11.0 RADIOACTIVE WASTE MANAGEMENT

11.1 Design Objective and Criteria

The radioactive waste management system for Crystal River, Unit 3, will be designed to provide for the controlled handling and treatment of radioactive liquid, gaseous and solid wastes. The applicant's design objective for these systems is to restrict the amount of radioactivity released from normal plant operation to unrestricted areas to levels that are as low as practicable.

The technical specifications issued as part of the operating license will require the applicant to maintain and use existing plant equipment to achieve the lowest practicable releases of radioactive materials to the environment in accordance with the requirements of 10 CFR Part 20 and 10 CFR Part 50. The applicant will also be required to maintain radiation exposures to inplant personnel and the general public "as low as practicable" in conformance with the requirements of 10 CFR Part 20.

Our evaluation of the design and expected performance of the waste management system for Crystal River, Unit 3, is based on the following design objectives:

Liquids

(1) Provisions to treat liquid waste to limit the expected releases of radioactive materials in liquid effluents to the environment

to less than 5 Ci/yr, excluding tritium and noble gases.

(2) The calculated annual average exposure to the whole body or any organ of an individual at or beyond the site boundary not to exceed 5 mrem for expected releases.

(3) Concentration of radioactive materials in liquid effluents not to exceed the limits in 10 CFR Part 20, Appendix B, Table II, Column 2, for the expected and design releases.

Gaseous

(1) Provisions to treat gaseous waste to limit the expected release of radioactive materials in gaseous effluent from principal release points so that the annual average exposure to the whole body or any organ of an individual at or beyond the site boundary not to exceed 10 mrem.

(2) Provision to treat expected and design radioiodine released in gaseous effluent from principal release points so that the annual average exposure to the thyroid of a child through the pasture-cow-milk pathway be less than 15 mrem.

(3) Concentration of radioactive materials in gaseous effluents not to exceed the limits in 10 CFR Part 20, Appendix B, Table II, Column 1, for the expected and design releases.

Solid

(1) Provisions to solidify all liquid waste from normal operation including anticipated operational occurrences prior to shipment to a licensed burial ground.

(2) Containers and method of packing to meet the requirements of 10 CFR Part 71 and applicable Department of Transportation regulations.

11.2 Liquid Waste System

Treatment of the waste is dependent on the source, activity and composition of the particular liquid waste and on the intended disposal procedure. The liquid waste treatment system is divided into two subsystems, i.e., the makeup and purification subsystem and the miscellaneous waste processing subsystem. The wastes in these two subsystems will normally be collected and processed through separate evaporators; the condensates from each evaporator will be passed through common demineralizers, and collected in the evaporator condensate storage tanks. The two subsystems are normally isolated from each other; however, cross connection between the subsystems provides flexibility for processing by alternate methods. Treated wastes will be handled on a batch basis as required to permit optimum control and release of radioactive waste. Prior to the release of any treated liquid wastes, samples will be analyzed to determine the

type and amount of radioactivity in a batch. Based on the analytical results, these wastes will either be recycled, reprocessed, or released. Radiation monitoring equipment will automatically trip a valve on the discharge pipe terminating the release of liquid waste if the levels of activity are above a predetermined value.

The makeup and purification subsystem will maintain the quality of the primary coolant. A normal 45 gpm stream will be continuously let down, cooled, passed through a mixed-bed demineralizer, filtered and fed to the makeup tank from which it will be returned to the reactor or discharged. The boron concentration will be maintained by diverting a portion of the letdown stream to one of the three 76,000 gal bleed tanks. Equipment drains and miscellaneous high purity liquid wastes will also be collected in the bleed tanks. From the bleed tanks the radioactive liquid wastes will be processed through a cation demineralizer and the 12.5 gal reactor coolant evaporator. The condensate from the evaporator will be processed through a mixed-bed demineralizer and collected in one of the two 8,230 gal evaporator concensate storage tanks. After sampling, this liquid will be sent to the primary water storage tanks for recycling in the reactor or discharged to the river with the circulating water system.

Our evaluation assumed that 425 gal/day of deaerated wastes from the primary drain tank and 320 gal/day from the shim bleed for boron

control will be processed by the makeup and purification system and that 90% will be recycled and 10% discharged.

We estimate that approximately 0.5 Ci/yr excluding tritium and noble gases will be discharged from this source. The applicant did not estimate the release of radioactive material in liquid effluents by subsystems.

