11 RADIOACTIVE WASTE
AND RADIATION PROTECTION

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11. RADIOACTIVE WASTES AND RADIATION PROTECTION

11.1 RADIOACTIVE WASTES

11.1.1 SCOPE

The radioactive waste treatment system is designed to collect, store, process and monitor all liquids, gases and solids which are potentially radioactive. The system permits controlled release of radioactivity to the environment in accordance with 10 CFR, Part 20, other applicable governmental regulations, and the Arkansas State Board of Health Rules and Regulations for Control of Sources of Ionizing Radiation (1), Sections 3 and 5. Wherever reference is made to 10 CFR 20, it is to include the Arkansas State Board of Health Regulations. All potentially radioactive liquids which may be discharged to the environment are sampled and analyzed on a batch basis prior to discharge and are monitored during discharge. Gates are continually monitored by monitoring equipment using two channels.

11.1.2 DESIGN BASIS

11.1.2.1 Waste Activity

Activity accumulation in the reactor coolant system and associated waste handling equipment has been determined on the basis of fission product leakage through clad defects in 1 per cent of the fuel. The activity levels were computed assuming ultimate core power operation of 2568 MWt for two core cycles with no defective fuel followed by operation during the 3rd core cycle with 1 per cent defective fuel. Continuous reactor purification at a rate of one reactor system volume per day was used with a zero removal efficiency for Kr, Xe, Cs, Mo, and Y, and a 99 per cent removal efficiency for all other nuclides except Te, all Te is assumed to plate out on system surfaces. Activity levels are relatively insensitive to small changes in demineralizer efficiencies, e.g., use of 90 per cent instead of 99 per cent would result in only about a 10 per cent increase in the coolant activity. Activity reduction by lifetime shim bleed was also considered, since none of the coolant bleed is returned to the system.

The quantity of fission products released to the reactor coolant during steady state operation is based on the use of "escape rate coefficients" as determined from experiments involving purposely defected fuel elements (2, 3, 4, 5). Values of the escape rate coefficients used in the calculations are shown in Table 11-2.

Calculations of the activity released from the fuel were performed with a digital computer code which solves the differential equations for a five-member radioactive chain for buildup in the fuel, release to the coolant, removal from the coolant by purification and leakage, and collection on a resin or in a hold-up tank. The activity levels in the reactor coolant during operation at the end of 100 ultimate power days during the 3rd core cycle are shown in Table 11-3.

The liquid waste generated by leakage, sampling, and demineralizer sluice or rinse is assumed to have an activity concentration equal to the concentration in the reactor coolant. Reactor coolant bleed is taken from the downstream side of the purification demineralizer. It is assumed to have the same activity concentration as the reactor coolant reduced by the decontamination factor of the purification demineralizer. Laundry and shower wastes are assumed to contain relatively small amounts of radioactivity.

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The major part of the gaseous activity is generated by the degasification of radioactive gases from liquids prior to their storage in waste receiver tanks. Therefore, the activity of the gases is dependent upon the liquid activity. The assumptions for liquid activity are described above.

11.1.2.2 Sources of Radioactive Wastes

The major sources of liquid waste are bleed-off of the primary coolant during a reduction in primary coolant boron concentration, and an increase in coolant volume due to heat-up of the primary system.

Other sources of liquid waste are equipment drains, low point drains, resin bed flushing operations, leakage from pumps and valves, laundry drains, laboratory drains, and drains from decontamination operations.

The sources of gaseous waste are primary system vents, equipment and tank vents, purging from the sampling system and the vacuum degasifier.

The sources of solid waste are demineralizer resins, filter elements, contaminated clothing, contaminated equipment, and paper, rags and plastics used in decontamination and contamination control.

11.1.2.3 Waste Quantities

The estimated annual quantities of liquid, gaseous and solid wastes accumulated during a normal operating cycle are tabulated in Table 11.1. An operating cycle is defined as:

Refuel and start-up.
One cold shutdown and restart immediately following initial full power operation.
Four hot shutdowns and restarts with one occurring within the last 30 days of core life.
One cold shutdown and drain for primary coolant loop maintenance followed by restart, occurring after the third hot shutdown and restart.

