLUENT RADIOACTIVITY MONITORING SYSTEMS

					Upscale Set Point				
Monitored Process	No. of Channels	Detector Type	Sample Line or Detector Location	Channel Range	Warnin g Alarm	Trip	Scale	Purpose of Measurement	Principal Radionuclides Detected
A. **Safety Related Systems**									
Main Steam Line	4	Gamma Sensitive Ionization Chamber	Immediately downstream of last main stm line isol valve	$1\text{-}10^6$ mr/hr	1.5x Full power bknd	TRM	6 dec. log	Monitors MSLs -Initiates mech. vac pump isolation and Rx water sample line isolation	N-16, Xe-133 0-19,Xe-135
Containment and Drywell Vent Exhaust	4	Geiger-Muller Tube	Exhaust dust upstream of exhaust ventilation isol valve	0.01 mr/hr to 100 mr/hr	tech spec	tech spec	4 dec. log	Monitor exhaust - Isolates containment ventilation	Xe-133, Kr-85
Aux Bldg Fuel Handling Area Vent Exhaust	4	Geiger-Muller Tube	Exhaust dust upstream of exhaust ventilation isol valve	0.01 mr/hr to 100 mr/hr	tech spec	tech spec	4 dec. log	Isolate building & initiate standby gas treatment	Xe-133, Kr-85 Xe-135, Kr-87,88
Aux Bldg Fuel Handling area Pool Sweep Exhaust	4	Geiger-Muller Tube	Exhaust duct upstream of exhaust ventilation isol valve	0.01 mr/hr to 100 mr/hr	tech spec	tech spec	4 dec. log	Isolate building & initiate standby gas treatment	X-133, Xe-135, Kr-85 87, 88 I-1317
Control Room Ventilation	4	Geiger-Muller Tube	Supply duct upstream of exhaust ventilation isol valve	0.01 mr/hr to 100 mr/hr	tech spec	tech spec	4 dec. log	Isolate control room & initiate emergency ventilation	Xe-133,Kr-85 I131 Cs-137 Co-60

TABLE 11.5-1: PROCESS AND EFFLUENT RADIOACTIVITY MONITORING SYSTEMS (Continued)

Monitored Process	No. of Channels	Detector Type	Sample Line or Detector Location	Channel Range	Upscale Set Point: Warnin g Alarm	Upscale Set Point: Trip	Scale	Purpose of Measurement	Principal Radionuclides Detected
B. **System Required for Plant Operation**									
Liquid Radwaste Effluent	1	Scintillation	Sample Line	10 to 10^6 counts/min	tech spec	tech spec	5 dec. log	Isolate discharge	Cs-137, Co-60
Component Cooling Water System	1	Scintillation	Sample Line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Detect heat exchanger leaks	Cs-137, Co-60
Standby Service Water System	2	Scintillation	Sample Line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Detect heat exchanger leaks	Cs-137, Co-60
Plant Service Water System	1	Scintillation	Sample Line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Detect heat exchanger leaks	Cs-137, Co-60
Offgas Post-treat	2	Geiger-Muller Tube	Sample Line	10 to 10^6 counts/min	tech spec	tech spec	5 dec. log	Monitor and control process after treatment	Kr-85, Xe-133
Offgas Pretreat	1	Geiger-Muller Tube	Sample Line	1 to 10^6 mr/hr	tech spec	N/A	6 dec. log	Monitor process before treatment	Kr-85, 87, 88 Xe-133m, 135
Carbon Bed Vault	1	Geiger-Muller Tube	Carbon bed vault	1 to 10^6 mr/hr	tech spec	N/A	6 dec. log	Monitor process	Xe-135, 135m Kr-87, 88
Containment Ventilation (GE System)	1	Geiger-Muller Tube	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
Offgas and Radwaste Bldg Vent (GE System)	1	Geiger-Muller Tube	Sample line	10 to 10^6 counts/min	tech spec	1 x 10^6	5 dec. log	Audit discharge to environs	Xe-133, Kr-85

TABLE 11.5-1: PROCESS AND EFFLUENT RADIOACTIVITY MONITORING SYSTEMS (Continued)

Monitored Process	No. of Channels	Detector Type	Sample Line or Detector Location	Channel Range	Upscale Set Point Warning Alarm	Upscale Set Point Trip	Scale	Purpose of Measurement	Principal Radionuclides Detected
Fuel Handling Area Vent (GE System)	1	Geiger-Muller Tube	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
Turbine Bldg Vent (GE System)	1	Geiger-Muller Tube	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
Containment Vent (Microprocessor System) (See Note 1)	1	Scintillation Detector	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	I-131
	1	Scintillation Detector	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	Cs-137
	1	Scintillation Detector	Sample line	10^{-7} to 6 x 10^{-2} μCi/cc	tech spec	N/A	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	2 x 10^{-2} to 4 x 10^2 μCi/cc	tech spec	N/A	4 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	10^{-4} to 10^1 μCi/cc	tech spec	N/A	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	10^1 to 10^5 μCi/cc	tech spec	N/A	4 dec. log	Audit discharge to environs	Xe-133, Kr-85

TABLE 11.5-1: PROCESS AND EFFLUENT RADIOACTIVITY MONITORING SYSTEMS (Continued)

Monitored Process	No. of Channels	Detector Type	Sample Line or Detector Location	Channel Range	Upscale Set Point		Scale	Purpose of Measurement	Principal Radionuclides Detected
					Warning Alarm	Trip			
Offgas & Radwaste Bld Vent (Microprocessor System)	1	Scintillation Detector	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	I-131
	1	Scintillation Detector	Sample line	10 to 10^6 counts/min	tech spec	N/A	5 dec. log	Audit discharge to environs	Cs-137
	1	Scintillation Detector	Sample line	10^{-7} to 6 x 10^{-2} µCi/cc	tech spec	tech spec	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	2 x 10^{-2} to 4 x 10^2 µCi/cc	tech spec	N/A	4 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	10^{-4} to 10^1 µCi/cc	tech spec	tech spec	5 dec. log	Audit discharge to environs	Xe-133, Kr-85
	1	Geiger-Muller Tube	Sample line	10^1 to 10^5 µCi/cc	tech spec	N/A	4 dec. log	Audit discharge to environs	Xe-133, Kr-85

Note:

1. Typical for FHA Vent, Turbine Building Vent, Standby Gas Treatment Vent A, and Standby Gas Treatment Vent B Systems also.

