Report Number: EI/NNI-77-7-P, Revision 1

Report Title: RWR-1 Radwaste Volume Reduction System

Report Date: October 1980

Originating Organization: Newport News Industrial Corporation (NNI)

Reviewed By: Effluent Treatment Systems Branch, Radiological Assessment Branch, and the Chemical Engineering Branch

1.0 Summary of Topical Report

The RWR-1 system is a volume reduction system which utilizes the fluidized bed technology to incinerate or calcine radioactive wastes within a process vessel. These wastes include evaporator bottoms, spent resin slurries, filter sludges and dry combustible trash.

The topical report addresses the design bases for the RWR-1 system, the system layout and its operation. In addition, the report discusses the safety implications of the system, radiation protection both on-site and off-site and incorporates various appendices which expand the discussion of some of the topics presented in the body of the report. The appendices include discussions of the bases for material selection, a fire and pressure excursion analysis, experimental results of a pilot plant, a safety analysis and radiation protection.

The principal findings presented in the report are that:

(1) the RWR-1 system is capable of reducing the volume of spent resin slurries, filter sludges, evaporator bottoms and compactible trash generated at a nuclear power plant;

(2) volume reduction utilizing the RWR-1 system can be accomplished with reasonable certainty that the contribution to off-site doses will not result in the total dose impact from a nuclear power plant exceeding the applicable requirements of 10 CFR Part 20, 10 CFR Part 50, or 40 CFR 190;

(3) operation of the RWR-1 system can occur without jeopardizing the operation of the remainder of the plant, its safety and the health and safety of the general public;

(4) the RWR-1 system can be operated within the in-plant ALARA criteria of Regulatory Guide 8.8; and

(5) the RWR-1 system will meet the appropriate fire protection criteria of Regulatory Guide 1.120, however, compliance with Branch Technical Position CMEB 9.5-1 (NUREG-0800, July 1981) must be addressed in a plant specific basis.

2.0 Summary of Regulatory Evaluation

The staff's review of the RWR-1 topical report encompasses (1) the design bases for the system; (2) the system layout, its components and the instrumentation and control associated with it; (3) the operation of the system including shutdown, startup, and maintenance; (4) an analysis of various potential accidents involving the RWR-1; (5) impact of RWR-1 operation on the public health as a result of gaseous and liquid effluents and on the plant personnel as a result of normal operation and maintenance.

2.1 Evaluation of Design Bases

NNI presented in the topical report the design bases for the RWR-1. These included regulatory bases, component quality group classification, process design bases, a material selection basis, and industrial codes and standards.

2.1.1 Regulatory Bases

NNI addressed the regulatory bases for the RWR-1. These bases included conformance with 10 CFR Parts 20 and 50 and various regulatory guides. NNI has indicated that the various components of the RWR-1 will be placed behind concrete walls in order to attenuate radiation which may be emitted from these components. NNI also designed the RWR-1 to operate at a negative pressure thus reducing the possibility of leakage of radioactive material to restricted areas. This and other design features should allow the RWR-1 to operate such that the concentration limits of radioisotopes are within the limits of Table I, Appendix B to 10 CFR Part 20. NNI has incorporated in its design various off-gas treatment system components so that the radioactivity in effluents to unrestricted areas are within the limits of 10 CFR Part 20.106. NNI has also indicated that the in-plant monitors and area radiation detectors will be addressed on a plant specific bases. The staff concurs with this approach.

RWR-1 systems installed at nuclear power plants must meet the general design criteria of Appendix A to 10 CFR Part 50, the quality assurance criteria of Regulatory Guide 1.143, and the contribution of effluents from the system must be such that the doses from the nuclear power plant do not exceed the criterion of "As Low As Reasonably Achievable" of Appendix I to 10 CFR Part 50. NNI has addressed the capability of the RWR-1 to meet General Design Criteria (GDC) 60, 63, and 64 of Appendix A. GDC 60 requires a nuclear power plant design to include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal operation, including anticipated operational occurrences. GDC 60 also requires that sufficient holdup capacity be provided for the retention of gaseous and liquid effluents containing radioactive materials.

The RWR-1 off-gas cleanup system includes dry cyclones, wet cyclones, a venture scrubber, and a filter train consisting of a HEPA filter, charcoal adsorber and another HEPA filter. The staff considers the off-gas treatment system of the RWR-1 as adequate for controlling the release of gaseous effluents. NNI has indicated that the purged scrub liquid may return to the liquid waste feed tank. NNI has indicated that all liquid wastes generated by the RWR-1 will be sent to the liquid waste storage tank for processing in the RWR-1. This is considered acceptable by the staff. However, the comments in Section 2.2.1 of this SER should be noted.

