Radioactive Waste Volume Reduction System

Topical Report No. AECC-2-NP, Amendment 1
October 1, 1982

Prepared For:
Office of Nuclear Reactor Regulation
Division of Reactor Licensing
United States Nuclear Regulatory Commission
Washington, D.C. 20555

Aerojet
Energy Conversion
Company

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TOPICAL REPORT AECC-2-NP,
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Aerojet Energy Conversion Company
Sacramento, California

Proprietary information has been deleted from this report and is presented in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P. The information deleted from this report is:

(1) Figure 7. Piping and Instrumentation Diagrams for the AECC VR System.

(2) Figure 8. Material Balance Flow Diagram for the AECC VR System.

(3) Figure 8A. Statepoints for Option Mode 1 - Fluid Bed Dryer Only.

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*Figures 1 through 6 are contained in the Topical Reports No. AECC-2-NP and AECC-2-P.

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*Tables 1 through 29 are contained in the Topical Reports No. AECC-2-NP and AECC-2-P.

NRC QUESTIONS AND AECC RESPONSES CONCERNING
TOPICAL REPORT AECC-2-P(NP)

A. Effluent Treatment Systems Branch Questions and AECC Responses

1. WASH-1258 and ERDA-76-43 are inappropriate references on which to base expected annual volumes and activities for wet wastes and combustible dry wastes from nuclear power plants. System capacity should be based on data which incorporates recent operating reactor experience relative to the generation of radwaste and/or a more recent document such as NUREG-0782, "Draft Environmental Impact Statement on 10 CFR Part 61, Licensing Requirements for Land Disposal of Radioactive Waste". NUREG-0782, in turn, relies heavily on ONWI-20, "A Waste Inventory Report for Reactor and Fuel Fabrication Facility Wastes".

All subsequent sections of the report which are based on or related to estimated annual quantities and activities of radwaste should be revised.

RESPONSE:
The estimated annual quantities and activities of radwaste expected to be processed by the AECC VR System have been revised to reflect the data presented in ONWI-20 (Reference 5). Table 30 presents the expected annual volumes and activity of the concentrated liquid wastes and combustible dry active wastes from a 1000 MW(e) plant to be processed by the AECC VR System. Table 30 was constructed from Tables 1.2-1 and 1.2-3 of Reference 5.

NUREG-0782 (Reference 6) was also reviewed. Table D.7 of Reference 6 is based on the Reference 5 data. Thus, Table 30 reflects the position of References 5 and 6.

Although Reference 5 listed the radionuclides present in the various waste streams, the % distribution of each isotope is not given. This information was extracted from Reference 7, which is an unpublished NRC Working Paper (June, 1981). Table 18 of Reference 7 presents the isotope distribution for spent resins/filter sludge and evaporator bottoms for a BWR and PWR. No isotopic distribution for dry active wastes is given. Table 31 presents the isotopic distribution for the evaporator bottoms (based on Table 18 of Reference 7) and also includes the most commonly reported isotopes in dry active wastes (based on Table 4.2-52 of Reference 5). Since the total activity associated with the dry active wastes is low compared to the evaporator concentrates, no effort was made to determine the % distribution in the dry wastes. A first approximation would be to assume the same % distribution in the dry wastes as the evaporator concentrates.

1. Response (cont.)

TABLE 30

EXPECTED WASTE STREAMS PROCESSED BY AECC VR SYSTEM *

Plant Type	Waste Type	Annual Volume		Activity		Solids Present
		Ft^3	M^3	Ci/year	μCi/cc	
BWR	Evaporator concentrates	12,700	360	580	1.61	20% Na_2SO_4
Deep bed condensate cleanup	Dry active wastes	7,800	221	5.2	0.024	Miscellaneous combustibles
BWR	Evaporator concentrates	600	17	16	0.94	20% Na_2SO_4
Powdered resin condensate cleanup	Dry active wastes	7,800	221	5.2	0.024	Miscellaneous combustibles
PWR	Evaporator concentrates	3,900	111	200	1.81	10% H_3BO_3
Without condensate cleanup	Dry active wastes	7,600	216	4.9	0.023	Miscellaneous combustibles
PWR	Evaporator concentrates	4,800	136	24	0.18	10% H_3BO_3
With condensate cleanup	Dry active wastes	7,600	216	4.9	0.023	Miscellaneous combustibles

*1000 MW(e) Plant.

1. Response (cont.)

TABLE 31

ISOTOPIC DISTRIBUTION IN WASTE STREAMS

Waste Type	Isotope	BWR, %	PWR, %
Evaporator concentrates	Cr-51	—	2
	Mn-54	2	3
	Co-58	1	32
	Co-60	16	36
	Sb-124	—	2
	I-131	1	4
	Cs-134	29	11
	Cs-137	51	11
Dry active wastes	Cr-51	—	*
	Mn-54	*	*
	Co-58	*	*
	Co-60	*	*
	Zn-65	*	—
	Cs-134	*	*
	Cs-137	*	*

*Most commonly reported isotope (Reference 5, Table 4.2-52).

2. The report should be revised to include a description of design features or methods of operation that will minimize the probability or consequences of an explosion or overpressure transient, especially for the oil-burning mode of operation.

RESPONSE:

In general, interlocks are provided to prevent introduction of raw fuels into the dry waste processor when the bed temperature is below operating temperature. These interlocks are indicated on the revised Piping and Instrumentation Diagram (Figure 7, Sheet 5 of 5) as TSLL/108, which reflects a low level temperature switch interrupting fuel flow (oil and dry active waste).

The system components are designed for 12 psig continuous operation while the burst pressure of the hardware is approximately 48 psig based on ASME Section VIII criteria. The system operating pressure is approximately 7 psig and the total volume of the hardware is 460 cubic feet. The worst case corresponds to failure of the interlocks which prevent introduction of raw fuels into the dry waste processor when the bed temperature is below operating temperature. In this unlikely event, the reaction of oil with the oxygen present would result in carbon monoxide (incomplete combustion). If the equilibrium temperature of the <u>entire</u> system volume were to exceed 2600°F, the potential for system rupture would be present. However, the incomplete combustion of the oil to yield carbon monoxide yields a combustion temperature well below 2600°F, and only a portion of the total system volume would be at the maximum combustion temperature. Also, in the unlikely event that the system was overpressurized, high pressure alarms and interlocks would automatically shut down the system to prevent release of the gas to the building.

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 1 of 6)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 2 of 6)

2. Response (cont.)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 3 of 6)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 4 of 6)

2. Response (cont.)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 5 of 6)

2. Response (cont.)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 7. Piping and Instrumentation Diagrams (P&ID) for the AECC VR System (Sheet 6 of 6)

3. The report should estimate the anticipated levels of contamination that will build up on the refractory lining of the incinerator vessel and the frequency of refractory replacement.

RESPONSE:

An incinerator has been operated by Ontario Hydro at the Bruce Generating Station for several years, processing dry active wastes. This unit employs a sprayed-castable refractory lining at the base of the primary pyrolysis chamber and in the second stage burner. These refractory linings were examined after processing about 3000 cubic meters (106,000 ft^3) of waste, and the surface dose rate was found to be approximately 2.5 mRem/hour. Thus, buildup of contamination has been minimal.

AECC anticipates similar or lower dose rates on the refractory lining of the dry waste processor for the following reasons:

1. The refractory lining used is a high density, low porosity material whose surface is similar to the castable refractory used in the Ontario Hydro unit.

2. The dry active wastes to be processed in the AECC unit have similar activity to the waste processed at Ontario Hydro.

3. The AECC dry waste processor refractory walls are continually scrubbed by the action of the bed material rubbing the refractory. It is anticipated this action will remove surface activity continually.