11.1.2.4 Methods of Disposal

Disposal of all wastes will be in accordance with 10 CFR 20 and other applicable governmental regulations.

Liquid wastes are collected, held up for decay, processed, analyzed, and released to the plant discharge canal at a controlled release rate.

Gaseous wastes are disposed of by:

a. Continuous dilution and discharge through waste gas filters to the station vent with sweep gas being drawn through tank voids.

b. Diversion to waste gas holdup tanks with sampling and controlled subsequent release through waste gas filters to the station vent.

Solid wastes are collected, prepared for off-site disposal as necessary, and stored. A shipper licensed to perform off-site disposal of such wastes will periodically remove these wastes.

11.1.2.5 Shielding

Shielding for the components of the waste disposal system will be designed on the basis of system activity levels with 1 per cent failed fuel. Most of the radwaste system components are located in the auxiliary building. The shield design criteria for the auxiliary building is a dose rate of up to 2.5 mrem/hr. in normally controlled and fully accessible areas, up to 15 and 100 mrem/hr. in areas requiring limited access, and above 100 mrem/hr. for inaccessible areas. The components of the waste disposal system will be shielded by concrete walls and floors of varying thickness depending on the magnitudes of the sources in each component and on the access requirements in that particular area. In some areas local shielding in the form of removable concrete blocks will be utilized to facilitate maintenance or repair operations.

11.1.3 SYSTEM DESIGN AND EVALUATION

The radioactive waste treatment systems are shown on Figures 11.1 and 11.2.

11.1.3.1 Liquid Waste

Liquid wastes are processed as follows:

1) Reactor Coolant Liquid Waste

When bleed and feed operation is used to regulate the concentration of boron in the reactor system, the stream is bled to the clean waste receiver tanks for processing through the radwaste demineralizers.

The reactor coolant bleed stream is routed through a vacuum degasifier to the clean waste receiver tanks. These tanks will normally be used for collecting, holding and processing the liquids. Pumps recirculate and/or transfer the liquid between tanks. The wastes will be processed through radwaste demineralizers for removal of radioactivity and collected in one of two waste monitor tanks. After these wastes are sampled and analyzed, they will be normally discharged to the main condenser circulating water discharge canal.

2) Equipment Drains

Equipment drains and other drains which contain reactor coolant are first collected in drain tanks, monitored and then pumped to the clean waste receiver tanks for processing with the normal bleed stream.

3) Dirty Wastes and Floor Drains

These normally low activity wastes are first received in the decontamination area drain tank, from which they are pumped through a filter for removal of particulates, and then to the filtered waste monitor tank. From this tank, the liquid can be discharged to the circulating water discharge canal or returned to the system for further processing.

4) Laundry Wastes

Laundry drains are collected for holdup and monitoring prior to batch disposal to the circulating water discharge canal.

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11.1.3.2 Gaseous Waste

Gases vented from the various components handling the reactor coolant and the vacuum degasifier are collected in the waste gas surge tank. Normally, gases will be monitored and continuously released directly to the station vent. Equipment is provided, however, to compress and hold up the gases. Gas from the gas surge tank can be compressed by a gas compressor and stored in a waste gas storage tank. After an appropriate decay period, these gases are again monitored and released to the station vent at a controlled rate.

11.1.3.3 Solid Waste

Radioactive spent resins sluiced from demineralizers are collected and stored in the spent resin holdup tank until a quantity sufficient for disposal is accumulated. The tank is sized for at least a one-year accumulation. The holdup tank is arranged with pump-out connections for resin transfer to portable disposal containers.

Other solid wastes are removed to the solid waste storage area for eventual packaging, using a baler, into ICC approved containers and shipment to an off-site disposal facility.