Aerated liquid wastes from the containment and auxiliary buildings, laboratory drains and sampling sources, demineralizer regeneration solutions and sluice, and other wastes will be collected in the 20,500 gal miscellaneous waste storage tank and processed by the 12.5 gpm miscellaneous waste evaporator. The condensate is processed through a mixed-bed demineralizer and collected in one of the evaporator condensate storage tanks. After sampling, this liquid will be sent to the primary waste storage tanks for recycling in the reactor or discharged to the river with the circulating water system.

Our evaluation assumed that 375 gal/day of aerated wastes will be processed by the evaporator and polishing demineralizer and that 100% of the distillate will be discharged. We estimate that approximately 0.12 Ci/yr excluding tritium and noble gases will be discharged from this source. The applicant did not estimate the release of radioactive material in liquid effluents by subsystems.

In addition to the sources listed above, we estimate slightly less than 0.1 Ci/yr will be released in untreated effluent from the turbine building drains and about 0.04 Ci/yr will be discharged from the laundry system. The applicant did not estimate the release of radioactive material in liquid effluents by subsystem.

We calculate that approximately 0.6 Ci/yr excluding tritium and dissolved gases will be discharged to the unrestricted area from the plant. To compensate for equipment downtime and expected operational occurrences, we have normalized our calculated release rate of radioactivity release in liquid effluents has been normalized to 5 Ci/yr, excluding tritium and dissolved gases. The applicant estimated 0.0025 Ci/yr of mixed radioisotopes will be discharged. Based on operating experience of other pressurized water reactors, we estimate that tritium releases will be approximately 350 Ci/yr. The applicant has also estimated that approximately 350 Ci/yr of tritium will be released.

Our estimates are based on a revised version of ORIGEN code which is adjusted to apply to this plant. The ORIGEN code is described in ORNL 4628, "Oak Ridge Isotope Generation and Depletion Code." The The waste stream activities and flows used in our evaluation are based on experience and data provided from operating reactors. The model uses somewhat different values for the parameters than those

of the applicant. The applicant has considered less volume being processed and discharged from the system, a lower release fraction of fission products and uses higher decontamination factors. Our calculated effluents are therefore different than the applicant's.

From our evaluation of the expected liquid radioactive releases we calculate a total whole body and organ dose of less than 5 mrem/yr. The applicant calculates a total whole body dose of 0.08 mrem/yr and a total critical organ dose of 0.016 mrem/yr. We conclude that the liquid radwaste system will reduce radioactive effluents to as low as practicable in accordance with 10 CFR Part 20 and 10 CFR Part 50.

11.3 Gaseous Waste

The gaseous waste treatment and ventilation systems will process waste gases from degassing of the primary coolant, auxiliary building ventilation, containment purging, and sweep gas for the various liquid tanks. The primary source of gaseous radioactive waste will be from the degassing of the primary coolant during letdown of the reactor coolant into the various holding tanks.

Gases stripped from the primary coolant letdown flow in the makeup and purification system, and from the deaerated wastes and shim bleed in the bleed tanks will be processed by the waste gas vent header system. This system is divided into two subsystems; one subsystem

in the auxiliary building and one subsystem in the containment building. Waste gases from the reactor coolant drain [illegible] in the containment building flow into the miscellaneous waste storage tank. The waste gases from the three reactor coolant bleed tanks and the miscellaneous waste storage tank discharge to the waste gas surge tank. The gas that will be removed from the circulating stream will be removed from the surge tank to one of the three decay tanks for holdup before processing through the charcoal and HEPA filters (gaseous waste disposal filters) and released to the containment building. All releases of the environment from the decay tanks will be monitored twice, once as it leaves the decay tanks and after it mixes with exhaust ventilation from the auxiliary building. Either monitor will terminate the gas discharge automatically when release of radioactive material exceeds that specified in the technical specifications.

Considering an annual average gas flow of 144 cu ft/day and a total storage capacity of approximately 20,000 cu ft in two of the three delay tanks, we calculate that approximately 135 days decay will be provided. In our evaluation, we assumed a minimum of 90 days holdup will be provided prior to release to the environment, as used by the applicant. The difference in the activity released after a delay of 90 days or 135 days is negligible since Kr-85 becomes the predominant isotope after 90 days delay which has a half-life of 10.7 yrs.

We estimate that approximately 650 Ci/yr of noble gases and less than negligible amounts of I-131 will be discharged from this source. The applicant estimates approximately 340 Ci/yr of noble gases and 5.3 x 10^{-13} Ci/yr of I-131 will be discharged.