Commercial fluid bed incinerators used for combustion of pulp mill effluent wastes and sewage sludges have been in operation for at least 15 years. Several of these units were designed and built by Copeland Process, Inc., Oakbrook, Ill., using the same type of firebrick included in the AECC fluid bed dry waste processor. Operating units are located at Carthage, Ind. (1962 startup), and Circleville, Ohio (1963 startup) and several other locations. The firebrick has not failed in these units. AECC predicts a 10 year frequency of replacement for the dry waste processor refractory.

4. The material used as the fluidized bed particle media should be specified.

RESPONSE:

Alumina (Al_2O_3) is used as the inert bed for the fluid bed dry waste processor. It has been chosen for its high melting temperature and its chemical stability.

The recommended starting bed media for the fluid bed dryer is commercially available sodium sulfate salts or sand. During operation, the bed particle media in the dryer is comprised of the starting bed and the salts present in the incoming liquid waste stream. If the waste stream is boric acid, then the dryer bed at equilibrium will be sodium metaborate salt; if the waste stream contains sodium sulfate, then the dryer bed at equilibrium will be sodium sulfate salt; and if the waste stream is a combination of salts, the dryer bed will be a combination of salts in the same relative composition as the solids in the liquid feed.

Some of the fluidized bed media is elutriated from the bed and leaves the vessels with the gas stream. Since this particulate can potentially cause erosion of the interconnecting piping, erosion measurements were made during the past year in the full-scale prototype system for the piping from the incinerator (R-3) and the dryer (R-1) to the gas/solids separator (S-1). The data obtained is as follows:

Piping Run	Measured Wear
R-3 to S-1	0.003 - 0.006 inches per year
R-1 to S-1	0.001 - 0.002 inches per year

The observed wear is due to the combined effects of erosion from the particulate and corrosion from the high temperature gas stream. The values are low, and the major contributor is erosion from the particulate based on visual observation of the wear.

5. Describe the smallest sized metal object capable of being detected by the metal detector and the smallest sized object (metallic or non-metallic) capable of jamming the shredder. With normal dry waste handling practices at an operating nuclear power plant, how frequently is it anticipated that the metal detector will alarm and that the shredder will jam or encounter an object that it cannot shred.

RESPONSE:

The sensitivity of the metal detector depends on the type of metal and the location of the metal in the bag of trash being processed. The sensitivity at the center of the search coil is less than at the sides. The detector can detect a steel object as small as 0.2 inches in diameter. Sensitivity to non-magnetic stainless steel is lower with the minimum detectable size being as large as 0.4 inch at the center of the coil.

Under normal operation, the shredder is not expected to jam on metal which is not detected by the metal detector. However, in the event of an obstruction, the anti-jamming controls will reverse the cutters to release the jam. The anti-jamming controls will reverse up to three times to relieve a jammed condition before shutting down the shredder to prevent damage. The anti-jamming controls apply to all stages and if a lower stage is jammed, the prior stages are stopped to prevent feeding additional material while the jammed stage is freeing itself.

The frequency of metal detection or shredder jamming is a function of dry waste handling practices at the individual plant. It is reasonable to expect that these practices will be consistent with the capabilities of the shredder to process dry waste without excessive problems due to metal ingestion.

6. One mode of operation of the system consists of fluid bed incineration of the dry active waste in conjunction with operation of the fluid bed dryer at a low flow rate. Discuss the effect of reducing flow to the venturi scrubber on the scrubbing efficiency.

RESPONSE:

The scrubbing liquid which is used as feed to the fluid bed dryer is recirculated from the scrubber sump to the venturi throat at a rate of 20 to 30 gpm. The scrubbing efficiency is proportional to the pressure drop across the throat, which in turn is dependent on the recirculation flowrate and not on the dryer feed rate (1/4 to 1/2 gpm maximum). Therefore, the scrubbing efficiency is not dependent on the dryer feed rate.

7. Provide an estimate of and supporting basis for the effectiveness of the decontamination of system components with warm water and/or decontamination solution.

RESPONSE:

In general, the bulk of the radioactivity is associated with the liquid waste stream. The radionuclides are uniformly dispersed in the salt solution. Consequently, when the solution is dried, the radionuclides are trapped within the salt particles. The bulk of the salts within the liquid waste streams are either sodium sulfate or sodium metaborate (AECC adds caustic to boric acid wastes to form sodium metaborate). Both of these salts are very soluble in hot or cold water as follows:

	20°C	60°C
Sodium Sulfate	44gm/100gmH_2O	45.3gm/100gmH_2O
Sodium Metaborate	25gm/100gmH_2O	61.3gm/100gmH_2O

Based on the high solubility of these salts, hot water will easily dissolve any salt residue left in the equipment and form a very dilute solution of salts and radionuclides which can be drained from the equipment. This procedure can be repeated if necessary, to achieve the required decontamination.

8. Provide information which supports the statement that regular maintenance can be accomplished in a two-week period each year. Describe the components to be serviced and the servicing operations, the components to be inspected and the method of inspection, estimate total man-hours of effort to accomplish the maintenance, and expected lifetime of system components or component parts that will need repair or replacement.

RESPONSE:

The AECC VR System annual maintenance schedule is shown in Table 32. A complete system decontamination, followed by inspection and necessary servicing of all components, will be accomplished within the two-week annual period.

8. Reponse (cont.)

TABLE 32

AECC VR SYSTEM ANNUAL MAINTENANCE SCHEDULE

Component	Service/Inspection Operation	Frequency	Units	Man-Hours Required	Expected Lifetime, Years
Total System	Decontamination	1/Year	1	60	40
Centrifugal Pumps P-1, P-3, P-5 & P-8	Check shaft runout		5	10	5
	Change oil		5		
	Check seals		5		
	Check alignment		5		
	Inspect impeller		5		
Progressing Cavity Pumps P-2 & P-4	Replace rotor & stator	1/Year	2	4	5
Diaphragm Pump P-6	Change oil	1/Year	2	2	5
Gear Pump P-9	None required	—	1	--	5
Air Blowers C-2 & C-3	Check & lubricate bearings, seals & drive coupling. Adjust packing	1/Year	2	1	10
HEPA Filters F-1A, F-1B & F-4	Inspect gaskets, seals & valves per RG 1.140	1/Year	2	1	40
	Change HEPA filters F-1A/B	2/Year	2	6	
	Change HEPA filter F-4	4/Year	1	8	
Charcoal Adsorbers D-1A & D-1B	Inspect gaskets, seals & valves.	1/Year	2	1	40
	Change charcoal adsorber media.	2/Year		4	

TABLE 32 (cont.)

AECC VR SYSTEM ANNUAL MAINTENANCE SCHEDULE

Component	Service/Inspection Operation	Frequency	Units	Man-Hours Required	Expected Lifetime, Years
Air Heaters E-1, E-2 & E-4	Check elements & controls.	1/Year	3	1	10
Process Vessels R-1 & R-3	Inspect vessel & nozzles.	1/Year	2	1	40
Product Conveyor R-2	Inspect & service drive motor & shaft seals.	1/Year	1	1	10
Off-Gas Cleanup System Components S-1, S-2, S-3 & S-4	Inspect vessel & nozzles.	1/Year	4	2	40
Hoppers H-1, H-2, H-3A, H-3B, H-4 & H-5	Inspect & service valves, drive motors & seals.	1/Year	6	20	40
Trash Shredder G-2	Inspect & service per manufacturer's schedule.	1/Year	1	160	10
Trash Elevator G-1	Inspect & service per manufacturer's schedule.	1/Year	1	4	10
Metal Detector/Trash Conveyor XJ-101 & G-3	Inspect & service per manufacturer's schedule.	1/Year	1	4	10
Control Panels CP-1, CP-2 & CP-3	Inspect & calibrate.	1/Year	3	40	40

9. Throughout the report, the design of the system should be compared to the criteria of Revision 1 of Regulatory Guide 1.143 issued October 1979, not the proposed revision issued for comment in July 1978. All references to BTP-ETSB 11-1 (September 11, 1975) should be deleted, since it was replaced in its entirety by Regulatory Guide 1.143.