GDC 63 requires that appropriate systems be provided for radioactive waste systems and in associated handling areas in order that conditions that may result in excessive radiation levels may be detected and that appropriate safety actions may be initiated. The RWR-1 design will include appropriate instrumentation to detect conditions that may result in excessive radiation levels within the RWR-1. The RWR-1 will be equipped with controls designed to sense abnormal occurrences and to activitate an alarm upon such an occurrence. An annunciator panel will provide identification of the causes of the alarm. Corrective action may be taken manually or automatically depending upon the occurrence. The staff has concluded that the instrumentation and control is satisfactory with respect to GDC 63. Area radiation monitors will be a plant specific responsibility and will be reviewed at the time of application.

GDC 64 requires that means be provided for monitoring effluent discharge paths for radioactivity released from normal operations, including anticipated operational occurrences, and from postulated accidents. NNI has indicated that the off-gas from the RWR-1 will be monitored. When the off-gas is routed to a plant ventilation exhaust system the plant monitoring system will also be used to monitor the releases. The staff concurs with this approach and will review the plant specific design to ensure that the effluents from the RWR-1 are monitored prior to release to any vent or offsite discharge.

Appendix B of 10 CFR Part 50 outlines the quality assurance criteria for nuclear power plants. The RWR-1 system has been designed to conform with the requirements of Regulatory Guide 1.143, "Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants," which details the quality assurance requirements for radwaste management systems in Regulatory Position 6 of this regulatory guide. The staff finds this conformance to this regulatory position of Regulatory Guide 1.143 an acceptable approach.

Appendix I of 10 CFR Part 50 establishes numerical guides for design objectives and limiting conditions for operation to meet the criteria "As Low As Reasonably Achievable" for radioactive material in nuclear power plant effluents. The effluents from the RWR-1 must be considered in conjunction with the effluents from the remaining portions of the plant and the impact from the total effluents must be within the guides of Appendix I. NNI has indicated that specific compliance will be addressed on a plant specific basis. The staff agrees with this approach.

NNI has also addressed the design bases of the RWR-1 to various additional regulatory guides. These guides include Regulatory Guide 1.120, "Fire Protection Guidelines For Nuclear Power Plants", Regulatory Guide 1.140, "Design, Testing, and Maintenance Criteria for Normal Ventilation Exhaust System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants," and Regulatory Guide 8.8, "Information Relevant to Ensuring That Occupational Radiation Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable."

NNI discussed the conformance of the RWR-1 design with respect to each regulatory position of Regulatory Guide 1.120. Regulatory Positions 1, 2, and portions of 4, 5, and 6 will be addressed on plant specific basis. The RWR-1 system places no constraints on the building which would preclude compliance with the building design guidelines of Regulatory Position 4. Electrical cable construction will also be in accordance with this position. Combustible materials associated with the RWR-1 systems will be controlled and contained in accordance with this position. The fire detection and suppression provisions in the RWR-1 system are in accordance with Regulatory Position 5. The RWR-1 system has been designed to minimize the probability and the effect of fires and pressure excursions in accordance with GDC 3 of Appendix A of 10 CFR Part 50. The staff has concluded that the RWR-1 design, with respect to the regulatory positions of Regulatory Guide 1.120, is acceptable, however, review will be required on a plant specific basis because Regulatory Guide 1.120 is a draft regulatory guide that has been issued only for comment. It has not been issued as a formal regulatory guide and is not used in the licensing process. Applicable fire protection requirements have been incorporated in a revision to SRP Section 9.5.1 of NUREG-0800, July 1981, in Branch Technical

Position (BTP) CMEB 9.5.1 which contains guidelines for fire protection for nuclear power plants. Any plants which would utilize the RWR-1 would be reviewed to this criteria on a plant specific basis.

NNI has stated that the RWR-1 will be built and operated in accordance with Regulatory Guide 1.140. While they can guarantee that the RWR-1 will be built and pre-operationally tested in accordance with Regulatory Guide 1.140, they cannot guarantee that the system will be operated and tested in accordance with this regulatory guide following system start-up. That is dependent upon the owner of the RWR-1 system. Therefore, the staff will require the owner to operate and test the RWR-1 in accordance with Regulatory Guide 1.140.