11.1.3.4 Radiation Monitoring

Radiation monitoring of station effluents will include alarms and indicators designed to provide early warning of possible equipment malfunctions or potential biological hazards. Station effluents will be monitored to insure that prescribed limits of radiation release are not exceeded. The release of gaseous and liquid effluents will be controlled within the limits of 10 CFR 20 and other applicable governmental regulations. All solid waste will be monitored prior to off-site shipment to meet the requirements of applicable regulations for the transport of radioactive materials.

(a) Liquid Monitors

The liquid process flow monitoring system will be of a gamma scintillation type liquid monitor. The output from the rate meter will be recorded and also activate an alarm in the control room if the activity is above a preset value. The monitors will continuously survey:

1. The liquid wastes being discharged into the circulating water discharge
2. The circulating water discharge canal
3. The service water effluent
4. The intermediate cooling system

(b) Gaseous Monitors

The gaseous effluent and containment monitoring system will be a scintillation type detector. The output from the rate meter will be recorded

and also activate an alarm in the control room if the activity is above a preset value. The monitors will continuously survey:

1. The condenser air ejector discharge (single-channel)
2. The containment building (single-channel)
3. The waste gases being discharged into the station vent (single-channel)
4. The station vent (two-channel, one for stack gas and the other for stack gas particulates)

These radiation monitors are commercially available equipment. The required characteristics will be established during detailed station design. The minimum sensitivity of detectors, when combined with appropriate dilution factors, will insure safe limits of release.

11.1.3.5 Reliability

To release liquid or gaseous waste effluents to the environment, two valves in series must be opened. As these effluents leave the waste disposal system, they are continuously monitored. If the radioactivity level approaches maximum permissible limits, a signal from the line monitor automatically closes the downstream discharge valve.

Backup monitoring of gases is provided by the station vent monitors. Backup monitoring of liquids is provided by a continuous discharge canal monitor. Excessive radiation levels at either of the monitoring stations is alarmed in the control room.

11.1.3.6 Design Evaluation

All analyses on liquid and gaseous waste disposal were performed with 1 per cent failed fuel. Although it is not expected that the number of clad defects will ever approach 1 per cent of the total fuel, the objective is to demonstrate the capability of safe station operation within the limits of 10 CFR 20 with quantities of radioactive fission products in the system.

A summary of the various operations consideered in the analyses, and the total concentrations resulting in the station effluents from operations with failed fuel, are given in Table 11-4. It has been conservatively estimated that an activity reduction factor of 1500 will exist in the radwaste system due to decay in the holdup tanks and passage through two demineralizers in series. The activity concentrations resulting are given as fractions of the MPC for unrestricted areas, i.e., the concentration of each radioactive nuclide has been divided by its respective concentration as set forth in 10 CFR 20.

11.1.4 RADIOACTIVE WASTE DISPOSAL SYSTEM FAILURES

The possibility of a significant activity release off the site from accidents in either the solid or the liquid waste disposal equipment is extremely remote. The systems are located in shielded, controlled-access areas with provisions for maintaining contamination control in the event of spills or leakage. Solid wastes are disposed of by licensed contractors in accordance with ICC regulations.

Liquid wastes are sampled prior to discharge and are monitored during discharge to insure compliance with 10 CFR 20. A tabulation of potential waste disposal system failures and their consequences is presented in Table 11-5.

Radioactive gases are sampled and discharged in compliance with the requirements of 10 CFR 20. In the event of waste gas decay tank failure these gases would be released to the decay tank compartment, and then released to the station vent via the normal ventilation system.

The maximum activity in a waste gas decay tank will occur following a cold shutdown. The reactor coolant water activity used for the analysis assumes prior operation for an extended period with failed fuel rods, equivalent to exposure of 1 per cent of the fuel. Approximately 0.8 of an equivalent reactor coolant system volume would be let down at this time. It is assumed that the purification demineralizers have a removal factor of only 100 for iodine, although factors of 10^3 to 10^4 have been reported in the literature. Only the noble gases (Kr & Xe) will be stripped from the reactor coolant bleed stream in the vacuum degasifier. The degasifier is a packed column which provides a means for mixing of the gas and liquid phases. Since iodine is soluble in water it will remain with the liquid rather than being released along with the noble gases.