RESPONSE:

The AECC VR System complies with NRC Regulatory Guide 1.143, October 1979, with the exceptions discussed on Pages 49 and 50 of the Topical Report. All references to BTP-ETSB 11-1 in Section 7.0 of the Topical Report will be deleted and replaced with Regulatory Guide 1.143.

10. A discussion of bed media loss and makeup should be provided. Describe the rate at which the bed is lost due to carryover in both the dryer and incineration vessels and the rate at which bed media is lost due to continuous removal by the product conveyor from the dryer vessel. Describe the mechanism and instrumentation for bed media makeup. Provide an estimate of the respective percentages of bed media and dried salt that are carried out of the dryer vessel by the product conveyor.

RESPONSE:

The dry waste processor is designed to operate with an inert bed. This bed material, about 900 pounds total, is lost due to attrition and carryover at the rate of approximately 0.1 pounds per hour. Instrumentation is provided to measure the differential pressure across the bed which is proportional to the height and quantity of the fluid bed. This measurement is recorded and alarms are provided to indicate the limits of operation. In the event of a low level alarm (about 700 pounds of bed material), the operator can transfer bed media from the H-4 storage hopper into the dry waste processor without shutting down the system. The H-4 storage hopper is equipped with a manual fill port.

The fluid bed dryer does not utilize an inert bed. The bed particles are composed only of the salts contained in the liquid waste (see answer to Question 32). In this case, bed material is continually being produced and must be removed by the product conveyor. Since the waste solution is flash evaporated in the dryer, a portion of the salts are carried out of the dryer as fine particulate. The quantity of fine particulate generated varies with feed composition and is also influenced by the presence of various organic contaminants such as oils and detergents. In general, the ratio of fines to bed product increases with increasing concentration of organics in the feed. The following table indicates the worst-case product distribution for various feed streams:

Feed Stream	Bed Production Rate, Lbm/Hour	Fines Production Rate, Lbm/Hour
Sodium sulfate	48	12
Sodium metaborate	30	30
80% sodium metatorate, 20% sodium sulfate	24	36
Salt mixture with >1% oil and other organics	--	60

The dry product accumulated in the dryer bed is removed by the product conveyor at the rate shown above.

10. Response (cont.)

The same type of level instrumentation is used for both the dry waste processor and dryer. When the dryer bed level reaches the high alarm, the operator starts the product conveyor which removes the excess bed product (about 125 pound batches). The low level alarm function automatically closes the inlet valve to the product conveyor to prevent excessive discharge of the dryer bed. Bed material can be conveyed into the dryer vessel from either the H-2 or H-4 hoppers. The H-4 hopper is used only as a redundant method of introducing bed material into the dryer.

11. Clarify whether area radiation monitors discussed in Section 8.2.1.2 are within the scope of AECC supply.

RESPONSE:

AECC does not supply area radiation monitors.

12. Provide a more detailed discussion of the specific activity of the dryer/incinerator product for the types of waste streams encountered in both BWRs and PWRs using data found in NUREG-0782 or reported by utilities in the semi-annual effluent release reports. Identify the percentages of the product that will be classed as Class A segregated waste, Class B stable waste, and Class C intruder waste, per proposed 10 CFR Part 61.

RESPONSE:

Table 30 defines the expected waste volumes and activity from BWR and PWR plants that will be processed by the AECC VR System. The specific activity of the untreated wastes are also included in Table 30. The specific activity of the dryer/dry waste processor product resulting from the waste streams defined in Table 30 are easily calculated based on the volume reduction achieved, as follows:

Waste Type	Volume Reduction Factor (Before Immobilization)
10% Boric Acid	11
20% Sodium Sulfate	5
D-- wastes (uncompacted)	200

Table 33 lists the expected specific activity of the dryer/dry waste processor product. The dryer product specific activity ranges from 4.7 to 8.05 μCi/cc for a BWR and 1.98 to 19.91 μCi/cc for a PWR. The dry waste processor product specific activity is nearly the same for a BWR or PWR, 4.6 to 4.8 μCi/cc. In reality, the dryer and dry waste processor product are simultaneously accumulated in the product storage hopper (supplied by others). Thus, they exist as one mixture. Since the volume of dryer product is so much greater than the dry waste processor ash, the specific activity of the final mixture is approximately that of the dryer product.

Table 1 of proposed 10CFR61 lists the specific activity limits on the various isotopes for Class A segregated waste, Class B stable waste, and Class C intruder waste. A quick examination of Table 1 indicates that the specific activity of Cs-137 in an actual waste package will likely determine the waste classification due to the 1 μCi/cc limit for Class A segregated waste. The VR wastes will contain the same isotopes present in the evaporator concentrates and the dry active wastes (Table 31). For the VR waste product, Table 33 lists the expected isotopes, % distribution, and the specific activity of each isotope for BWR and PWR plants. The proposed 10CFR61 limits for Class A segregated waste are also listed. The following conclusions are drawn:

12. Response (cont.)

1. The VR waste product from a BWR plant (deep bed or powdered resin condensate cleanup) will likely be Class B stable waste, since the Cs-137 specific activity is greater than 1 μCi/cc. However, if the untreated waste has somewhat less Cs-137 than assumed in this analysis, the VR waste product may qualify as Class A segregated waste. Immobilization of the VR product will reduce the Cs-137 level, but probably not to the 1 μCi/cc limit.

2. The VR waste product from a PWR plant without condensate cleanup will likely be Class B stable waste, while the VR waste product from a PWR plant with condensate cleanup will likely be Class A segregated waste.

3. The dry VR waste product can be immobilized with a suitable binder such as polymer binder or bitumen, or can be packaged directly in a High Integrity Container (HIC) such that the final waste form characteristics will meet the requirements of proposed 10CFR61, Part 61.56, Sections (a) and (b).

12. Response (cont.)

TABLE 33

EXPECTED ACTIVITY OF VR PRODUCT & 10CFR61 WASTE CLASSIFICATION

BWR PLANTS

Isotopes Present	%	Deep Bed SA/Isotope, μCi/cc Dryer	Deep Bed SA/Isotope, μCi/cc Dry Waste Processor	Powdered Resin SA/Isotope, μCi/cc Dryer	Powdered Resin SA/Isotope, μCi/cc Dry Waste Processor	Proposed 10CFR61 Limit for Class A Segregated Waste, μCi/cc
Mn-54	2	0.16	0.10	0.09	0.10	700
Co-58	1	0.08	0.05	0.05	0.05	700
Co-60	16	1.29	0.77	0.75	0.77	700
I-131	1	0.08	0.05	0.05	0.05	700
Cs-134	29	2.33	1.39	1.36	1.39	700
Cs-137	51	4.11	2.45	2.40	2.45	1
Total Activity, μCi/cc.		8.05	4.81	4.7	4.81	

Conclusion: BWR VR wastes are all Class B stable waste.

PWR PLANTS

Isotopes Present	%	No Condensate Cleanup SA/Isotope, μCi/cc Dryer	No Condensate Cleanup SA/Isotope, μCi/cc Dry Waste Processor	Condensate Cleanup SA/Isotope, μCi/cc Dryer	Condensate Cleanup SA/Isotope, μCi/cc Dry Waste Processor	Proposed 10CFR61 Limit for Class A Segregated Waste, μCi/cc
Cr-51	2	0.40	0.09	0.04	0.09	700
Mn-54	3	0.60	0.14	0.06	0.14	700
Co-58	32	6.37	1.47	0.63	1.47	700
Co-60	36	7.17	1.66	0.71	1.66	700
Sb-124	2	0.40	0.09	0.04	0.09	700
I-131	4	0.80	0.18	0.08	0.18	700
Cs-134	11	2.19	0.51	0.22	0.51	700
Cs-137	11	2.19	0.51	0.22	0.51	1
Total Activity, μCi/cc		19.91	4.6	1.98	4.6	

Conclusion: Evaporator concentrates from a PWR plant without condensate cleanup will be Class B stable waste. All other PWR wastes will be Class A segregated waste.