In the report it has been declared that the RWR-1 will meet the applicable sections of Regulatory Guide 1.143 with the exception of Regulatory Position 5. NNI has indicated that the conformance of the building housing the RWR-1 system is outside the scope of the report. The staff agrees. The staff will require the owner of the RWR-1 system to meet the building requirements of Regulatory Position 5 of Regulatory Guide 1.143.

NNI has stated that the RWR-1 equipment design is consistent with the guidelines of Regulatory Guide 8.8. The conformance of the RWR-1 design with this guide will be discussed later in this SER.

2.1.2 Design Bases For Components

The design bases for components of the RWR-1 system was based upon the guidelines of Regulatory Guide 1.143. The design bases for the HEPA filters and charcoal adsorber of the off-gas treatment system was the guidelines of Regulatory Guide 1.140 as discussed in the above section. The staff, as noted previously, finds these design bases acceptable.

2.1.3 System Design Bases

The system was designed to process evaporator bottoms, spent ion exchange resins, filter sludges, and dry combustible waste. The system was designed to process these wastes at a rate which would ensure process capability for a 3500 MWt nuclear power plant. NNI has indicated that a reasonable processing rate would involve RWR-1 operation 264 days per year. During this period 1100-1250 m^3/yr would be processed depending upon the distribution of waste. In response to a staff question NNI has indicated that more than one RWR-1 system may be required for a 3400 MWt or greater BWR with deep bed demineralizers. The staff concurs with this assessment and the projected processing rates for the RWR-1.

2.1.4 Material Selection Basis

NNI recognized that material problems had existed in past incinerator application. Following a review of the literature, NNI embarked on a materials testing program the basis of which was testing of candidate materials in the RWR-1 pilot plant system under conditions representative of those to be experienced by the operating systems. Test coupons were placed in positions representative of locations most likely to produce corrosion and were removed periodically for study. The choice of materials for the various components of the RWR-1 was based upon published technical data, results of the corrosion tests, material properties, costs and compliance with ASME Boiler and Pressure Vessel Code, Section VIII requirements where applicable. The staff has concluded that this is a reasonable approach.

2.1.5 Codes and Standards

NNI has committed to designing the RWR-1 to the design criteria of Regulatory Guides 1.140 and 1.143 which utilize various industry codes and standards in the design of radwaste system equipment. The staff has concluded that such a commitment is an acceptable design basis for the RWR-1 system and its components.

2.2 Radiation Protection

2.2.1 Normal Operating Releases

NNI has estimated the quantity of radioactivity that would be released from the RWR-1 off-gas. An estimate was made for both a PWR and a BWR for both average and maximum feed concentration cases. NNI assumed a DF of 4×10^4 for particulates and 10^5 for radioiodine. Based upon the waste generation rates presented in Appendix 8A of the report and the waste processing rates, the maximum dose rates were calculated to be 12.8 mrem/yr to the liver of an infant via the goat milk pathway. from a BWR, and 0.91 mrem/yr also to the liver of an infant via the goat milk pathway from a PWR. These dose rates were based upon a relative deposition (D/Q) value of 4.75×10^{-8} per square meter at a distance of 0.79 miles from a plant. The mean contribution to the dose came from the isotopes Cs-134 and Cs-137.

The staff has estimated the concentration of various input streams to the RWR-1 for a BWR and PWR. As noted by NNI the activity and volumes associated with streams to be processed by the RWR-1 are a function of the plant's liquid radwaste system design and therefore may vary considerably from plant to plant. Therefore, the staff assumed in its calculations anticipated feed concentrations to the RWR-1 system based upon the radwaste system designs of the Shearon Harris Nuclear Power Plant (a PWR) and the Perry Nuclear Power Plant (a BWR). Using a particulate decontamination factor (DF) of 10^4 and 2.5×10^3 for radio-iodines the staff confirmed that the offsite doses would be within the limits of Appendix I of 10 CFR Part 50. Based on a D/Q value of 10^{-7} the staff estimates a dose of 0.77 mrem/yr to the thyroid and 2.42 mrem/yr to the liver for the goat milk infant pathway for a BWR. For a PWR the staff estimated the doses to be 3.4 mrem/yr to the thyroid and 3.7 mrem/yr mrem/yr to the liver. Only the goat milk infant pathway was considered. Table 1 presents the projected releases from the model PWR and BWR plants respectively.