The area surrounding the waste gas decay tanks is ventilated and discharges to the station vent. The discharge from the station vent is conservatively assumed to mix in the wake of the building structures rather than remain at its elevated release point. This assumption produces less favorable dilution and therefore, higher ground concentrations at the exclusion distance. Also, with this assumption, the doses at the exclusion distance are essentially the same whether or not the ventilation system is operating.

The activity from a waste gas tank failure is assumed to be released as a puff from the station vent. Atmospheric dilution is calculated using the two-hour meteorological model discussed in 14.2.2.3.6. The total integrated dose to the whole body at the 0.65 mile exclusion distance is 1.23 REM. This dose is well below the guideline values of 10 CFR 100.

11.1.5 TESTS AND INSPECTIONS

Functional operational tests and inspections of the Waste Disposal System will be made as required to insure performance consistent with the requirements of 10 CFR 20.

11.1.6 REFERENCES

(1) Arkansas State Board of Health, Rules and Regulations for Control of Sources of Ionizing Radiation, Little Rock, Arkansas, May 1966.

(2) Frank, P. W., et al., Radiochemistry of Third PWR Fuel Material Test - X-1 Loop NRX Reactor, WAPD-TM-29, February 1957.

(3) Eichenberg, J. E., et al., Effects of Irradiation on Bulk UO_2, WAPD-183, October 1957.

(4) Allison, G. M. and Robertson, R. F. S., The Behavior of Fission Products in Pressurized-Water Systems. A Review of Defect Tests on UO_2 Fuel Elements at Chalk River, AECL-1338, 1961.

(5) Allison, G. M. and Roe, H. K., The Release of Fission Gases & Iodines from Defected UO_2 Fuel Elements of Different Lengths, AECL-2206, June 1965.

11.2 RADIATION PROTECTION

11.2.1 PRIMARY, SECONDARY, AND REACTOR BUILDING SHIELDING

11.2.1.1 Design Bases

The shielding is designed to perform two primary functions: (1) to insure that during normal operation the radiation dose to operating personnel and to the general public is within the limits set forth in 10 CFR 20, and (2) to insure that operating personnel are adequately protected in the event of a reactor accident so that the accident can be terminated without undue hazard to the general public. The shielding design is based on operating at the ultimate expected power level of 2,568 MWT with system activity levels equivalent to 1 per cent failed fuel, and is governed by the following criteria for radiation levels.

(See Table, Next Page)

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DURING NORMAL FULL POWER OPERATION

Area Zone Designation	Design Dose Rate in mrem/hr	Description of Access Conditions
I	≤1.0	Uncontrolled, unlimited access.
II	≤2.5	Controlled, limited access.
III	≤15	Controlled, limited access for routine tasks.
IV	≤100	Controlled, limited access for short period.
V	>100	Normally inaccessible. Controlled access for short periods of less than one hour. Access during emergencies.
Site Boundary	Design dose rate based on a continuous exposure.	0.05 mrem/hr

DURING MAXIMUM HYPOTHETICAL ACCIDENT

Site Boundary	Radiation exposures for the two hours immediately following onset of the accident shall not exceed 25 REM to the whole body.
Control Room	Shielding design will provide protection only inside the plant-control room. Radiation exposures to plant personnel during the 30-day period of the postulated accident shall not exceed 25 REM to the whole body. This shall include exposures received (1) while entering and leaving the premises and (2) during short-time excursions to emergency equipment for correction of unforeseen malfunctions.

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11.2.1.2 Description

11.2.1.2.1 Reactor Building Primary and Secondary Shielding

The reactor building containment shielding is a reinforced, prestressed concrete structure with a cylindrical wall and a spherical dome. In conjunction with the primary shield which surrounds the reactor vessel and the primary coolant loop equipment and components, it will limit the exposure level outside the reactor building from all radiation sources inside the reactor building to no more than 1.0 mrem/hr at full power operation. The reactor building containment shield is also designed to protect station personnel from the contained activity inside the reactor building following an MHA.

Containment shielding, in addition to shielding surrounding the plant control room, will insure that exposures to operating personnel are less than 25 REM for the duration of an MHA.