TABLE 11.5-2: RADIOLOGICAL ANALYSIS SUMMARY OF LIQUID PROCESS SAMPLES

Sample Description	Grab Sample Frequency	Analysis	Sensitivity μCi/ml	Program
1. Equipment Drain Collector Tanks (2)	Periodically	Gross γ	10^{-5}	Evaluate system performance
2. Floor Drain Collector Tank	Periodically	Gross γ	10^{-5}	Evaluate system performance
3. Chemical Waste Tank	Periodically	Gross γ	10^{-5}	Evaluate system performance
4. Evaporator bottoms	Periodically	Gross γ	10^{-6}	Comparison of activity with that determined by drum readings
5. Offgas Monitor (SJAE) Sample	Monthly	Gamma Spectrum	10^{-4}	Determines offgas activity
6. Post treatment sample	Monthly	Gamma Spectrum	10^{-4}	Determines offgas system cleanup performance
7. Floor Drain Sample Tanks (2)	Batch[a]	Principal gamma emitters	5×10^{-7}	Effluent discharge record
8. Equipment Drain Sample Tanks(2)	Batch[a]	Principal gamma emitters	5×10^{-7}	Effluent discharge record

TABLE 11.5-2: RADIOLOGICAL ANALYSIS SUMMARY OF LIQUID PROCESS SAMPLES (Continued)

Sample Description	Grab Sample Frequency	Analysis	Sensitivity µCi/ml	Program
9. Distillate Sample Tank	Batch[a]	Principal gamma emitters	5×10^{-7}	Effluent discharge record
10. Liquid Radwaste Effluent Ba/La-140 & I-131	Batch[a]	Principal gamma emitters	5×10^{-7}	Effluent discharge record
Composite of all tanks discharged	Monthly	Tritium Gross Alpha Dissolved Gas[b]	5×10^{-5} 10^{-7} 10^{-5}	
	Quarterly	Sr-89/90	5×10^{-8}	

(a) If tank is to be discharged, analyses will be performed on each batch.
(b) Typical batch of average release. All other samples are proportional composites.

Sample Description	Grab Sample Frequency	Analysis	Sensitivity µCi/ml	Program
11. Auxiliary Building, Radwaste Building, Turbine Building, and Containment Vents	Weekly	Principal gamma emitters (a) for at least I-131 & Ba-La-140	10^{-11}	Effluent Record
		I-131(b)	10^{-12}	

TABLE 11.5-2: RADIOLOGICAL ANALYSIS SUMMARY OF LIQUID PROCESS SAMPLES (Continued)

Sample Description	Grab Sample Frequency	Analysis	Sensitivity µCi/ml	Program
	Monthly	Principle gamma emitters[c]	10^{-4}	
		Gross Alpha[a]	10^{-11}	
		I-133 & 135[b]	10^{-10}	

(a) On particulate filter

(b) On charcoal cartridge

(c) Gas samples

TABLE 11.5-3: PROVISIONS FOR MONITORING AND SAMPLING GASEOUS AND LIQUID STREAMS

	Monitor Provisions				Sample Provisions		
	In Process		In Effluent		In Process	In Effluent	
Process System	Cont.[1]	ACF[2]	ACF[2]	Cont.[1]	Grab[3]	Grab[3]	Cont.[1]
A. Gaseous Streams							
Offgas posttreatment	NG	NG			NIGR		
Offgas pretreatment (Condenser Air Removal)	NG				NIG		
Containment ventilation system[4]	NG	NG		NGI		NIGRT	NGI
Offgas & RW bldg. vent. system[5]			NG	NGI		NIGRT	NGI
Fuel-handling area vent. system[6]	NG	NG		NGI		NIGRT	NGI
Turbine bldg. vent. system[7]				NGI		NIGRT	NGI
Standby gas treatment "A"				NGI		NIGRT	NGI
Standby gas treatment "B"				NGI		NIGRT	NGI
Carbon bed vault	NG				IG		
B. Liquid Streams							
Floor drain sample tanks[8]						GR	
Equip. drain sample tanks[8]						GR	
Chemical waste distillate sample tanks[8]					G	GR	
Condensate storage tank					GR		
Laundry waste monitoring tank[9]					GR		
Refueling water storage tank					GR		
Condensate storage tank dike sump[10]					G		

TABLE 11.5-3: PROVISIONS FOR MONITORING AND SAMPLING GASEOUS AND LIQUID STREAMS (Continued)

	Monitor Provisions				Sample Provisions		
	In Process		In Effluent		In Process	In Effluent	
Process System	**Cont.[1]**	**ACF[2]**	**ACF[2]**	**Cont.[1]**	**Grab[3]**	**Grab[3]**	**Cont.[1]**
Liquid radwaste effluent			G	G		GRT	
Component cooling water system	G				G		
Standby service water system[11]	G				GR		
Plant service water system (ADHRS effluent only)	G				G		

Notes

1. Continuous radiation monitor.
2. Automatic control feature.
3. Sample point available to obtain grab samples for laboratory analyses indicated.
4. Includes drywell purge and containment and drywell ventilation exhaust process monitor.
5. Includes offgas system, radwaste evaporator condenser vents, radwaste tank vents, and laboratory and sample system hood vents.
6. Includes auxiliary building FHA ventilation exhaust and auxiliary building FHA pool sweep ventilation exhaust process monitors and auxiliary building ventilation system.
7. Includes mechanical vacuum pump and gland seal condenser vent.
8. All liquid radwaste tanks are pumped to one of these tanks. These tanks are sampled and analyzed prior to release.
9. This tank will be used only in abnormal situations. Refer to subsection 9.2.4.2.
10. A sample will be taken and analyzed prior to pumping down the sump to the plant Storm Drainage System.

11. Grand Gulf will use the results of the analyses referenced in this table to calculate radioactive releases via the standby service water system.

Guide to Abbreviations

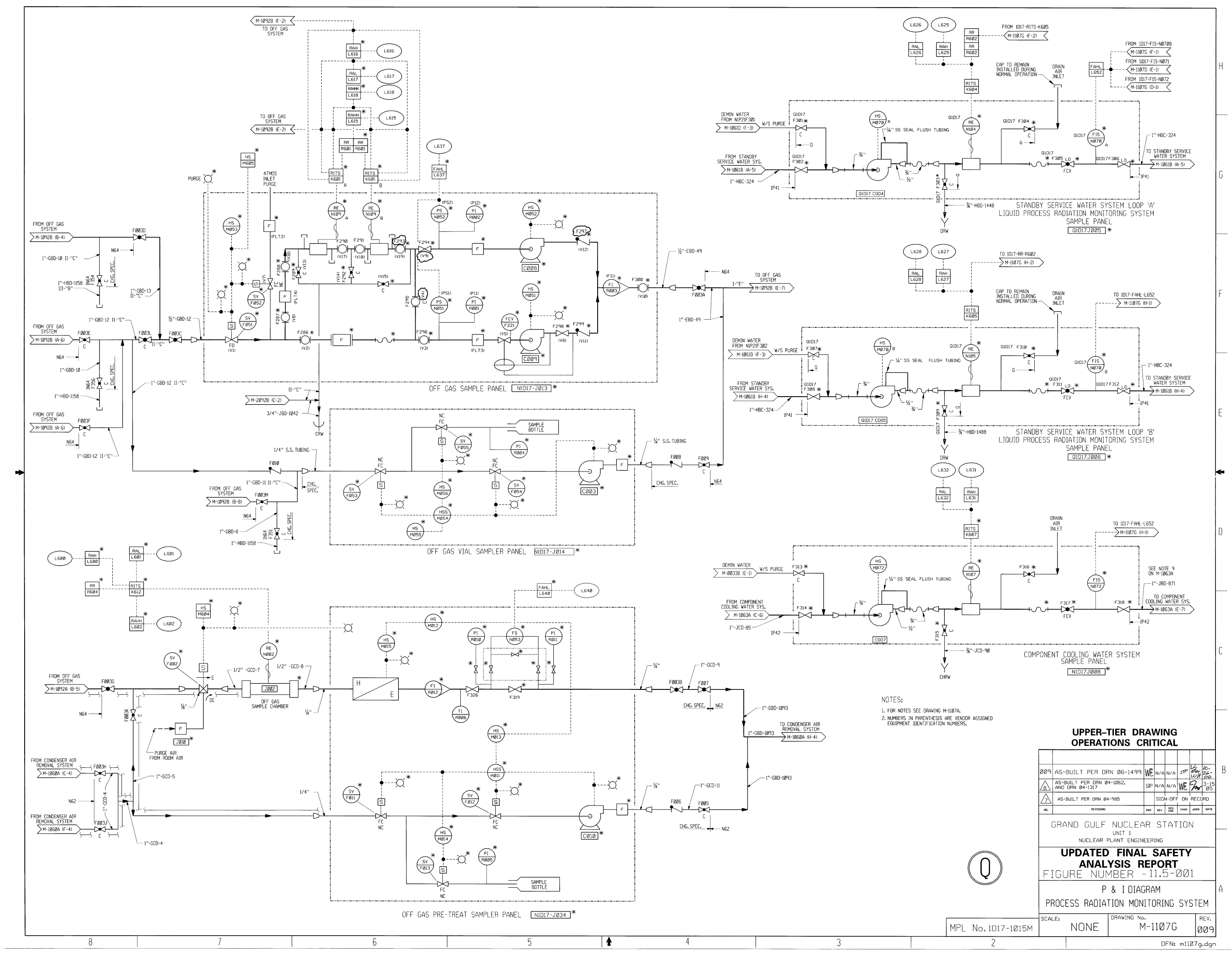
N - Noble gas radioactivity.