The condenser air ejectors will remove gases which collect in the condenser. These gases will be vented directly to the atmosphere without treatment. There is no blowdown from the once-through type steam generators used in this plant. We calculate that approximately 970 Ci/yr of noble gases and 0.01 Ci/yr of I-131 will be discharged from the air ejector exhaust. The applicant estimates approximately 210 Ci/yr of noble gases and 4.6 x 10^{-5} Ci/yr of I-131 will be released.

Radioactive gases may be released in the auxiliary and turbine buildings due to equipment leaks. The ventilation system for the auxiliary building has been designed to insure that air flow will be from areas of low potential to areas having a greater potential for the release of airborne radioactivity. During normal operation the auxiliary building ventilation will draw air from the equipment rooms and open areas of the building through HEPA filter and charcoal adsorbers and discharge to the atmosphere through the plant vent. The turbine building is open and therefore not amenable to treat gaseous releases.

We calculate that approximately 970 Ci/yr of noble gases and 0.008 Ci/yr of I-131 from the auxiliary building, and small amounts of noble gases and 0.09 Ci/yr of I-131 from the turbine building, will be discharged from these sources. The applicant made no estimates of the release of radioactive material from the auxiliary building and the turbine building.

Radioactive gases may be released inside the reactor containment when components of the primary system are opened to the building atmosphere or when minor leaks occur in the primary system. The reactor containment atmosphere will be purged through charcoal and HEPA filters, and discharged to the containment building vent. Based on a composite leak of 40 gal/day in the containment building, we calculate that approximately 470 Ci/yr of noble gases and 0.11 Ci/yr of I-131 will be discharged from this source. The gaseous source terms are calculated by means of STEFFEG code as described in the F. T. Binford, et. al., report, "Analysis of Power Reactor Gaseous Waste Systems," 12th Air Cleaning Conference. The applicant estimates approximately 70 Ci/yr of noble gases and 0.0017 Ci/yr of I-131 will be discharged.

We calculate that a total of 3050 Ci/yr of noble gases and 0.13 Ci/yr of iodine-131 will be released to the unrestricted area by this plant. The applicant estimates about 620 Ci/yr of noble gases

and 0.0017 Ci/yr of iodine-131 will be released from the plant. These differences in estimates can be explained by the applicant not considering a source for auxiliary building leakage assuming a containment leak rate of 10 gpd rather than 40 gpd used in our evaluation, a fission product release of 0.1% rather than 0.25% used in our evaluation an an removel efficiency of 95% rather than 90% used in our evaluation.

From our evaluation of the gaseous radioactive releases to unrestricted areas, we calculate a total whole body and critical organ dose of less than 5 mrem/yr and less than 15 mrem/yr to a child's thyroid due to the pasture-cow-milk chain with the cow at the nearest dairy cow located 4 miles ENE of the plant. Based on our evaluation, we conclude that the gaseous radw[illegible] system will meet the low as practicable requirements of 10 CFR Pa[illegible]50 and 10 CFR Part 20.

11.4 Solid Radwaste

The solid radwaste system will be designed to collect, monitor, process, package, and provide temporary storage for radioactive solid wastes prior to offsite shipment and disposal in accordance with applicable regulations.

Spent demineralizer resins from the various treatment systems will be transferred to a spent resin storage tank. The resins will then be dewatered. The resin sluice water will be processed later by the aerated waste system. The spent resins will be discharged into a truck mounted shipping cask.

Evaporator concentrates are stored in the concentrated waste storage or concentrated boric acid tanks. From these tanks the concentrates will be pumped to an evaporator concentrates shipping container where it will be mixed with a solidifying absorbent.

Expended filter cartridges will be placed into a shielded drum for storage and offsite shipment. Other dry solid wastes consisting of contaminated rags, paper, protective clothing and miscellaneous contaminated items will be packaged in drums or other suitable containers for disposal.

Containers will be filled and sealed by remote control when the radiation levels so require. All containers will be contained and shipped in accordance with AEC and Department of Transportation (DOT) regulations.

The staff estimates approximately 15,000 Ci/yr of solid wastes will be shipped offsite. We find the proposed system acceptable.

11.5 Design

Decay tanks and surge tanks are designed to meet ASME Class III, Section C and seismic Category I requirements. The tanks, demineralizers, and evaporators in the liquid radwaste system are designed to meet ASME, Class III, Section C and seismic Category I requirements. All piping is designed to USAS B31.1-1967, but is fabricated and installed in accordance with USAS B31.7 Class N3.