Secondary shielding at the "air space," which is the only accessible area inside the reactor containment during operation, will protect personnel both during operation and shut-down.

Auxiliary Building Primary and Secondary Shielding -- The primary shielding in the auxiliary building is located at the spent fuel pool and the spent fuel transfer tube. All other shielding inside the auxilliary building is secondary in nature.

11.2.1.2.2 Materials

The material used for the primary, secondary, and reactor building shields is ordinary concrete with a density of approximately 145 lbs/ft^3. Since the primary and secondary shielding walls serve as the refueling structure, give support for the reactor coolant components under pipe rupture conditions, and provide missile shielding, they are reinforced and designed to be self-supporting.

11.2.1.3 Evaluation

11.2.1.3.1 Radiation Sources

Gamma-ray yield and spectral distributions from prompt fission and gross fission product activity are based on the information in Volume III, Part B, of the Reactor Handbook. The yield and spectral data for capture gammas are taken from ANL-5800, Reactor Physics Constants, and the Reactor Handbook. Data on activation product gamma rays are derived primarily from the Review of Modern Physics, Vol. 30, No. 2, April 1958. The production of N-16 in the reactor coolant is calculated with a code by the Babcock & Wilcox Company which computes the integral of the O-16 (n,p) N-16 cross-section over the neutron flux in a water-cooled reactor, subject to variables in coolant flow and density and in neutron flux spectra and magnitude. The O-16 (n,p) N-16 cross-section used is that reported in WAPD-BT-25. Activities of individual fission products in the core, reactor, coolant, and reactor auxiliary systems are determined by a B&W computer code designed to predict activities from a five-member radioactive chain at any point in the core history. Fission product leakage from the core to the coolant, and removal from the coolant by purification and leakage, are calculated.

11.2.1.3.2 CALCULATION METHODS

Neutron and gamma ray penetration and attenuation calculations will be performed by hand as well as by computer programs. Hand and computer calculations will be made using well-established and well-proven methods and mathematics.

11.2.1.3.3 MHA DOSE CALCULATION

The thickness of the reactor building shielding, in accordance with the design dose rate criteria, is based upon radiation levels due to fission product release following a reactor accident. For the calculations it was assumed that 100 per cent of the noble gases, 50 per cent of the halogens, and 1 per cent of the solid fission products were instantaneously released to the reactor building following a buildup period in the core of 600 ultimate power (2,568 MWt) days.

The fission product activity was assumed to be uniformly dispersed throughout the reactor building volume, and the reactor building was represented by a cylindrical source for the dose calculations. The integrated dose over various time intervals was computed as a function of distance from the reactor building. The results are given in 14.2.2.4.

11.2.1.3.4 OPERATING LIMITS

All parameters governing the shield design, including heating and dose rate profiles, temperature distributions, and coolant flow requirements, will be performed during the detailed design of the station.

11.2.1.3.5 RADIATION SURVEYS

Neutron and gamma radiation surveys will be performed in all accessible areas of the station as required to determine shielding integrity. Plans and procedures for radiation surveys during operation and following shutdown will be formulated during the detailed station design.

11.2.2 AREA RADIATION MONITORING SYSTEM

11.2.2.1 DESIGN BASES

The area radiation monitoring system will be designed to indicate and alarm high radiation levels inside the station. Indication from the beta-gamma detectors located in selected areas of the station will be used in conjunction with operating procedures to assure that personnel exposure does not exceed 10 CFR 20 limits.

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11.2.3 HEALTH PHYSICS

The station superintendent is responsible for radiation protection and contamination control for the Russellville Nuclear Unit. This responsibility is, in turn, shared by all supervisors. All personnel assigned to the station and all visitors will be required to follow rules and procedures established by administrative control for protection against radiation and contamination.