13. Information should be included which provides reasonable assurance that solidification of the dryer and incinerator product will result in a waste form which is capable of satisfying the proposed requirements of 10CFR Part 61.

RESPONSE:

Immobilization of the VR waste product is capable of being conducted in the solidification system supplied by others. However, AECC has conducted immobilization tests of the VR product with polymer binder obtained from Dow Chemical Co. In addition, Dow Chemical Co. has conducted substantial testing with AECC-supplied dry product. Werner & Pfleiderer Corp. has conducted limited testing with AECC-supplied dry product using bitumen as the immobilization agent. The results of these test programs provide strong assurance that the final waste form, using Dow polymer binder or bitumen, will satisfy the proposed requirements of 10CFR61, Part 61.56, as follows:

Part 61.56, Section (a)

The waste form will meet 10CFR71 and 49CFR, Parts 171-179, as applicable. The waste form is expected to be free of liquids and will not be explosive, toxic, or pyrophoric, and will not contain biological, pathogenic, or infectious material.

Part 61.56, Section (b)

The requirements in this section are intended to provide stability of the waste for at least 150 years. The AECC VR waste product, immobilized either with Dow polymer binder or bitumen, should provide the necessary structural stability, in that a homogeneous, free-standing monolithic solid is formed. The specific activity of the waste is low, so that radiolytic decomposition would be minimal. No free water was detected or is anticipated in the waste product, and void spaces within the waste and between the waste and its package are small.

14. Provide information regarding expected corrosion rates of system materials using feed composition (PVC content, e.g.) assumptions that are likely to bound the worst to be encountered in a normal operating nuclear plant. If test coupons to measure corrosion rates have been used, provide the results of that testing.

RESPONSE:

AECC limits the concentrations of sulfur to 1000 ppm and chlorides (PVC, e.g.) to 5000 ppm in the incoming dry active waste. This yields gaseous concentrations at the dry waste processor exit of 120 ppm SO_2 and 300 ppm HCl. These concentrations are further diluted by combining with the fluid bed dryer exhaust. The equilibrium gaseous concentrations before the scrubber/preconcentrator are 50 ppm SO_2 and 125 ppm HCl.

At these concentrations of corrosive SO_2 and HCl, AECC has selected the stabilized stainless steels AISI 321/347 as a cost effective material for components operating in dry air and superheated steam in the temperature range of 900 - 1400°F, based on corrosion data in the literature. Furthermore, these materials exhibited performance equal to Incoloy 825 in superheated steam in 18 months exposure at 1350°F.

Test coupons to measure corrosion rates were used in the AECC 12-inch development incinerator. Three materials were evaluated: CRES 304, Incoloy 825, and Inconel 625. The coupons were installed in the upper freeboard portion of the dry waste processor and exposed at 1360°F average temperature for 116 hours in the exhaust gas containing average amounts of 751 ppm SO_2 and 55 ppm Cl^-. The CRES 304 specimen exhibited significant scaling, while the Incoloy 825 and Inconel 625 specimens were coated with a light oxide.

CRES 304 is not a stabilized alloy and is not suitable for this application, whereas the other 2 materials tested are acceptable. Incoloy 825 would be the recommended material from this investigation. However, as noted above, the AISI 321/347 materials behave similarly to the Inconel 825 at 1350°F. The AISI 321/347 SS are less expensive and more readily available than Incoloy 825.

14. Response (cont.)

In addition, the following corrosion allowances have been made on the high temperature components containing potentially radioactive particulate in the gas stream:

Component	Corrosion Allowance	Remarks
Dry Waste Processor (R-3)	None	The unit is refractory lined with dense firebrick 9 inches thick, separating the gas from the containment vessel, which is fabricated of 347 SS.
Dryer (R-1)	1/8 in.	Operating temperature is 900°F - 1100°F. Inconel is used above 900°F, and 347 SS is used elsewhere.
Gas/Solids Separator (S-1)	3/32 in.	Operating temperature <900°F. 347 SS is used.
Scrubber/Preconcentrator (S-2)	1/16 in.	Operating temperature is 200°F - 800°F. Inconel is used at 800°F, and 316 SS is used elsewhere.

15. Describe the features incorporated in the design of the system to prevent, minimize, or clean plugged feed and/or venturi nozzles.

RESPONSE:

Nozzles which have exhibited any tendency to plug have been provided with an air purge. This has proven adequate for keeping nozzles, lines, and instruments unplugged. Heat tracing has been incorporated into the system design as required to prevent crystallization which could cause plugging of some nozzles. The system has been designed to maintain flow velocities above saltation levels and to insure that fines do not settle in the pipelines or vessels and cover the nozzles. This has been a significant factor in the freedom from nozzle plugging. The decontamination nozzles, the dryer feed nozzles, and the dry waste processor bed and gas coolant nozzles are all removable inserts which can be decontaminated and cleaned using standard utility practices or simply replaced since they are a low cost item.

16. Describe the features incorporated in the design of the system to prevent "poisoning" of the charcoal adsorbers by contaminants in the off-gas stream such as SO_2 produced by the burning of rubber. Provide any test data available that document the concentrations of SO_2 that are expected to be encountered by the charcoal adsorbers and document the expected life of the filters in terms of acceptable removal efficiencies.

RESPONSE:

AECC limits the concentration of sulfur to 1000 ppm in the incoming dry active waste. This yields 120 ppm SO_2 at the dry waste processor exit. This concentration is further diluted to 50 ppm SO_2 by combining with the fluid bed dryer exhaust. Two wet venturi scrubbers are then utilized to further reduce the SO_2 concentration. The scrubber/preconcentrator operates with scrubbing liquid at a very high pH of 11. This liquid reacts with the SO_2 to produce sodium sulfate which is processed by the fluid bed dryer. The SO_2 collection efficiency is greater than 99.7%. The secondary scrubber's collection efficiency is expected to be in the 75 - 85% range because the pH of the scrubbing media is greater than 7.

The SO_2 concentration upstream of the charcoal adsorber has been measured at less than 0.1 ppm in several tests conducted in the AECC full-scale prototype system. See the Response to Question 40 and Table 36 for the data. The charcoal in the adsorber is impregnated with KI and TEDA. Based on the data from NUREG/CR-2112, p. 56, Sept. 1981, AECC expects the adsorber to last approximately 3100 hours of operating time before changeout is required. AECC provides two charcoal adsorbers in parallel to allow decay and changeout without shutdown.

The time to changeout was calculated based on the following data and assumptions:

1. NUREG/CR-2112 utilized a 2-inch charcoal bed, 0.25 sec. residence time, 1.8 wt % SO_2 adsorbed, and no trace of SO_2 at the exit.
2. The AECC charcoal adsorber is 11.5 inch with a residence time of 0.75 seconds. About 4-inch charcoal (80 lbm) would provide the 0.25 sec. residence time consistent with the NUREG/CR-2112 test. The 1.8 wt % SO_2 allowable equals 1.44 lbm SO_2, or 8.71 SCF SO_2.
3. SO_2 concentration upstream of the AECC charcoal adsorber is 0.1 ppm, or (0.1×10^{-6}) (466 SCFM) = 4.66×10^{-5} SCFM SO_2.
4. Charcoal Adsorber Life to Changeout = 8.71 SCF/(4.66×10^{-5} SCFM) (60) = 3115 hours.

17. The volume of dry active waste 60,000 ft^3/yr presented in Table 7 appears to be in error. Please clarify (see Comment 1).

RESPONSE:

All waste volumes shown in Table 7 are based on expected waste volumes listed in the original Sargent & Lundy specification for a Volume Reduction System. For dry active wastes, a range of 12,000 - 60,000 ft^3/year was listed. AECC selected the 60,000 ft^3/year as a worst case condition.