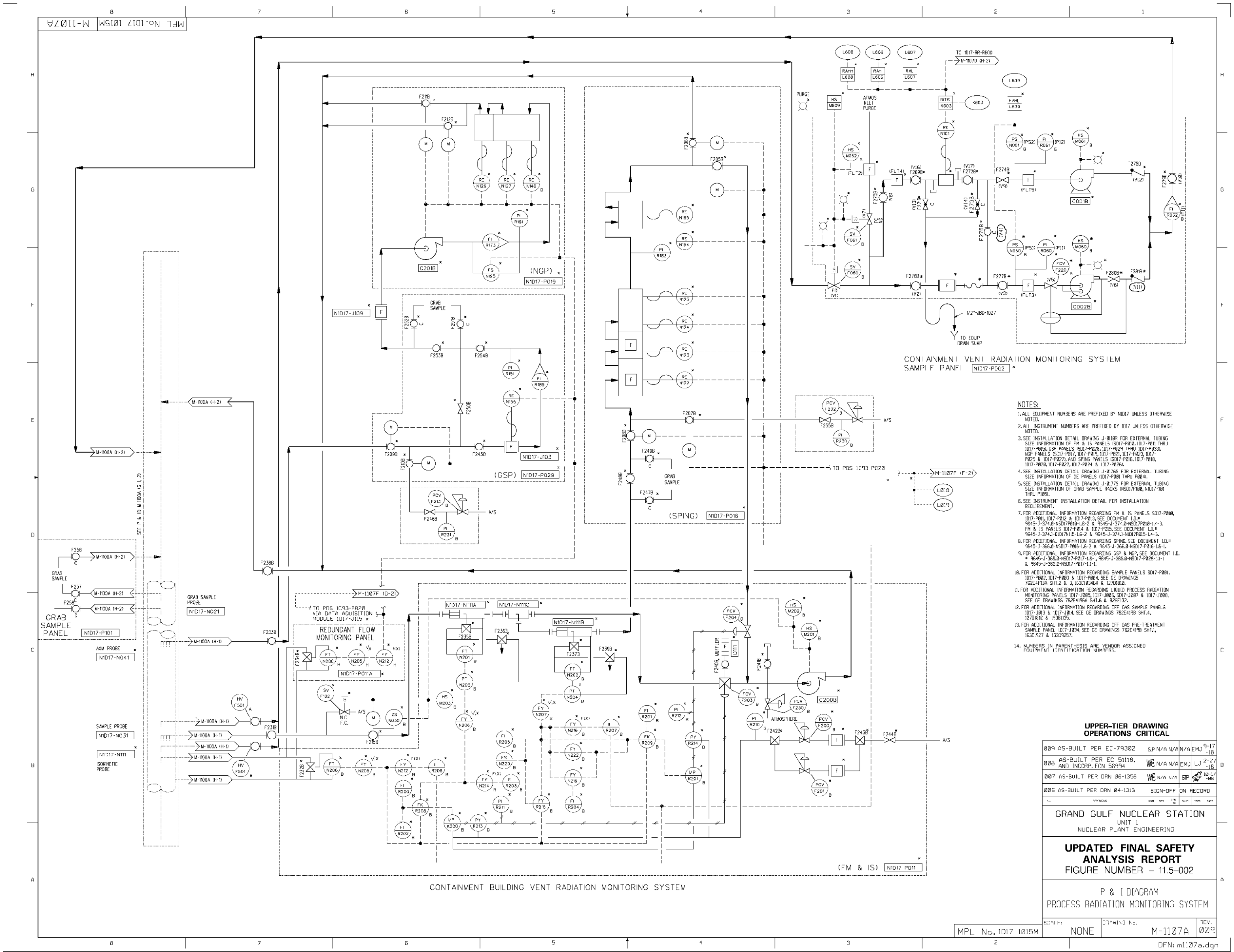
I - Radioiodine radioactivities and radioactivity of materials in particulate form and alpha emitters.