The administration of the radiation protection program will be the responsibility of the station Chemical and Radiation Engineer. It will be the responsibility of the Chemistry and Radiation section to train station personnel in radiation safety; to locate, measure and evaluate radiological problems; and to make recommendations for control or elimination of radiation hazards. The Chemistry and Radiation section will function in an advisory capacity to assist all personnel in carrying out their radiation safety responsibilities and to audit all aspects of station operation and maintenance to assure safe conditions and compliance with AEC and other federal and state regulations concerning radiation protection.

Administrative controls will be established to assure that all procedures and requirements relating to radiation protection are followed by all station personnel. The procedures that control radiation exposure will be subject to the same review and approval as those that govern all other station procedures (see Section 12.5, Administrative Control). These procedures will include a Radiation Work Permit system. All work on systems or locations where exposure to radiation or radioactive materials is or may be involved will require an appropriate Radiation Work Permit initiated by Chemistry and Radiation and approved by cognizant supervisors before work can begin. The radiological hazards associated with the job will be determined and evaluated prior to issuing the permit. The work permit will list the precautions to be taken, the protective clothing to be worn and any other radiation control and safety precautions that may be required.

11.2.3.1 PERSONNEL MONITORING SYSTEMS

Personnel monitoring equipment consisting of film badges or their equivalent will be assigned by the Chemistry and Radiation section and worn by all personnel at the Russellvile Nuclear Unit. In addition, those persons who ordinarily work in restricted areas or whose job requires frequent access to these areas will have pocket chambers, self-reading dosimeters, pocket high-radiation alarms, wrist badges and finger tabs readily available for use, when required by station conditions. This personnel monitoring equipment will also be available on a day-to-day basis for those persons, employees, or visitors not assigned to the station who have occasion to enter Restricted Areas or to perform work involving possible exposure to radiation. Records of radiation exposure history and current occupational exposure will be maintained by the Chemistry and Radiation section for each individual for whom personnel monitoring is required. The external radiation dose to personnel will be determined on a daily and/or weekly basis, as required, by means of the pocket chamber and dosimeter. Film badges will be processed monthly or more frequently when conditions indicate it is necessary.

11.2.3.2 PERSONNEL PROTECTIVE EQUIPMENT

Special "protective" or "anticontamination" clothing will be furnished and worn as necessary to protect personnel against contact with radioactive contamination. Change Rooms will be conveniently located for proper utilization of this protective clothing. Respiratory protective equipment will also be available for the protection of personnel against airborne radioactive contamination and will consist of full face filter masks, self-contained air-breathing units, or air-supplied masks and hoods. The first line of defense against airborne contamination in the work area is the ventilation system. However, respiratory protective equipment will be provided should its use become necessary.

Maintenance of the above equipment will be in accordance with the manufacturer's recommendations and rules of good practice such as those published by the American Industrial Hygiene Association in its "Respiratory Protective Devices Manual". The use and maintenance of this equipment will be under the direct control of the Chemistry and Radiation section, and personnel will be trained in the use of this equipment before using it in the performance of work.

11.2.3.3 CHANGE ROOM FACILITIES

Change room facilities will be provided where personnel may obtain clean protective clothing required for station work. These facilities will be divided into "clean" and "contaminated" sections. The "contaminated" section of the change rooms will be used for the removal and handling of contaminated protective clothing after use. Showers, sinks, and necessary monitoring equipment also will be provided in the change areas to aid in the decontamination of personnel.

Equipment decontamination facilities will also be provided at the station for large and small items of plant equipment and components.

Provision will also be made for decontamination of work areas throughout the station.

In order to protect personnel from access to high radiation areas that may exist temporarily or semipermanently as a result of station operations and maintenance, warning signs, audible and visual indicators, barricades, and locked doors will be used as necessary.

11.2.3.4 CHEMISTRY AND RADIATION LABORATORY FACILITIES

The station will include a laboratory with facilities and equipment for detecting, analyzing, and measuring all types of radiation and for evaluating any radiological problem which may be anticipated. Counting equipment(such as G-M, scintillation, and proportional counters) will be provided in an appropriate shielded counting room for detecting and measuring all types of radiation as well as equipment (such as a multichannel analyzer) for the identification of specific radionuclides. Equipment and facilities for analyzing environmental survey and bioassay samples will also be included in the Chemistry and Radiation Laboratory. Maintenance and use of the Chemistry and Radiation Laboratory facilities and equipment will be the responsibility of the Chemistry and Radiation section.