We conclude that the radwaste system design codes are in accordance with appropriate codes and standards and are acceptable.

11.6 Process and Area Radiation Monitoring Systems

The process radiation monitoring system is designed to provide information on radioactivity levels of systems throughout the plant, on leakage from one system to another, and on levels of radioactivity released to the environment. The system will consist of particulate, iodine, and gross activity monitors and samplers for auxiliary building exhaust, fuel building exhaust, nuclear sample room exhaust, radiochemical laboratory exhaust, and spent fuel area exhaust. The final discharge point for all gaseous releases from the plant will be through the containment purge exhaust or the auxiliary building exhaust. Other gaseous process monitors located within the plant measure the activity for control room ventilation intake, containment, waste gas decay tank, condenser vacuum pump exhaust, and gas sampling station. The liquid process monitors located within the plant measure the activity for the primary letdown coolant, spent fuel cooling water, decay heat closed cooling water, nuclear services closed cooling water, and the final monitor on the plant discharge line.

The area radiation monitoring system is designed to provide information on radioactivity fields in various areas with the plant. The system will consist of 19 monitors at the following locations

in the plant: control room, radiochemical laboratory, sample room, auxiliary building, and the containment building.

The system will detect, indicate, annunciate and/or record the levels or fields of activity to verify compliance with 10 CFR Part 20 and keep the radiation levels as low as practicable. We conclude that the plant is adequately provided with process and area monitoring equipment.

11.7 Radiation Protection Management

The objective of radiation protection is to ensure that radiation exposure to station personnel is as low as practicable. The applicant will establish health physics procedures under the direction of the health physics supervisor which will assure that all requirements related to radiation protection are followed by all station personnel. These procedures will provide rules for personnel monitoring, use of protective clothing and equipment and will require that a radiation work permit be obtained for certain areas of potential exposure. Supporting data regarding the effectiveness of the health physics program will be obtained through the collection of bioassay samples, comprehensive medical examinations and film badge or thermal luminescence dosimeter (TLD) data.

All areas within the plant will be identified by different radiation zones in accordance with the expected maximum occupancy. The applicant will provide four areas of radiation control within the plant during full power operation according to maximum design radiation dose rate. These are: Zone 0, continuous access, 0.5 mrem/hr or less; Zone I, periodic access, 2.5 mrem/hr or less; Zone II, limited access, 15 mrem/hr or less; and Zone III, controlled access, general, 25 mrem/hr or less, and Zone IV, restricted access, greater than 25 mrem/hr. These areas will be identified by radiation caution signs.

Personnel monitoring equipment shall be provided for all personnel at the plant. Records showing the radiation exposures of all personnel at the plant will be maintained by the applicant. Neutron film badges will be provided whenever neutron exposures are expected. Bioassays will be made as necessary to determine internal exposures to plant personnel. Protective clothing and respiratory protective equipment will be available for the protection of personnel, when required. Portable radiation monitoring instruments will be available to determine exposure rates and contamination levels in the plant.

The applicant's design objective for radiation shielding for normal operation is to maintain whole body dose rates for all controlled access areas of the plant to less than 1.25 rem per calendar quarter,

considering occupancy of each controlled access area. For areas outside the plant, the shielding design objective is to maintain whole body rates to less than 0.5 rem per calendar year. The principal shielding material used in the plant is ordinary concrete. Other material will be used by the applicant for special situations. Equipment, pumps, valves, and pipes that will contain significant levels of radioactive material will be segregated into modules by shield walls to minimize radiation exposures from maintenance of these items. We conclude that precautions taken for personnel protection satisfy the requirements of existing regulations as pertains to exposure of individuals to radiation, and are acceptable.

11.8 Conclusions

Based on our model and assumptions, we calculate an expected whole body and critical organ dose of less than 10 mrem/yr to an individual from gases and less than 5 mrem/yr from liquids at or beyond the site boundary. We calculate the potential dose to a child's thyroid from the pasture-cow-milk chain to be less than 15 mrem. Therefore, we conclude that the liquid, gas and solid waste treatment systems meet the requirements of "as low as practicable."

We also conclude that the system is designed in accordance with acceptable codes and standards, that the process monitoring system is adequate for monitoring effluent discharge paths as specified in

Criterion 64 of 10 CFR Part 50, and personnel protection systems satisfy the requirements of existing regulations as pertain to exposure of individuals to radiation.