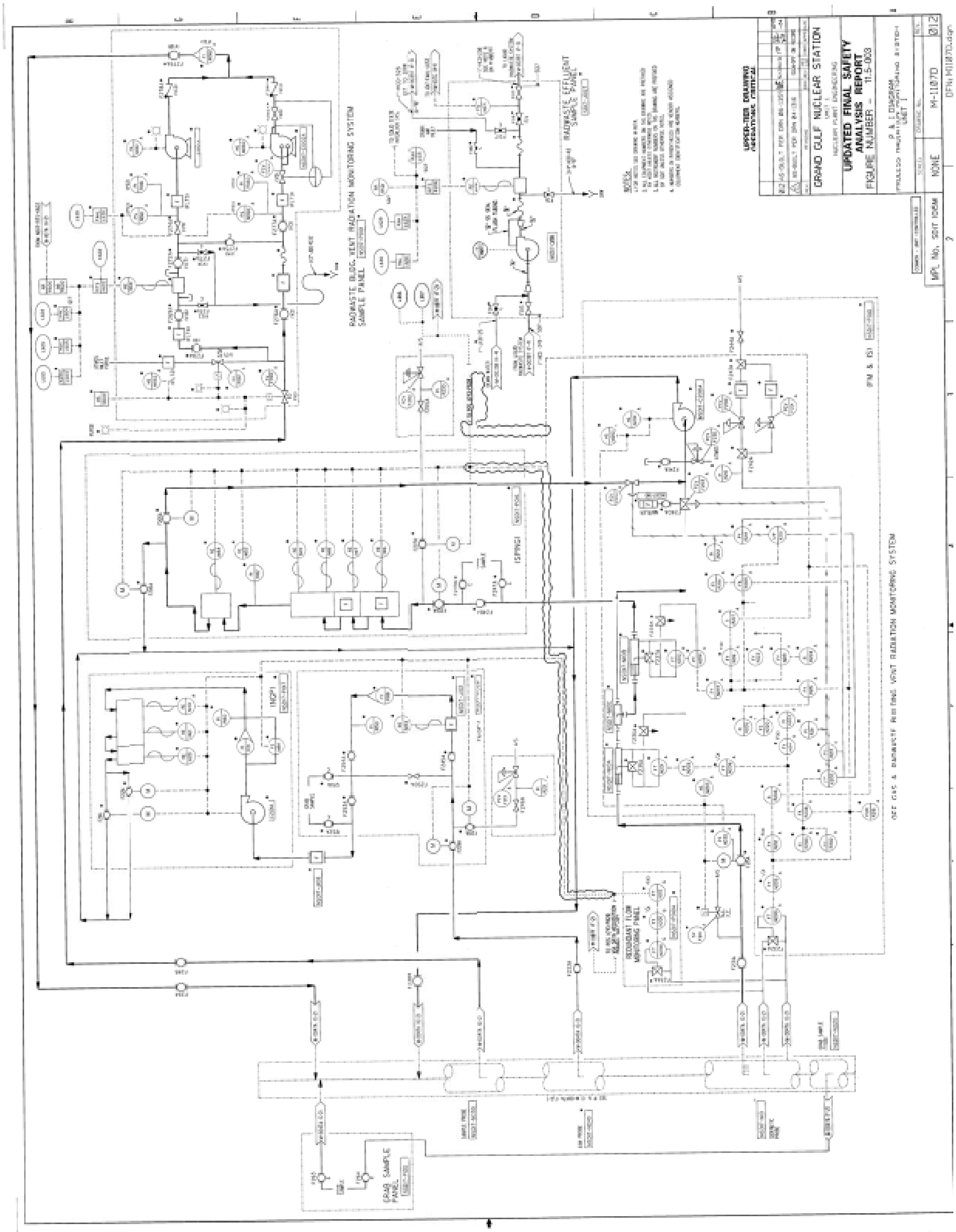
G - Gross radioactivity.

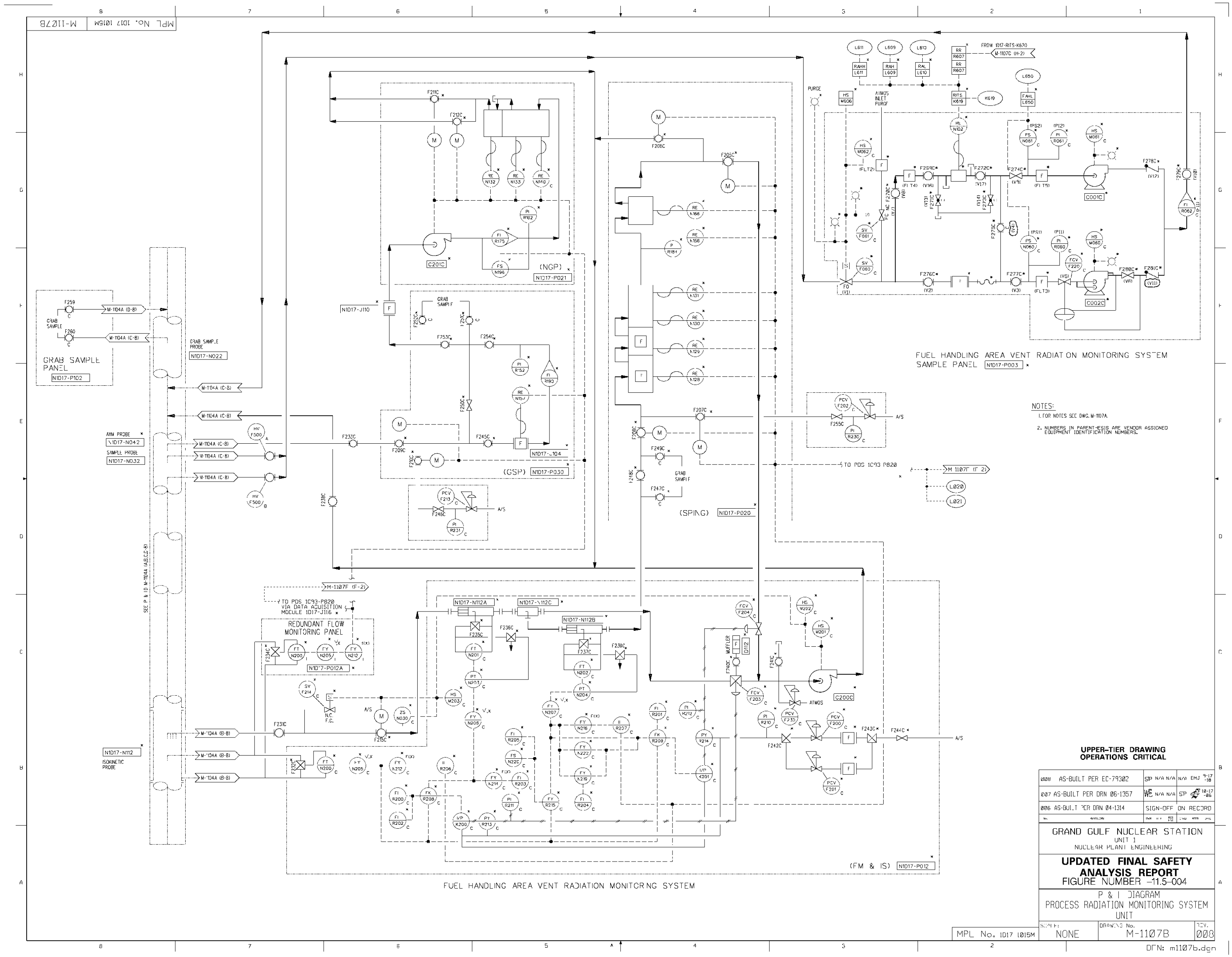
R - Principal identification and concentration of radionuclides and alpha emitters.