11.2.3.5 CHEMISTRY AND RADIATION INSTRUMENTATION

Portable radiation survey instruments will be provided for use by the Chemistry and Radiation section as well as for operating and maintenance personnel. A variety of instruments will be selected to cover the entire spectrum of radiation measurement problems anticipated at the Russellville Nuclear Unit. Sufficient quantities will be obtained to allow for use, calibration, maintenance, and repair. This will include instruments for detecting and measuring alpha, beta, gamma, and neutron radiation. In addition to the portable radiation monitoring instruments, fixed monitoring instruments, i.e., count rate meters, will be located at exits from restricted areas. These instruments are intended to prevent any contamination on personnel, material, or equipment from being spread into unrestricted areas. Appropriate monitoring instruments will also be available at various locations within the restricted areas for contamination control purposes. Portal monitors will also be utilized, as appropriate, to control personnel egress from restricted areas or from the station.

The station will have a permanently-installed remote radiation and radioactivity monitoring system for locations where significant levels can be expected. This system will monitor airborne particulate and gaseous radioactivity as well as external radiation levels. This system will present an audible alarm and radiation level indication in the area of concern in addition to an alarm in the control room.

11.2.3.6 MEDICAL PROGRAMS

A comprehensive medical examination program appropriate for radiation workers will be conducted to establish and maintain records of the physical status of each employee at the Russellville Nuclear Unit. Subsequent medical examinations will be held as determined necessary for radiation workers. Medical doctors, preferably in the local area, will be used for this program. The Chemical and Radiation section will be responsible for the program and will assist the physicians in maintaining medical control of personnel. This program will be designed to preserve the health of the employees concerned and to confirm the radiation control methods employed at the station.

11.2.3.7 EVACUATION PROCEDURE

A detailed evacuation procedure will be formulated and followed in the event radioactive products are released to the surroundings in an amount that would be harmful to the public. Local appropriate agencies are being contacted for their cooperation in evacuation of affected areas on land or water.

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TABLE 11-1

ESTIMATED ANNUAL ACCUMULATIONS OF RADIOACTIVE WASTES

Forms of Waste	Accumulations
Liquid (gals)	450,000
Gaseous (scf)	5,000
Solid (cu ft)	200

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TABLE 11-2

Escape Rate Coefficients for Fission Product Release

Element	Escape Rate Coefficient, Sec^{-1}
Xe	1.0×10^{-7}
Kr	1.0×10^{-7}
I	2.0×10^{-8}
Br	2.0×10^{-8}
Cs	2.0×10^{-8}
Rb	2.0×10^{-8}
Mo	4.0×10^{-9}
Te	4.0×10^{-9}
Sr	2.0×10^{-10}
Ba	2.0×10^{-10}
Zr	1.0×10^{-11}
Ce and other rare earths	1.0×10^{-11}

TABLE 11-3

Reactor Coolant Activities From One Per Cent Defective Fuel

Isotope	Activity, μc/ml	Isotope	Activity, μc/ml
Kr 85m	1.5	I 131	3.2
Kr 85	9.8	I 132	4.7
Kr 87	.84	I 133	3.8
Kr 88	2.7	I 134	.50
Rb 88	2.7	I 135	2.7
Sr 89	.041	Cs 136	.76
Sr 90	.0029	Cs 137	26
Sr 91	.046	Cs 138	.74
Sr 92	.017	Mo 99	5.4
Xe 131m	2.0	Ba 139	.081
Xe 133m	2.7	Ba 140	.065
Xe 133	243	La 140	.021
Xe 135m	.94	Ce 144	.0027
Xe 135	5.6	Y 90	.26
Xe 138	.51	Y 91	.18

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Tables 11-2, 11-3

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TABLE 11-4

Maximum Activity Concentrations in the Station Effluent
Operating with One Per Cent Failed Fuel