It is the staff's position that each application of RWR-1 system must be approached on an individual basis when determining effluent releases. Releases will vary from plant to plant, perhaps significantly, based upon the feed streams to the RWR-1 and the sources of these feed streams. The calculations presented by NNI and the staff show that the releases from the RWR-1 system will not result in the Appendix I design objectives being exceeded. However, these releases must be included with the releases from the remainder of the plant so that the entire plant may be evaluated with respect to Appendix I; therefore, the staff has concluded that compliance with Appendix I must be judged on a plant specific basis for each application of the RWR-1 system.

NNI has indicated that no liquid effluents will result from operation of the RWR-1 system and that liquid collected in the floor drain and equipment drain collection systems of the building housing the RWR-1 would be sent to the liquid waste storage tank for processing in the RWR-1. In most plants the floor drain and equipment drain collections sytems would transport these liquids to a treatment system. It does not seem likely that the liquid would be sent to the liquid waste storage tank for processing by the RWR-1 unless the liquid was processed by some radwaste treatment system. NNI has not indicated whether the piping flush used to flush resin waste and the liquid waste recirculation lines at the completion of processing will be treated in the plant's liquid waste system or the RWR-1 nor how the decontamination solution will be treated. It is the staff's position that these wastes streams should be addressed on a plant specific basis and the potential impact on the plant's liquid radwaste system loading and the effluents arising from these sources may be addressed at that time. This would also be an appropriate time for the plant's liquid radwaste to be evaluated as to its capability to handle the volume of recycled scrub solution when the RWR-1 is operating in the incineration only mode. Therefore, the staff has concluded that the impact of RWR-1 operation on liquid effluents and on the operation of the liquid radwaste system will be judged on a plant specific basis.

2.2.2 In-plant Radiation Protection

The general radiation protection design features for the RWR-1 radwaste system are consistent with the guidelines of Section C.2 (Facility and Equipment Design Features) of Regulatory Guide 8.8, Rev. 3, "Information Relevant to Ensuring that Occupational Exposures at Nuclear Power Stations Will Be As Low As Is Reasonably Achievable". Plant specific ALARA concerns, such as those involved with training and operational procedures, are not within the scope of this Topical Report.

The RWR-1 system incorporates several features which are designed to maintain personnel radiation doses ALARA. Operation and monitoring of the system is performed from a central control room located in a low background (less than 1 mR/hr) area. Where practicable, equipment and controls are isolated from contaminated areas and equipment by shielding walls. Major components that would provide significant radiation exposures are isolated in separate shielded cells. Cells containing radioactive components have labyrinth access ways to minimize radiation streaming. Where practicable, pumps and valves are located in lower radiation areas outside equipment cells. Design features provided to minimize the build-up of radioactive material in the RWR-1 system include minimizing the use of flange connections in the system, and the use of butt welds, ground smooth, at all weldments. In addition, a decontamination subsystem is provided to allow remote decontamination of the system components. This subsystem is designed so that the entire RWR-1 system, or individual components within the system, can be decontaminated via flushing and/or spraying prior to performing maintenance activities. All decon nozzles will be oversized to prevent clogging.

The RWR-1 facility has also been provided with several design features to minimize the release and spread of contamination. The entire waste reduction train is operated at a lower than atmospheric pressure so that leakage is into, rather than out of, the system. The shreader isolation chamber is ventilated to minimize operator exposure during loading. HEPA filters in the off gas system will be changed out using a "bag-in, bag-out" method to minimize the potential for airborne contamination.

NNI has performed an assessment of the dose rates associated with the RWR-1 system. The cubical design of the typical system is divided into five radiation zones. Access to the high radiation zones (Zones IV and V) is through lower radiation zones (Zones II and III). NNI has estimated that the annual integrated dose due to maintenance of RWR-1 will be 0.97 person-rem. This dose estimate is based on expected occupancy factors, dose rates, and estimates of time and manpower necessary to perform the various tasks involved in the operation of the RWR-1 system. The basis for this exposure estimate is consistent with the acceptance criteria in the Standard Review Plan, Section 12.4.

Based on the information presented in the topical report, and on the applicant's responses to the staff's review questions, the staff has concluded that the applicent's design features are consistent with the guidelines contained in Regulatory Guide 8.8 and that the design is intended to maintain radiation exposures as low as is reasonably achievable.

2.2.3 Accident Evaluation

NNI included in the topical report an analysis of three separate accidents involving the RWR-1. One accident was the rupture of the product hopper. The second was the spilling of the contents of the scrub tank and the third involved the rupture of the HEPA filters and charcoal adsorbers. Other accidents considered by the staff were failure of the incinerator vessel itself and the impact of fire on the system.

The impact of thse accidents were determined to be less than the impact from the accidents analyzed by NNI.