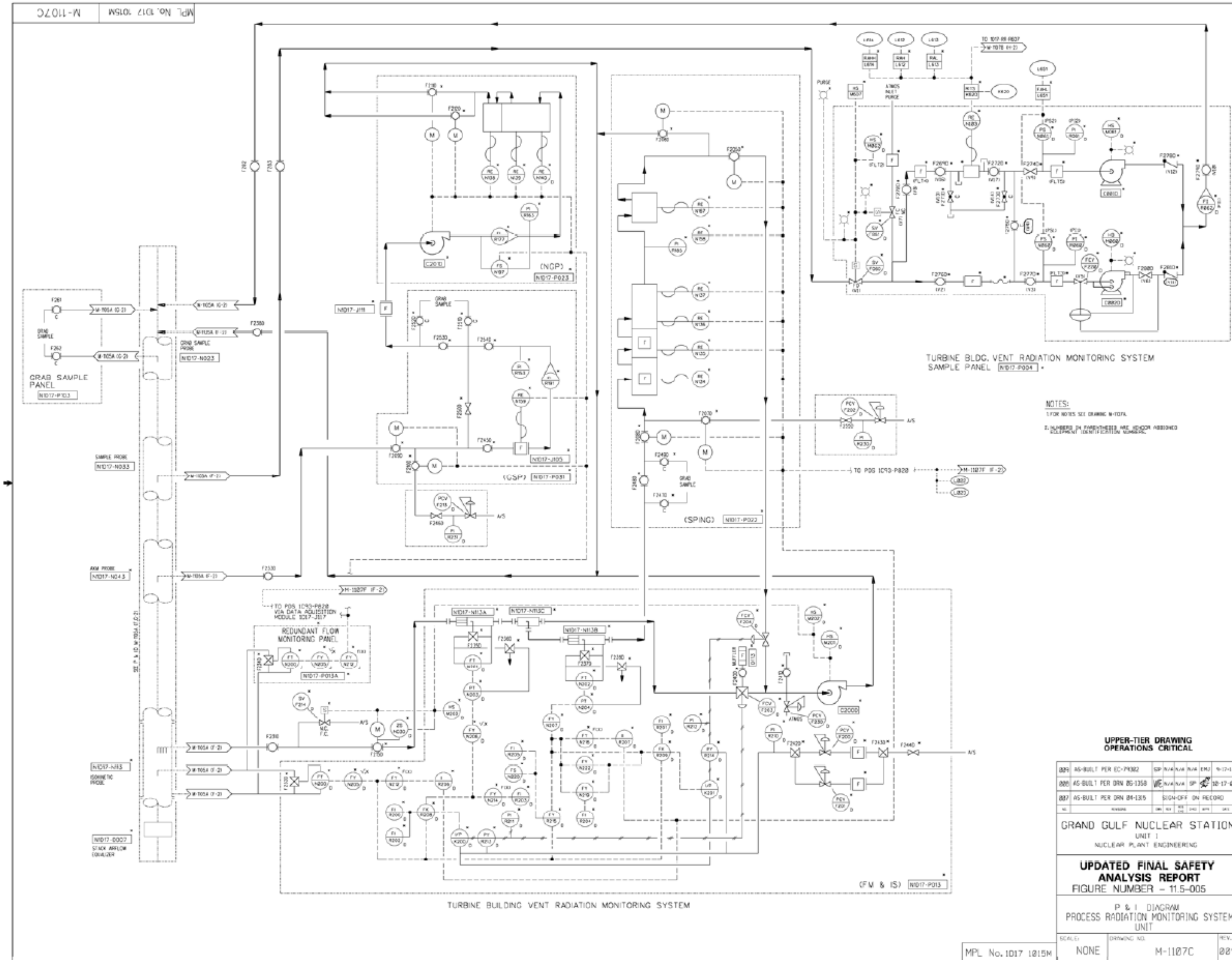
T - Tritium radioactivity

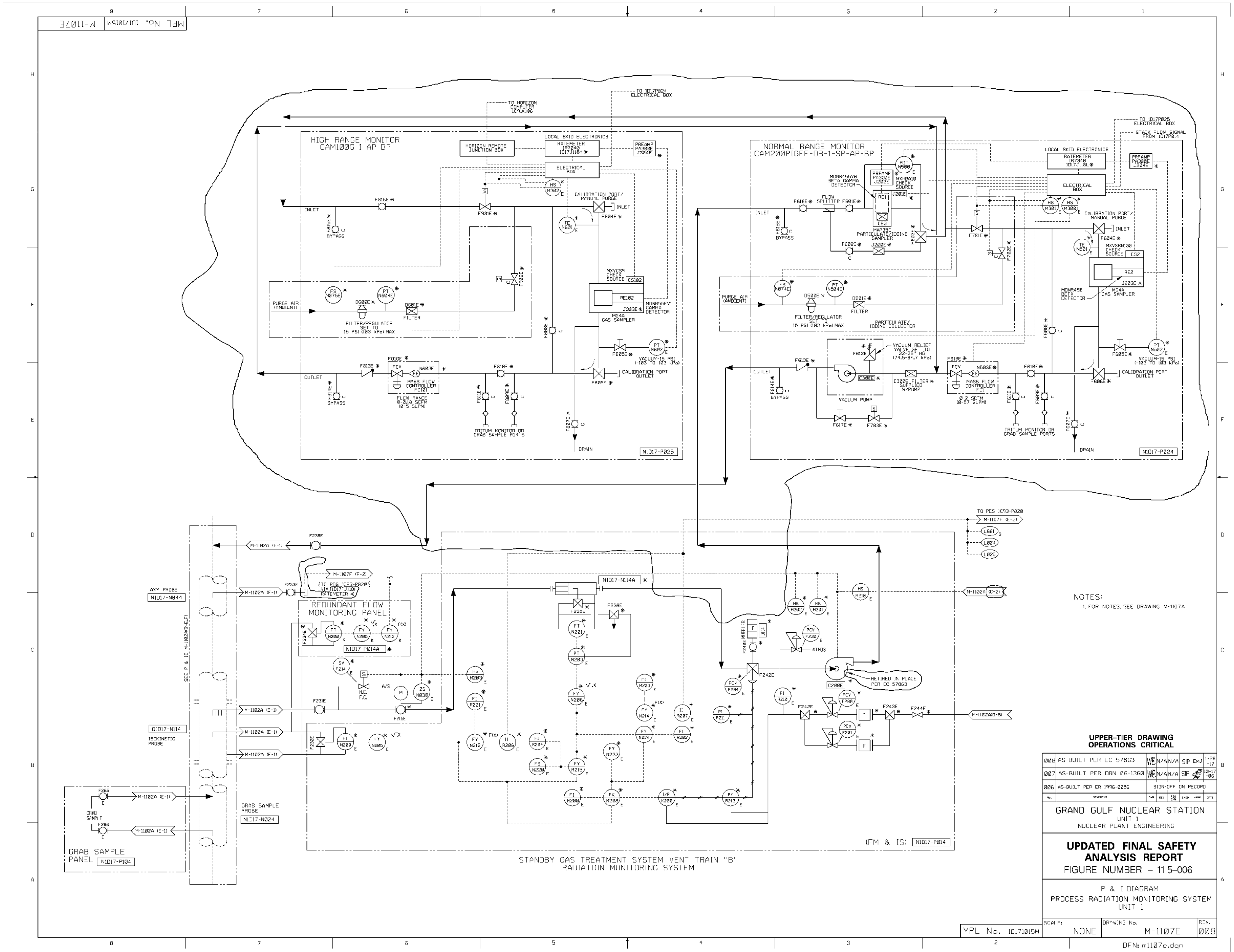

OFF GAS SAMPLE PANEL
OFF GAS VIAL SAMPLER PANEL
OFF GAS PRE-TREAT SAMPLER PANEL
STANDBY SERVICE WATER SYSTEM LOOP 'A' LIQUID PROCESS RADIATION MONITORING SYSTEM SAMPLE PANEL
STANDBY SERVICE WATER SYSTEM LOOP 'B' LIQUID PROCESS RADIATION MONITORING SYSTEM SAMPLE PANEL
COMPONENT COOLING WATER SYSTEM SAMPLE PANEL
NOTES:
1. FOR NOTES SEE DRAWING M-1107A.
2. NUMBERS IN PARENTHESIS ARE VENDOR ASSIGNED EQUIPMENT IDENTIFICATION NUMBERS.
UPPER-TIER DRAWING OPERATIONS CRITICAL
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.5-001
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
MPL No. 1D17-1015M
SCALE: NONE
DRAWING No. M-1107G
REV. 009