18. Overflow of condensate from the condenser sump is not discussed in the text. This stream should be discussed along with its contribution to the effluents (liquid) from the remainder of the plant. Is this flow recommended to be returned to the liquid waste storage tank for feed to the calciner or to the liquid radwaste treatment system for processing and release?

RESPONSE:

The condenser will condense approximately 90% of the water in the incoming liquid waste stream. This condensate is used internally within the VR system to provide dilution water for the (S-2) scrubber/preconcentrator to maintain density and to provide cooling water for the dry waste processor (R-3) to maintain temperature. The excess condensate is returned to the liquid radwaste treatment system for processing. The condensate is good quality water with less than 300 ppm solids. It can be processed by either the evaporators or the demineralizers for reuse or release.

19. The dry waste processor has no provisions for removing ash, non-combustible materials or "clinkers" from the bed media. Without such a provision, this material may build up in the dry waste processor. How is such a problem handled?

RESPONSE:

The combustion process in the fluid bed dry waste processor results in a fine fly ash which carries over with the exhaust gases and is removed by the gas/solids separator or the scrubber. The shredder and classifying equipment limit the size of the non-combustibles to less than 1/2 inch. The fluid bed dry waste processor is an isothermal process in that the combustion temperature within the bed is controlled within 5°F of the setpoint. The bed operates at 1350°F, which is well below the fusion point of nearly all the contaminants in the trash. Therefore, agglomerates (clinkers) are not likely to form. In over 4,000 hours of testing in the full-scale prototype system, no clinkers of any size have been observed.

Small non-combustible items such as pins, staples, etc. are likely to have a finite life within the dry waste processor due to the highly erosive and oxidizing environment within the fluid bed. In the unlikely event that these items impede the gas flow and the bed mixing, it will be necessary to remove them by disassembling the dry waste processor bottom section. A full diameter flange is provided for this purpose.

20. Figure 6 does not show the path of Option Mode 2. Provide a figure similar to Figure 6 for Optional Mode 2 from which a material balance may be calculated.

RESPONSE:

Figure 6 has been replaced with Figure 8, which reflects the proper hardware scope of supply. Figure 8 does represent Option Mode 2, which is the combined dryer/dry waste processor mode of operation. For the dryer only mode (Option Mode 1), the basic difference is that the dry active waste is not introduced into the pneumatic transport system (line FFF is zero). All the gas and liquid flows remain essentially the same with the exception that the scrubber/preconcentrator (S-2) dilution water is reduced by the quantity used to cool the dry waste processor gas. The major statepoints for Option Mode 1 are shown on the attached computer sheets, Figure 8A, which can be used in conjunction with the Figure 8 schematic diagram.

20. Response (cont.)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 8. Material Balance Flow Diagram for the AECC VR System

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 8A. Statepoints for Option Mode 1 - Fluid Bed Dryer Only (Sheet 1 of 2)

The information contained in this Figure is judged to be proprietary by the Aerojet Energy Conversion Company and is contained in the companion proprietary report, Amendment 1 to Topical Report No. AECC-2-P.

Figure 8A. Statepoints for Option Mode 1 - Fluid Bed Dryer Only (Sheet 2 of 2)

21. It would seem that decontamination nozzles would also be useful for such equipment as the bed storage and transfer hopper (H-4), trash hoppers (H-3A and H-3B), and condenser (S-3) in addition to the major process vessels and selected hoppers which have such nozzles. Estimate the levels of contamination on these components and describe the decontamination methods that will be used prior to maintenance on this equipment.

RESPONSE:

Decontamination nozzles have not been provided on these components because (1) other means are available for component decontamination and (2) the expected dose rate after decontamination is expected to be low, as discussed below.

Bed Storage and Transfer Hopper (H-4)

This hopper receives the bed inventory from the dry waste processor (R-3) during shutdown and maintenance on R-3. Conversely, the hopper is decontaminated prior to maintenance by pneumatically conveying the bed material to R-3 or R-1. The inert bed material (Al_2O_3) is only slightly radioactive since the ash generated in R-3 is carried over with the off-gas. After decontamination of H-4, the expected residual dose rate is 0.002 R/hour.

Trash Hoppers (H-3A and H-3B)

Provisions have been included for the decontamination (dry method) of these hoppers. Each hopper is provided with a manway above the feed screw at the bottom of the hopper. The shredded trash could be manually shoveled from the hopper in the event that the feed screw fails, with the residual being removed by vacuuming. It is expected that very little activity would remain in the hopper due to the predominant dry nature of the trash. The expected residual dose rate is 0.002 R/hour.

Condenser (S-3)

The condenser is provided with a decontamination nozzle and is decontaminated by draining the inventory back to the liquid radwaste system, and flushing with warm water or decontamination solution, as required. Residual condensate would amount to 1 gallon or less. The system decontamination factor upstream of the condenser is about 1000. Thus, the condensate specific activity is about 2×10^{-3} uCi/cc. The expected residual dose rate at the condenser is at most 0.002 R/hour.

22. No volumes of decontamination solutions and associated radioactivity content have been discussed in the Topical Report, nor has the method to treat this solution been discussed. Include such information in the Topical Report. Additional liquid and gaseous effluents which would result from the decontamination solution should also be addressed.

RESPONSE:

A total system decontamination will yield approximately 1000 gallons of decontamination solution (warm water or Turco solution) based on experience from the AECC full-scale prototype system. Prior to decontamination, the bed media in the fluid bed dryer vessel (R-1), consisting of 600 lbm material (8 cubic feet), will be transferred to the packaging system. Thus, only a small amount of residual dry product, approximately 0.5 lbs in the complete system, will be contacted by the decontamination solution. The dry product would have a specific activity of approximately 20 μCi/gram. The total activity of the decontamination solution is only 0.005 Ci. The decontamination solution would be routed to the evaporator feed tank for processing in the evaporator and then back to the AECC VR System for volume reduction.

23. Is the offgas system designed to the requirements of ANSI N509-1980?

RESPONSE:

Yes, where applicable. The filters are relatively small units and therefore the following requirements of ANSI N509-1980 were considered to be inappropriate:

(1) The internal space requirement of 3 ft. between components (4.7.2).

(2) No test canisters are provided for the charcoal. As a result, the entire cell must be used for testing, as outlined in 3.26.

(3) The charcoal bed does not provide 0.25 seconds per 2 inches of bed depth, as required in Paragraph 5.2.2. However, the bed thickness of 11-1/2 inches will provide a total residence time in excess of 0.75 seconds during normal operating conditions, which we believe meets the intent of the specification.

24. Justify the projected processing time of 3600 hours per year for the Byron/Braidwood Stations (1120 MWe) when Table 6 shows that at a PWR the system would operate for 6714 hours per year, when Figure 6 shows a solids feed rate of 5-10 ft^3/hr and Table 7 shows an annual volume of dry active waste of 60,000 ft^3/yr. (Also, see Comment 1.)

RESPONSE:

Table 7 lists the expected waste streams to be processed by the AECC VR System at the Byron & Braidwood Stations. This waste stream definition was included in the Sargent & Lundy VR System specification developed for Commonwealth Edison Company and used to obtain bids for a VR System for Byron and Braidwood. The projected processing time of 3600 hours per year is based on:

1. Processing the two concentrates streams at a rate of 45 gph (16 wt % solids).
2. Processing the 60,000 cubic feet of dry active wastes (density = 6 lbm/ft^3) at a rate of 100 lbm/hour.

The VR System specification projected a dry waste volume of 12,000 - 60,000 ft^3 per year. For conservatism, the upper limit was used to calculate the required processing time. It is not surprising that the <u>projected</u> or <u>actual</u> waste volumes for a specific plant may deviate substantially from average volumes based on operating data from several plants.