Liquid Waste

Operation	Yearly Average Concentration in Discharge, Fraction of MPC
Lifetime Shim Bleed Including Startup Expansion and Dilutions	0.42

Gaseous Wastes

Operation	Yearly Average Concentration at Site Boundary, Fraction of MPC
Lifetime Shim Bleed including Startup Expansion and Dilution and Venting of Letdown Storage Tank	0.02
Steam Generator Tube Leakage of 1 GPM	0.20

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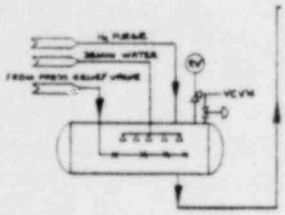
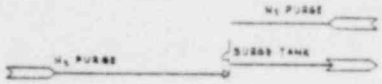
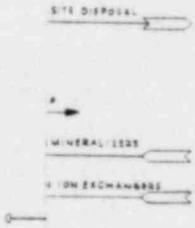
TABLE 11-5

WASTE DISPOSAL SYSTEM FAILURE ANALYSIS

Component	Failure	Comments and Consequences
Reactor Building Sump Drain Valve (inside or outside)	Fails to close.	Backup isolation is provided on opposite side of reactor building.
Reactor Building Drain Line Valve (inside or outside)	Fails to open.	Continuous drainage is not required; the valve is located for maintenance during operation.
Reactor Building Sump Pump	Fails to operate.	Continuous operation is not required; located for maintenance during operation.
Reactor Coolant Drain Tank Vent Valve	Fails to open.	Continuous venting is not required; relief protection is provided for tank.
	Fails to close.	Vent gas is conveyed to waste gas decay tank and discharged through filters to station vent.
Waste Gas Vent Filters	Rupture or lose efficiency.	High activity level monitored and alarmed if insufficient Station vent dilution is available. Waste gas is diverted to waste gas decay tanks.
Waste Gas Decay Tanks	Leak or rupture.	Building purged to station vent through filters. Tanks are protected by relief valves.
Clean Waste Receiver Tanks	Leak	Leakage is collected in auxiliary building drain sump for process or disposal; building is continuously purged to station vent.
Demineralizer Train	Fails to operate.	Continuous operation is not required; waste decay tanks provide for waste collection during maintenance.



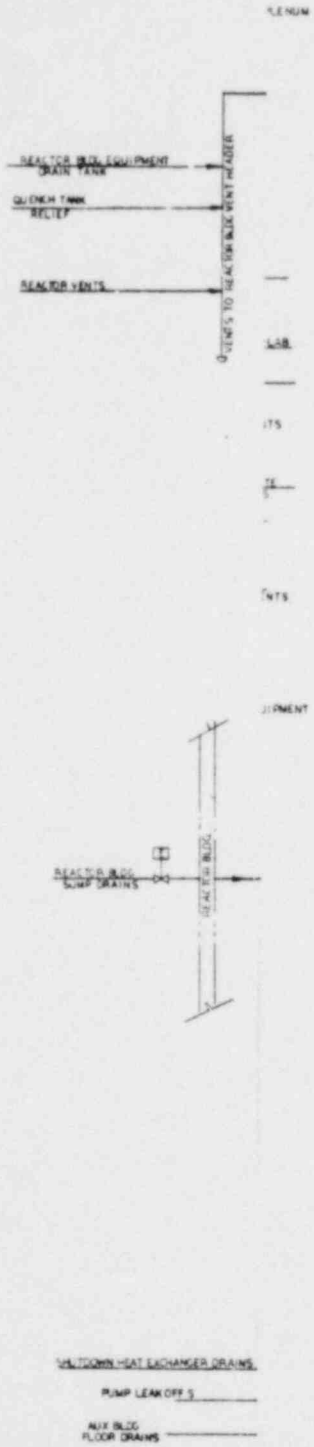




WASTE DISPOSAL

CLEAN RADIOACTIVE

Figure 11-1



GASEOUS AND DIRTY
RADIOACTIVE WASTE
DISPOSAL SYSTEM

Figure 11-2