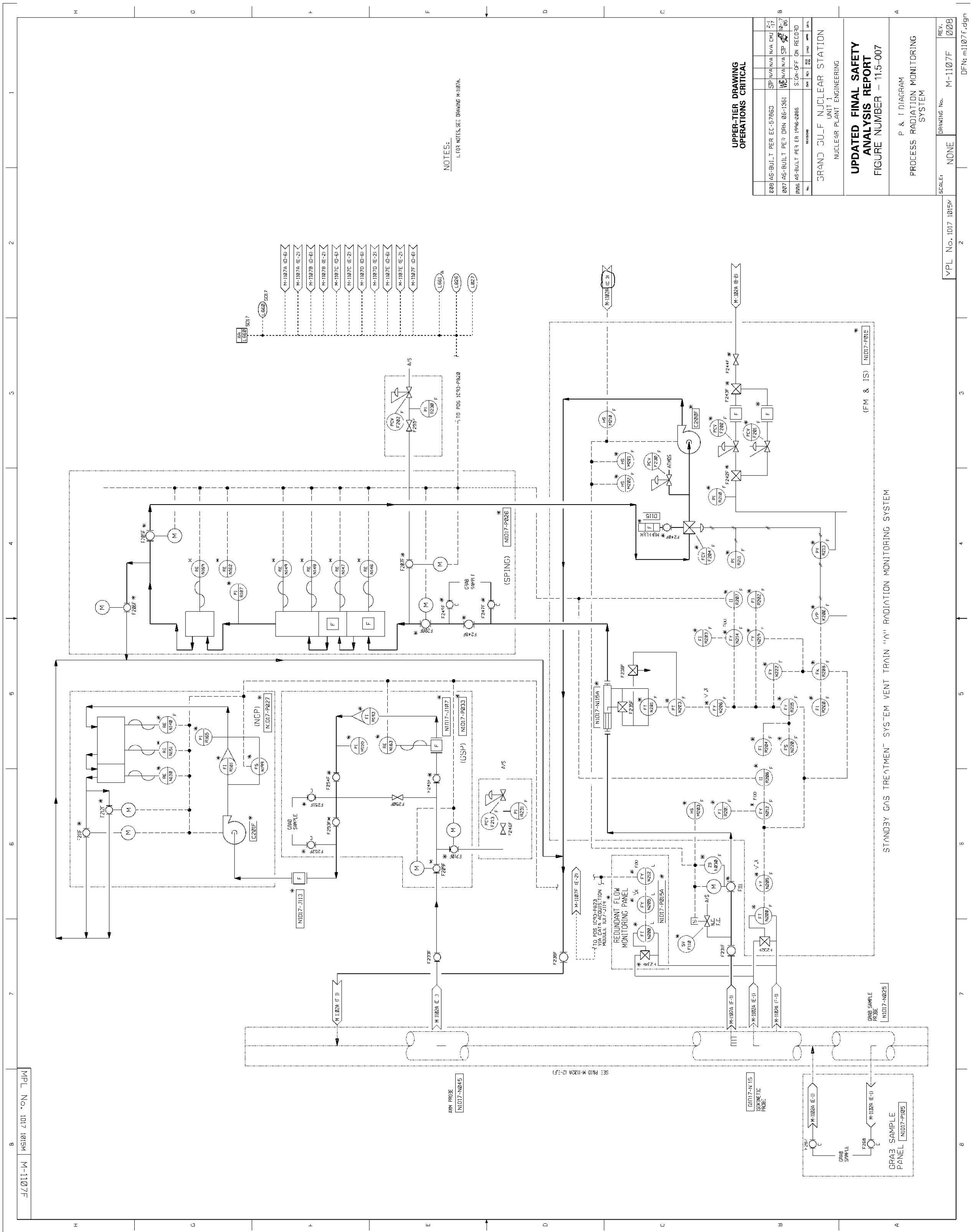

CONTAINMENT VENT RADIATION MONITORING SYSTEM
SAMPLE PANEL N1D17-P002
CONTAINMENT BUILDING VENT RADIATION MONITORING SYSTEM
(NGP) N1D17-P019
(GSP) N1D17-P029
(SPING) N1D17-P018
(FM & IS) N1D17-P011
GRAB SAMPLE PANEL N1D17-P101
REDUNDANT FLOW MONITORING PANEL
NOTES:
1. ALL EQUIPMENT NUMBERS ARE PREFIXED BY N1D17 UNLESS OTHERWISE NOTED.
2. ALL INSTRUMENT NUMBERS ARE PREFIXED BY 1D17 UNLESS OTHERWISE NOTED.
3. SEE INSTALLATION DETAIL DRAWING J-0110R FOR EXTERNAL TUBING SIZE INFORMATION OF FM & IS PANELS (SD17-P010, 1D17-P011 THRU 1D17-P015), GSP PANELS (SD17-P028, 1D17-P029 THRU 1D17-P033), NGP PANELS (SD17-P017, 1D17-P019, 1D17-P021, 1D17-P023, 1D17-P025 & 1D17-P027), AND SPING PANELS (SD17-P016, 1D17-P018, 1D17-P020, 1D17-P022, 1D17-P024 & 1D17-P026).
4. SEE INSTALLATION DETAIL DRAWING J-0176S FOR EXTERNAL TUBING SIZE INFORMATION OF GE PANELS (1D17-P001 THRU P004).
5. SEE INSTALLATION DETAIL DRAWING J-0177S FOR EXTERNAL TUBING SIZE INFORMATION OF GRAB SAMPLE RACKS (NSD17P100, N1D17P101 THRU P105).
6. SEE INSTRUMENT INSTALLATION DETAIL FOR INSTALLATION REQUIREMENT.
7. FOR ADDITIONAL INFORMATION REGARDING FM & IS PANELS SD17-P010, 1D17-P011, 1D17-P012 & 1D17-P013, SEE DOCUMENT I.D.# 9645-J-374.0-NSD17P010-1.6-2 & 9645-J-374.0-NSD17P010-1.4-3. FM & IS PANELS 1D17-P014 & 1D17-P015, SEE DOCUMENT I.D.# 9645-J-374.1-01D17N115-1.6-2 & 9645-J-374.1-N1D17P015-1.4-3.
8. FOR ADDITIONAL INFORMATION REGARDING SPING, SEE DOCUMENT I.D.# 9645-J-366.0-NSD17-P016-1.6-2 & 9645-J-366.0-NSD17-P016-1.6-1.
9. FOR ADDITIONAL INFORMATION REGARDING GSP & NGP, SEE DOCUMENT I.D. # 9645-J-366.0-NSD17-P017-1.6-1, 9645-J-366.0-NSD17-P028-1.1-1 & 9645-J-366.0-NSD17-P017-1.1-1.
10. FOR ADDITIONAL INFORMATION REGARDING SAMPLE PANELS SD17-P001, 1D17-P002, 1D17-P003 & 1D17-P004, SEE GE DRAWINGS 762E4193A SHT.2 & 3, 163C1034BA & 127D1810.
11. FOR ADDITIONAL INFORMATION REGARDING LIQUID PROCESS RADIATION MONITORING PANELS 1D17-J005, 1D17-J006, SD17-J007 & 1D17-J008, SEE GE DRAWINGS 762E4196A SHT.6 & 828E132.
12. FOR ADDITIONAL INFORMATION REGARDING OFF GAS SAMPLE PANELS 1D17-J013 & 1D17-J014, SEE GE DRAWINGS 762E419B SHT.4, 127D1812 & 193B1135.
13. FOR ADDITIONAL INFORMATION REGARDING OFF GAS PRE-TREATMENT SAMPLE PANEL 1D17-J034, SEE GE DRAWINGS 762E419B SHT.1, 163C1927 & 133D9257.
14. NUMBERS IN PARENTHESIS ARE VENDOR ASSIGNED EQUIPMENT IDENTIFICATION NUMBERS.
UPPER-TIER DRAWING
OPERATIONS CRITICAL
009 AS-BUILT PER EC-79302 S.P N/A N/A N/A EMJ 9-17-18
008 AS-BUILT PER EC 51118, AND INCORP. FCN 56994 WE N/A N/A EMJ LJ 2-2/-16
007 AS-BUILT PER DRN 06-1356 WE N/A N/A SIP 10-1/-06
006 AS-BUILT PER DRN 04-1313 SIGN-OFF ON RECORD
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.5-002
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
MPL No. 1D17 1015M
SCALE: NONE
DRAWING No. M-1107A
REV. 009
DFN: m1107a.dgn