Table 6 has been replaced with Table 34, which is now based on the expected waste stream data shown in Table 30 (based on Reference 5). Table 34 shows that for a PWR with condensate cleanup (similar to Byron or Braidwood), the AECC VR System will operate for 1520 hours per year. This is somewhat lower than the 3600 hours per year projected for the Byron/Braidwood Stations, since the dry active waste volume is lower.

The solids feed rate of 5-10 ft^3/hour shown in the Figure 6 Material Balance also shows 100 lbm/hour as the nominal solids feed rate. The range in bulk flowrate (5-10 ft^3/hour) reflects the wide density range possible with dry active wastes, on the order of 6-20 lbm/ft^3.

The original Material Balance shown in Figure 6 has been replaced with the Figure 8 Material Balance. Figure 8 indicates an average mass flowrate of 83 lbm/hour and an average bulk flowrate of 6.9 cubic feet per hour for the dry active wastes. These values are specific to the Byron and Braidwood Stations, based on a heating value of about 8400 Btu/lbm. A flowrate of 100 lbm/hour would correspond to a heating value of 7000 Btu/lbm. In any case, the total allowable heat release is 700,000 Btu/hour.

24. Response (cont.)

TABLE 34

AECC VR SYSTEM CAPACITY

Plant Type	Waste Type	Annual Volume Ft^3	Annual Volume M^3	Processing Time for Twin-unit Plant, Hours per Year	% of Total Capacity
BWR	Evaporator concentrates	12,700	360	6333 (30 gph)	72.3%
Deep bed condensate cleanup	Dry active wastes	7,800	221	1560 (100 lbm/hour)	17.8%
BWR	Evaporator concentrates	600	17	300 (30 gph)	3.4%
Powdered resin condensate cleanup	Dry active wastes	7,800	221	1560 (100 lbm/hour)	17.8%
PWR	Evaporator concentrates	3,900	111	926 (63 gph)	10.6%
Without condensate cleanup	Dry active wastes	7,600	216	1520 (100 lbm/hour)	17.4%
PWR	Evaporator concentrates	4,800	136	1140 (63 gph)	13.0%
With condensate cleanup	Dry active wastes	7,600	216	1520 (100 lbm/hour)	17.4%

25. Operating conditions for combusting contaminated oil are not provided in the Topical Report. Such information should be provided.

RESPONSE:

The dry waste processor is designed to operate with an equivalent heat load of 700,000 Btu/hr. whether the fuel is dry active waste or contaminated oil. Nominally, the oil equivalent to 700,000 Btu/hr. is about 4.4 gph. The system operating parameters such as gas and liquid flowrates and the temperature in the dry waste processor are the same when processing dry active waste or oil. The controlling parameter is the oxygen content of the dry waste processor off-gas which is maintained between 10 to 12% oxygen.

The oil is introduced into the fluid bed dry waste processor through an air atomized nozzle which produces a fine oil mist. The small oil droplets are immediately combusted, yielding only innocuous gases.

26. Describe any limits that AECC recommends on the amounts of plastics that may be processed in the incinerator.

RESPONSE:

AECC limits the quantity of halogenated plastics to less than 1 weight %. This restriction is based on corrosion rates and the ability of the scrubber/preconcentrator to capture the resulting acid gas. There is no restriction on the quantity of non-halogenated plastics other than to limit the total heat load on the dry waste processor to 700,000 Btu/hr.

28. It is the NRC staff's understanding that a second venturi scrubber was added to the design. The Topical Report should include details on this component and the reason for this design change.

RESPONSE:

Originally the system was designed with an overall particulate DF of 10^4. Under upset conditions during dry waste processor operation, the DF can drop to about 5×10^3. Consequently, the HEPA filter life could be reduced to less than 30 operating days. AECC felt that this was an unreasonable filter life based on the fact that the filter package is directly connected to the charcoal adsorber. In order to increase the HEPA life to about 6 months, the second scrubber was added to the system to collect additional particulate. In addition, the secondary scrubber also provides another opportunity to capture iodine. The second scrubber has increased the overall particulate DF to about 5×10^4 as demonstrated with the fullscale prototype equipment.

Essentially, the two scrubbers (scrubber/preconcentrator and secondary scrubber) are alike in operation except the secondary scrubber uses condensate as the scrubbing liquid. The condensate is recirculated at the rate of 20 gpm from the condenser sump into the throat of the secondary scrubber, where it contacts the gas and removes the remaining particulate. The liquid then passes through the condenser and into the sump for recirculation to the throat. In general, most of the particulate collected is transferred into the scrubber/preconcentrator with the dilution water that is used to control density (a portion of the recirculated condensate). The overall condensate quality has been only slightly affected by the additional particulate collection and the solids concentration of the condensate has changed from 150 ppm to 300 ppm.

27. What is the maximum feed rate of the fluidized bed dryer when it operates?

RESPONSE:

The maximum feed rate to the fluid bed dryer is dependent on the feed composition and concentration. The response to Question No. 35 summarizes the fullscale testing of the VR System with regard to feed rates.

30. Describe where liquids from the low point drains are routed.

RESPONSE:

The low point drains from the fluid bed dryer bed storage and transfer hopper (H-2), fluid bed dryer (R-1), and scrubber preconcentrator (S-2) are routed to the evaporator feed tank for reprocessing. Low point drains on the waste liquor storage tank recirculation pump are routed to the pump drain (floor drain connection).

29. Where is the backwashable filter F-3 located? The appropriate figures in the report should be revised to show this component.

RESPONSE:

The backwashable filter F-3 as shown in Figure 4, Page 78, is incorrectly located. The filter has been moved to the inlet of the waste liquor storage tank, i.e., to filter incoming concentrates from the holding tank. The flush outlet connection is connected to the spent resins holding tank. During operation, when the pressure drop across the filter indicates flushing is required, the operator initiates the flushing operation and the filter is automatically flushed of crud buildup. The revised Piping and Instrumentation Diagram (Figure 7, Sheet 1 of 5) shows the correction.

31. The design temperature of the charcoal adsorbers (T = 210°F, Table 12) is only 10 degrees greater than that of the maximum temperature expected. Is this sufficient to handle a transient involving lack of cooling?

RESPONSE:

The off-gas passes through two wet scrubbers and a condenser before passing through the charcoal adsorbers. Any one of these devices will cool the gas below 165°F, and all three must fail in order to produce temperatures greater than 210°F. In addition, automatic system shutdown occurs if the scrubber/preconcentrator outlet temperature is greater than 190°F. A similar interlock is provided if the secondary scrubber recirculation pump fails to produce the required scrubbing liquid flow. AECC provides these shutdown functions to preclude any loss of DF during a failure.

32. It is indicated that solids buildup on the bed increases the bed volume. Describe the respective percentages of bed media and dried feed being removed by R-2. Doesn't solids buildup also occur in the incinerator? If so, why isn't there a mechanism to remove some of the bed volume to handle this buildup of material?

RESPONSE:

There is no inert bed in the fluid bed dryer. The starting bed media consists of commercially available sodium sulfate salts or sand. During operation, the bed media consists of varying proportions of the starting bed media and the salts that exist in the waste liquids fed to the dryer. As the liquid is atomized into the dryer, it flash evaporates leaving a coating of salts on the bed particles. As the bed particles rub against themselves, the attrition results in fines which become the nuclei for new bed particles. Some of the fines are elutriated from the bed and some are coated by the incoming feed and become large enough to stay in the fluidized bed. Initially, R-2 would remove a large percentage of the starting bed media and a small percentage of the dried feed. However, as operation progresses, R-2 will remove larger and larger percentages of the dried feed until finally the bed will consist completely of the dried feed material. This process takes about 100 hours of operation.

The dry waste processor utilizes an inert bed as the fluidized media. The dry active waste contains only about 2% residual ash after combustion. This ash is finely divided and passes out of the dry waste processor as fine particulate. A portion of the ash is removed by the gas-solids separator and the remainder is captured in the scrubber/pre-concentrator and processed in the dryer.