NNI calculated an inhalation dose and a dose resulting from 2 hours of ground plane exposure. The accidents were analyzed for both PWR and BWRs and based upon calcination of evaporator bottoms and incineration of resins, doses were calculated at a site boundary located 1000 meters from the plant. An atmospheric dispersion factor (X/Q) of 1.8×10^{-4} sec per cubic meter and a D/Q of 2.1×10^{-6} m^{-2} were utilized in the calculation of the doses. The largest whole body dose was determined to occur as a result of the rupture of the off gas filter train and was calculated to be approximately 0.03 rem. The worst thyroid dose was calculated to occur as a result of the spill of the entire contents of the scrub solution tank. This dose was calculated to be 0.444 rem. The maximum dose for any accident was 0.48 rem to the lung as a result of a rupture of the ash hopper.

The staff calculated independently the doses from these accidents and confirmed that the doses would be in the range calculated by NNI. The staff has concluded that the potential offsite dose consequences of these accidents are within the guidelines established for the failure of components of the liquid and gaseous radwaste systems of nuclear power plants. The staff concludes that the accidents above will not degrade the operational capability of the reactor nor its capability to shutdown. As with the analysis of routine releases the staff has also concluded that plant specific applications of the RWR-1 should address potential accidents based upon the particular feed materials to the system and the site specific meteorological data.

2.3 Suitability of Volume Reduced Product For Disposal

The purpose of the RWR-1 is to reduce the volume of solid radwaste that must be shipped from a nuclear power plant. NNI has determined that the volume reduction factors prior to solidification are typically:

(a) compacted dry combustible solids	80
(b) spent resin slurries	18
(c) concentrated liquids	8
(d) filter sludges	5

The staff considers these values to be reasonable.

NNI has not provided data on the suitability of the dry incinerated ash or calcine product for solidification. However, NNI has developed a product solidification system designated Waste Solidification Process (WSP) for the purpose of solidifying the product. However, other processes may be used at any plant. It is the staff's position that the solidification of the product material should be addressed on a plant specific basis. However, the staff does not foresee any problems associated with the solidification of the product material which would be any more difficult than material currently solidified at nuclear power plants. Solidification criteria would be addressed in the plant specific process control program. It should be noted that the shipment of the ash or calcined product unsolidified has not been judged as unacceptable by the staff but is presently under review.

3.0 Regulatory Position

The NNI report EI/NNI-77-7-P, its revision, and NNI's response to NRC questions provide an acceptable basis for the following:

(1) The fluid bed dryer system can safely process liquid radioactive wastes, filter sludges, resins and compactible trash. The adequacy of the capacity of fluid bed dryer system is dependent upon the design of the liquid radwaste system, the concentration and volumes of feed solutions to the RWR-1 system and will be evaluated for individual license applications.

(2) The design, construction, and quality group classification of the RWR-1 is in accordance with Regulatory Guide 1.143.

(3) The design, construction and quality group classification of the off-gas filter system is in accordance with Regulatory Guide 1.140.

(4) The overall fluid bed dryer system DFs are 10^4 for particulates and 2.5×10^3 for radioiodine.

(5) A determination of the capability of the system to maintain releases within 10 CFR Part 20 and Appendix I of 10 CFR Part 50 must be

evaluated in conjunction with the entire plant since the releases will depend on the BOP design.

(6) Operation of the RWR-1 can occur with in-plant ALARA criteria of Regulatory Guide 8.8 being met.

(7) Operation of the RWR can occur without jeoparadizing the operation of the remainder plant or the safety of the general public. However, accident evaluations will be required on a plant specific basis.

(8) Report EI/NNI-77-7 is an acceptable nonproprietary summary of proprietary report EI/NNI-77-7-P.

(9) The operation of the RWR-1 can occur within the fire protection criteria of Regulatory Guide 1.120, however, detailed compliance will be addressed, based upon Branch Technical Position CMEB 9.5.1 on a plant specific basis.

TABLE 1

Calculated Releases From Model BWR and PWR Plants For The Purpose of Calculating Doses

	Release (Ci/yr)	
	BWR	PWR
Co-58	8.5(-3)	1.8(-3)
Co-60	2.8(-2)	3.3(-4)
Sr-89	3.0(-3)	3.4(-5)
Sr-90	3.6(-4)	1.7(-6)
I-131	4.4(-1)	2.5(-2)
Cs-134	9.4(-4)	3.9(-3)
Cs-137	1.9(-3)	2.9(-3)