GRAND GULF NUCLEAR STATION
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER - 11.5-003
M-1107D
RADWASTE BLDG. VENT RADIATION MONITORING SYSTEM SAMPLE PANEL
RADWASTE EFFLUENT SAMPLE PANEL
OFF GAS & RADWASTE BUILDING VENT RADIATION MONITORING SYSTEM
REDUNDANT FLOW MONITORING PANEL
GRAB SAMPLE PANEL

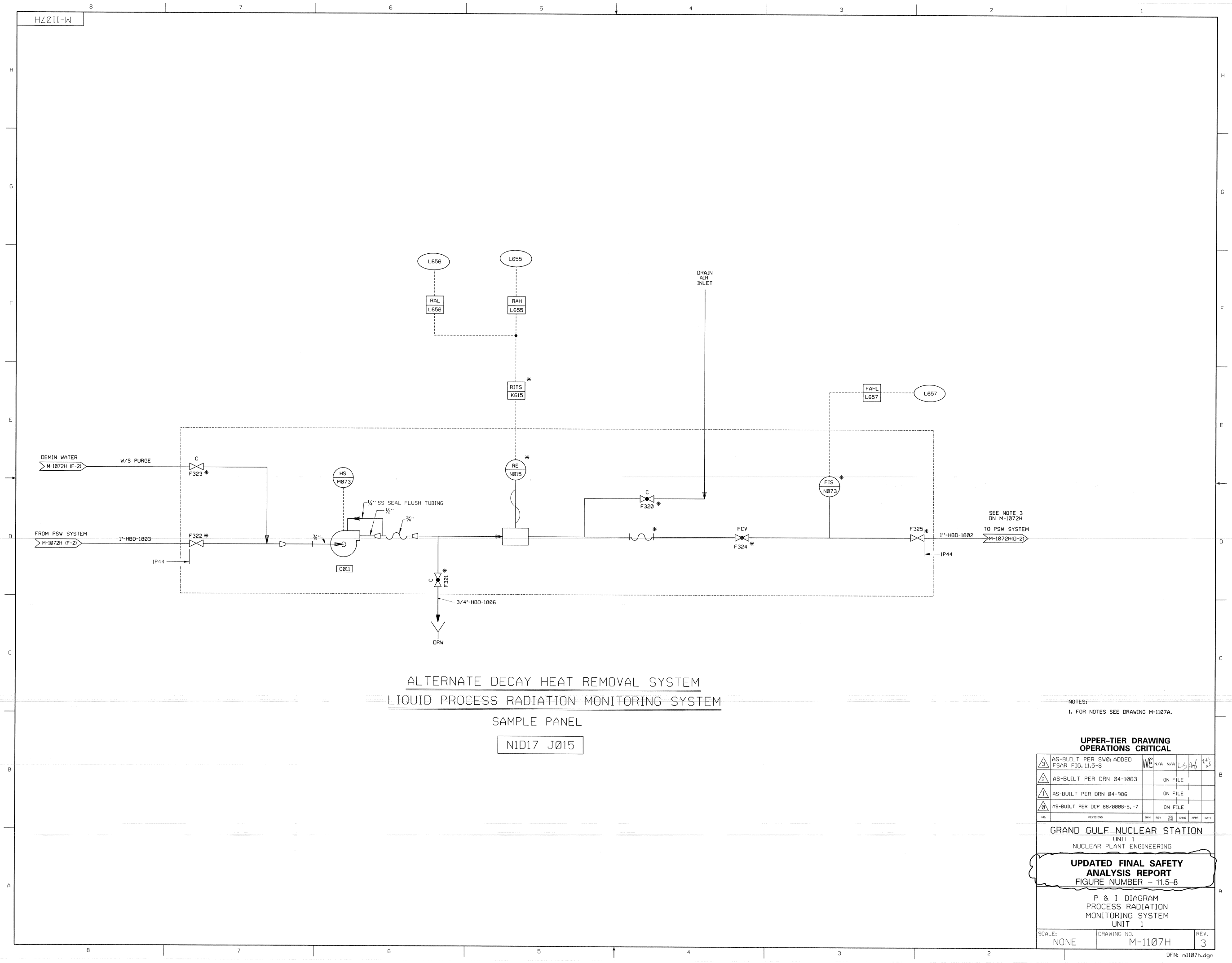

MPL No. 1D17 1015M
M-1107B
FUEL HANDLING AREA VENT RADIATION MONITORING SYSTEM
SAMPLE PANEL N1D17-P003
NOTES:
1. FOR NOTES SEE DWG. M-1107A.
2. NUMBERS IN PARENTHESIS ARE VENDOR ASSIGNED EQUIPMENT IDENTIFICATION NUMBERS.
GRAB SAMPLE PANEL
N1D17-P102
REDUNDANT FLOW MONITORING PANEL
N1D17-P012A
(NGP) N1D17-P021
(GSP) N1D17-P030
(SPING) N1D17-P020
(FM & IS) N1D17-P012
FUEL HANDLING AREA VENT RADIATION MONITORING SYSTEM
UPPER-TIER DRAWING
OPERATIONS CRITICAL
008 AS-BUILT PER EC-79302
007 AS-BUILT PER DRN 06-1357
006 AS-BUILT PER DRN 04-1314
SIGN-OFF ON RECORD
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER -11.5-004
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
UNIT
NONE
M-1107B
008
DFN: m1107b.dgn