A small portion of the ash is agglomerated on the inert bed in the dry waste processor, but the natural grinding action of the bed media produces more fines than the quantity of agglomerating ash. The overall result is a loss of bed at the rate of about 0.1 pounds per hour which must be replenished on a regular basis (see answer to Question 10).

33. Table 20 should be revised to indicate what parameter(s) are being monitored for process control.

RESPONSE:

All of the instrument loops are monitored for process control. Many of the loops are used to monitor upsets or transients and provide safeguards for the equipment. The following loops actually control process flows, temperatures, or pressures:

Tag No.	Service	Method
FRC-1	R-1 Dryer Fluidizing Air	Flowrate controlled by butterfly valve.
TIC-5	R-1 Dryer Bed	Temperature controlled by waste feed pump speed.
DRC-9	S-2 Preconcentrator Sump	Density controlled by adding condensate (S-3) through valve.
LRC-10	S-2 Preconcentrator Sump	Level controlled by speed of dilute waste feed pump.
TIC-17	E-1 Air Heater	Temperature controlled by amperage to heater.
TIC-18	E-2 Gas Heater	Temperature controlled by amperage to heater.
FRC-10	R-3 Dry Waste Processor Fluidizing Air	Flowrate controlled by butterfly valve.
O_2R-107	R-3 Dry Waste Processor Gas Outlet	Oxygen level in off-gas used to monitor dry active waste flow.
TIC-108	R-3 Dry Waste Processor Bed	Temperature controlled by condensate (S-3) flowrate (valve).
TIC-111	E-4 Startup Heater	Temperature controlled by amperage to heater.

The code for the symbols used above is contained on AECC Drawing No. 1189363, included with the revised P&ID drawings (Figure 7).

34. Provide the results of tests conducted to demonstrate the successful burning of contaminated oil.

RESPONSE:

Part of Run 501 (Part C-I, 7/22/82) was conducted in order to demonstrate the burning of contaminated oil. The contaminated oil, consisting by weight of 88% 30 wt. oil, 10% hydraulic fluid (ISO Grade 32), 1% water, and 1% particulate, was injected into the dry waste processor through an internal mixing type nozzle with approximately 10 SCFM of atomization air. The average oil feed rate for a 4-hour period during the run was 4.59 gph, or approximately 670,000 Btu/hr. Contaminated oil was fed for a total of 10.5 hours. During the 4-hour period, the bed temperature averaged 1354°F and the fluidizing air flow rate was 237 SCFM. The average dry waste processor exhaust gas composition (on a dry basis) during this time was as follows:

CO, ppm	approximately 20
CO_2, % vol.	5.47 ± .13
O_2, % vol.	13.2 ± .3
NO, ppm	28.5 ± .9
NO_x, ppm	29.6 ± 1.2
SO_x, ppm	1.0 ± .1
Hydrocarbons, ppm	3.3 ± 1.5

These gas samples were taken at the dry waste processor outlet, upstream of the junction with the dryer, and prior to dilution or scrubbing.

35. Page 14 indicates that the typical processing rate for liquid wastes range from 28 gph at 25 weight % solids to 75 gph at 10 weight % solids, yet the summary of tests presented in Table 23 shows when the weight % solids was in the range of 25% the feed rate was usually considerably lower than the 28 gph. The same comment holds for 10 weight % solids. The maximum feed rate was approximately 50 gph versus 75. Provide the data to show that the VR equipment will process the volume of waste and solids associated with the volumes on Page 14.

RESPONSE:

Tests on the VR prototype system have demonstrated the typical feed rates for the dryer and dry waste processor shown in Table 35. At 10 weight % solids, the processing rate for Boric Acid wastes is 63 gph and for Sodium Sulfate wastes 69 gph. At a concentration of about 28 weight % solids, the processing rate is 20 gph for borate wastes and 25 gph for sulfate wastes. The dry waste processor feed rate was demonstrated at 125 lbm/hour.

The following conservative processing rates were used in Table 34 to calculate annual processing time required for a twin-unit plant:

Waste Type	Processing Rate
10% Boric Acid	63 gph
20% Sodium Sulfate	30 gph
Dry wastes	100 lbm/hour

The BWR station with deep bed condensate cleanup requires slightly more than 6300 hours per year (72.3 % usage) to process the expected wastes. The other plant types require much lower utilization of the AECC VR System for processing evaporator concentrates and dry active wastes.

35. Response (cont.)

TABLE 35

DEMONSTRATED PROCESSING RATES FOR AECC VR SYSTEM

			Dryer Feed				Dry Waste Processor Feed	
Run #	Date	Processing Rate at 10 wt. % (Feed Tank to Scrubber)	Type	Concentration	Feed Rate	Dryer Bed Temp.	Type	Rate
310b	4/23/80	69 gph	100% Na_2SO_4	28.2%	24.9 gph	900°F		
410	10/19-23/81	63 gph	80% $NaBO_2$/ 20% Na_2SO_4	28.1%	20.8 gph	900°F		
403	3/25/81						Cardboard	125 lbm/hr.
405A	4/6-7/81						Cardboard	125 lbm/hr.
411	11/4-6/81	63 gph	100% $NaBO_2$	27.3%	20.2 gph	900°F		

36. The NRC DF of 10^4 assigned in our SER for AECC-1-A for iodine would no longer be justified since the amount of gas recycled to the fluid bed dryer has been reduced and the amount of gas discharged has been increased. The value of 10^4 would be divided by 8.

RESPONSE

The DF factor for iodine for the combined dryer/dry waste processor system can be calculated with reasonable confidence based on the data obtained on the earlier system (AECC-1-A) in which DF's for individual components were established. The addition of the scrubber/preconcentrator operating at a pH approximately 11 will increase the system DF before the charcoal adsorber. The measured collection efficiency of the scrubber/preconcentrator (S-2) is >99.7% of SO_2 recovery, and since iodine can be considered a weak acid gas, the DF of S-2 for iodine has been conservatively increased to 5 (83% collection efficiency). The overall DF for each of the system components are:

Component	Factor	Remarks
Fluid Bed Dryer (R-1)	2	Same as AECC-1-A
Scrubber/Preconcentrator (S-2)	5	Increased due to high pH
Secondary Scrubber/Condenser (S-3/S-4)	3	Same as AECC-1-A
Gas Filter/Charcoal Assembly (F-1)	6700	Same as AECC-1-A
Gas Recycle	2	Due to less re-cycle
Total System DF	4×10^5	

Thus, the DF value claimed for the AECC VR System is 4×10^5, well above the NRC DF of 10^4 assigned in the SER for AECC-1-A.

37. Were measurements conducted during the course of operation of the fluid bed dryer and the incinerator to determine DFs for the off-gas system and various pieces of equipment? Such information should be provided for operation under both conditions, to the extent it is available.

RESPONSE:

All the DF's measured were for the entire system excluding the HEPA filters. The most recent test results are given below:

Run#	Date	Dryer Feed	Dry Waste Processor Feed	Solids Prod. Rate (lb/hr.)	DF(#/#)
			Dry Waste Processor Only		
403	3/25/81	---	Cardboard (at 125#/hr.)	---	1.9×10^4*
			Dryer Only		
404	3/30-4/3/81	80%$NaBO_2$/ 20%Na_2SO_4	---	41.0	2.0×10^5
			Combined Operation		
410	10/19-23/81	80%$NaBO_2$/ 20%Na_2SO_4	Cardboard/oil	58.0	1.4×10^4
411	11/4-6/81	100%$NaBO_2$	Cardboard/oil/resins	55.6	1.6×10^4
412	11/16-20/81	100%$NaBO_2$	Cardboard/oil/resins	39.1	2.3×10^4

*This DF included the dry waste processor start from approximately 850°F, and was based on dry waste processor feed. The other DF numbers are based on product output from the system. In addition, the HEPA filter assembly is expected to have a DF of 200 which should be combined with the above data to yield the overall system DF.