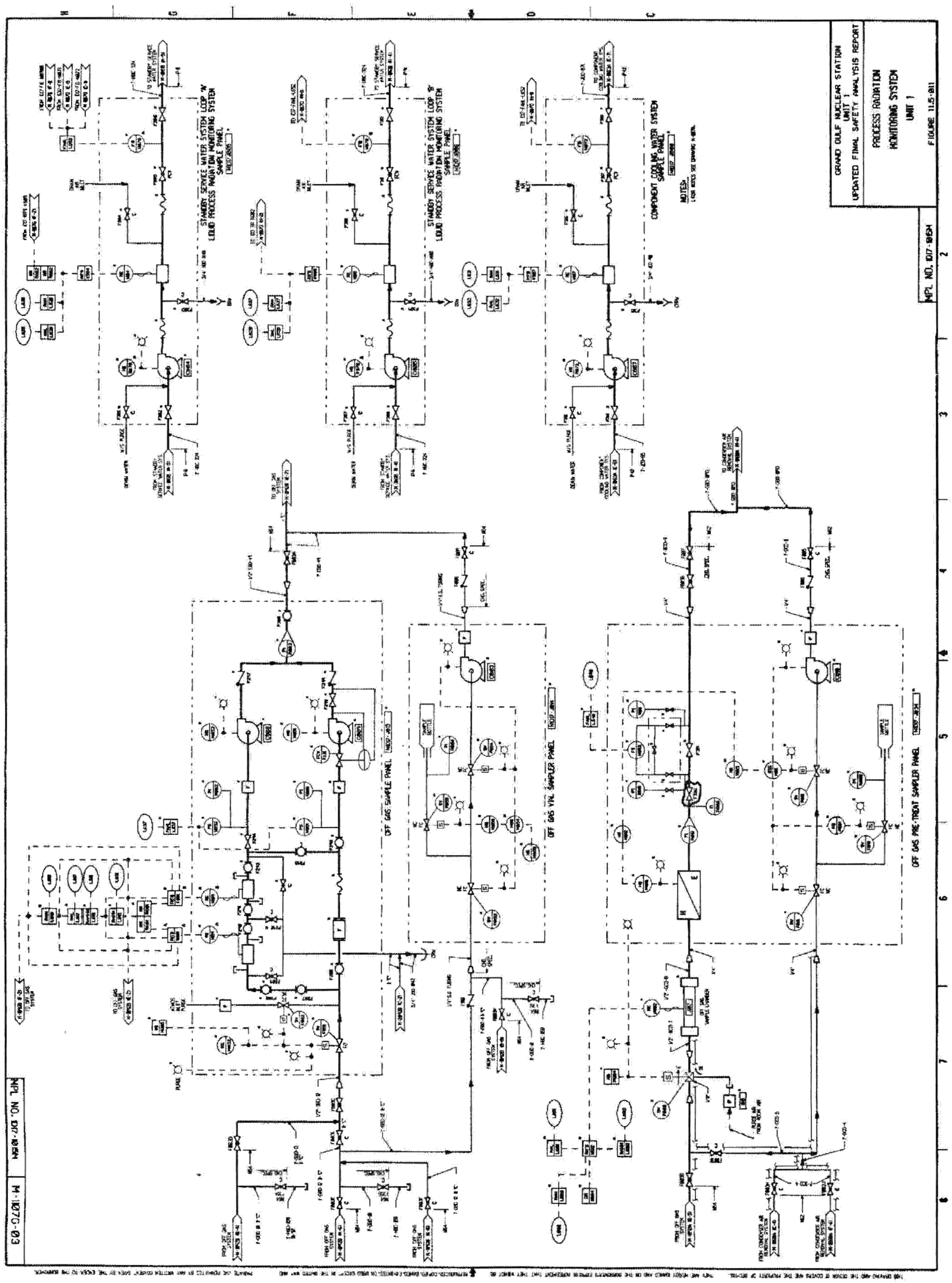

TURBINE BLDG. VENT RADIATION MONITORING SYSTEM SAMPLE PANEL
TURBINE BUILDING VENT RADIATION MONITORING SYSTEM
REDUNDANT FLOW MONITORING PANEL
GRAB SAMPLE PANEL
NOTES:
UPPER-TIER DRAWING OPERATIONS CRITICAL
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.5-005
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
UNIT
NONE
M-1107C
009
MPL No. 1D17 1015M


HIGH RANGE MONITOR
NORMAL RANGE MONITOR
LOCAL SKID ELECTRONICS
ELECTRICAL BOX
HORIZON REMOTE JUNCTION BOX
PURGE AIR (AMBIENT)
FILTER/REGULATOR
CALIBRATION PORT/ MANUAL PURGE
CALIBRATION PORT OUTLET
MASS FLOW CONTROLLER
VACUUM PUMP
TRITIUM MONITOR OR GRAB SAMPLE PORTS
INLET
OUTLET
BYPASS
DRAIN
REDUNDANT FLOW MONITORING PANEL
ISOKINETIC PROBE
GRAB SAMPLE PROBE
GRAB SAMPLE PANEL
STANDBY GAS TREATMENT SYSTEM VENT TRAIN "B" RADIATION MONITORING SYSTEM
RETIRED IN PLACE PER EC 57863
NOTES:
1. FOR NOTES, SEE DRAWING M-1107A.
UPPER-TIER DRAWING OPERATIONS CRITICAL
008 AS-BUILT PER EC 57863
007 AS-BUILT PER DRN 06-1360
006 AS-BUILT PER ER 1996-0056
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.5-006
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
UNIT 1
SCALE: NONE
DRAWING No. M-1107E
REV. 008
DFN: m1107e.dgn



UPPER-TIER DRAWING
OPERATIONS CRITICAL
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY
ANALYSIS REPORT
FIGURE NUMBER – 11.5-007
P & I DIAGRAM
PROCESS RADIATION MONITORING
SYSTEM
SCALE: NONE
M-1107F
REV. 008
STANDBY GAS TREATMENT SYSTEM VENT TRAIN "A" RADIATION MONITORING SYSTEM
(SPING)
(NCP)
(GSP)
(FM & IS)
REDUNDANT FLOW MONITORING PANEL
GRAB SAMPLE PANEL
NOTES:
1. FOR NOTES, SEE DRAWING M-1107A.


M-1107H
L656
L655
RAL L656
RAH L655
RITS K615
DRAIN AIR INLET
FAHL L657
L657
DEMIN WATER
M-1072H (F-2)
W/S PURGE
F323
HS M073
RE N015
FIS N073
F320
1/4" SS SEAL FLUSH TUBING
FROM PSW SYSTEM
M-1072H (F-2)
1"-HBD-1803
F322
1P44
C011
F321
3/4"-HBD-1806
DRW
FCV
F324
F325
1"-HBD-1802
SEE NOTE 3 ON M-1072H
TO PSW SYSTEM
M-1072H(D-2)
1P44
ALTERNATE DECAY HEAT REMOVAL SYSTEM
LIQUID PROCESS RADIATION MONITORING SYSTEM
SAMPLE PANEL
N1D17 J015
NOTES:
1. FOR NOTES SEE DRAWING M-1107A.
UPPER-TIER DRAWING OPERATIONS CRITICAL
AS-BUILT PER SW0; ADDED FSAR FIG. 11.5-8
AS-BUILT PER DRN 04-1063
AS-BUILT PER DRN 04-986
AS-BUILT PER DCP 88/0000-5,-7
ON FILE
GRAND GULF NUCLEAR STATION
UNIT 1
NUCLEAR PLANT ENGINEERING
UPDATED FINAL SAFETY ANALYSIS REPORT
FIGURE NUMBER – 11.5-8
P & I DIAGRAM
PROCESS RADIATION MONITORING SYSTEM
UNIT 1
SCALE: NONE
DRAWING NO. M-1107H
REV. 3


GRAND GULF NUCLEAR STATION
UNIT 1
UPDATED FINAL SAFETY ANALYSIS REPORT
PROCESS RADIATION
MONITORING SYSTEM
UNIT 1
FIGURE 11.5-011
M-1070-03