38. Document that the DF (especially for iodine) does not change when water is used for the venturi scrubber versus the use of evaporator liquid concentrates; provide information also that discusses the dependency of the system iodine DF on the type of liquid waste being processed.

RESPONSE:

If water is used as the scrubbing media in the venturi of the scrubber/preconcentrator in place of the liquid feed, then there is no source of iodine contamination into the system since it comes from the feed. However, assuming the iodine source is still present in the system during operation and water is used as the scrubbing media in the venturi scrubber/preconcentrator, the DF for iodine does not change if the pH in the scrubber/preconcentrator is maintained at about 11 during operation. The caustic used to maintain the pH would react with the acid gases formed in the combustion and collect not only iodine but SO_x and HCl.

Iodine DF is dependent on the liquid waste composition, particularly the quantity of organics present in the liquid waste. The organics will combine with the iodine and form organic iodides such as methyl iodide. Testing performed at AECC identified that the charcoal adsorber collected most of the organic iodide while inorganic iodide was collected in the scrubbers and the fluid bed dryer. A DF of 6700 was measured across the charcoal adsorber and this value is applicable to the organic iodide.

39. Contributions to Appendix I doses from various pathways such as cow milk ingestion, inhalation, vegetable ingestion, ground plane exposure, etc., should be calculated and provided in the Topical Report.

RESPONSE:

These calculations are site specific and should be treated on a plant-by-plant basis.

40. Provide the concentrations of HCl and H_2SO_4 expected in the off-gas based upon processing PVCs, rubber, contaminated oil, etc., and include the test data to substantiate these concentrations.

RESPONSE:

AECC limits the concentrations of sulfur to 1000 ppm and chlorides to 5000 ppm in the incoming dry active waste. This yields gaseous concentrations at the dry waste processor exit of 120 ppm SO_2 and 300 ppm HCl. These concentrations are further diluted by combining with the fluid bed dryer exhaust. The equilibrium gaseous concentrations before the scrubber/preconcentrator are 50 ppm SO_2 and 125 ppm HCl. These concentrations correspond to input rates to the dry waste processor of approximately 0.1 and 0.5 lb/hr of sulfur and chlorine, respectively. Tests on various types of sulfur-containing dry waste processor feeds at sulfur input rates ranging from 0.078 to 2.5 lb/hr have been conducted, wherein the concentration of SO_2 in the exhaust gases from the system was measured by two different analytical techniques. In all cases, the SO_2 concentrations in the exhaust from the system were less than 0.1 ppm (by volume, dry basis). The data are summarized in Table 36.

The concentration of HCl in the system exhaust has not been measured, but is expected to be significantly less than that of SO_2 based on the comparative equilibrium partial pressures of HCl and SO_2 over their respective aqueous solutions. See Table 37. Note that the ratio of the partial pressure of HCl to that of SO_2 (i.e., relative vapor concentrations) at similar liquid phase concentrations is on the order of 10^{-5} to 10^{-6}. Thus, the expected HCl concentrations in the exhaust of the system should be lower than that of SO_2 by several orders of magnitude (values probably well below detectable limits).

40. Response (cont.)

TABLE 36

SULFUR DIOXIDE EMISSIONS FROM VR SYSTEM FOR VARIOUS DRY WASTE PROCESSOR FEEDS

Dry Waste Processor Input		SO_2 Concentration in System Exhaust, ppm (by vol. dry basis)	
Type of Feed	Lb Sulfur/Hr	Wet Chemical (1) Method	Instrumental (2) Monitoring
Contaminated Oil	0.078	Approx. 0	——
Composite Trash	0.33 ± 0.16	0.04	——
Simulated Resins (3)	1.5	Approx. 0	Approx. 0
Simulated Resins (3)	2.5	Approx. 0.08	Approx. 0.05

(1) Based on absorption in aqueous $Na_2CO_3 + H_2O_2$ and turbidimetric determination of the resulting $SO_4^{=}$ ion.

(2) Based on a pulse fluorescence technique. Concentration values are relative to the ambient atmospheric background values, i.e., above the SO_2 concentration in the surrounding air.

(3) Resin incineration was simulated by the direct injection of SO_2 into the incinerator which was operating on No. 2 Diesel oil.

TABLE 37

EQUILIBRIUM PARTIAL PRESSURES OF SO_2 AND HCl OVER THEIR RESPECTIVE AQUEOUS SOLUTIONS AT 70°C (158°F) *

Concentration of SO_2 or HCl in the Liquid Phase, molality	Partial Pressure of SO_2 or HCl in the Gas Phase, mm Hg		Relative Partial Pressure, P_{HCl}/P_{SO_2}
	SO_2	HCl	
0.1	183	0.001	5×10^{-6}
0.2	363	0.002	6×10^{-6}
0.3	557	0.0035	6×10^{-6}
0.4	759	0.0056	7×10^{-6}
0.5	960	0.0083	9×10^{-6}

*Based on partial pressure data given in Chem. Engr. Handbook, Third Edition, pg. 167 (1950).

B. Radiological Assessment Branch Questions and AECC Responses

331.1 (3.1) In Chapter 3.1 you describe the typical dry waste materials which can be processed by the fluid bed incinerator. Include a list of materials, such as PVC, which if processed by the fluid bed incinerator, would result in damage to the system and a likely increase in occupational exposure associated with repair of the system. Describe stages taken to prevent the introduction of such materials into the shredder/fluid bed incinerator.

RESPONSE:

AECC has limited the quantity of halogenated plastics (PVC) to 5000 ppm and sulfur to 1000 ppm of the incoming dry active waste. At these values the acid gas concentrations immediately at the dry waste processor exhaust are 120 ppm SO_2 and 300 ppm HCl. These concentrations pose no threat to equipment in the system.

One method to limit the quantities of halogenated plastics and sulfur compounds is by limiting the procurement of these items by the utility.

The incinerator can handle the following generic list of waste materials:

Paper and paper products (cardboard, etc.)
Wood
Non-halogenated plastics (polyethylene, etc.)
Cloth
Low sulfur rubber
Lubricating oils

In general, compounds containing sulfur and halogens should be avoided, such as:

Polyvinylchloride
Teflon
Fluorocarbons
Polysulfones
Fluorosilicones
Chlorosulfonated Polyethylene

In the event that these compounds are introduced in large quantities to the dry waste processor, the resulting acid gases will lower the pH in the scrubber/preconcentrator which will alarm and identify the problem to the operator. The control interlocks within the AECC system prevent the low pH liquid from being fed to the fluid bed dryer to preclude damage. The low pH liquid can be transferred back to the T-1 waste storage tanks for pH adjustment by addition of caustic. The resultant waste can then be processed by the AECC VR System in the usual manner. When this event occurs, the incoming wastes to the incinerator must be inspected removal of material containing excessive amounts of halogenated plastics or sulfur.

331.2 (3.7) Describe the precautions taken to minimize personnel exposures during the remote cleaning of the decontamination nozzles in the various system components should these nozzles become clogged.

RESPONSE:

Nozzles which have exhibited any tendency to plug have been provided with an air purge. This has proven adequate for keeping nozzles, lines, and instruments unplugged. Heat tracing has been incorporated into the system design as required to prevent crystallization which could cause plugging of some nozzles. The system has been designed to maintain flow velocities above saltation levels and to insure that stagnant fines do not exist in lines that potentially carry solids particles. This has probably been a significant factor in the freedom from nozzle plugging. The decontamination nozzles, the dryer feed nozzles, and the dry waste processor bed and gas coolant nozzles are all removable inserts which can be decontaminated and cleaned using standard utility practices or simply replaced since they are a low cost item.

In the unlikely event that the decontamination nozzles become clogged and cannot be cleared by flushing with warm water or decontamination solution, maintenance personnel must manually remove the nozzle. The nozzle would then be unplugged or discarded. The removal operation consists of unbolting a flange and would be conducted in a low radiation field since the inventory (dry product or liquid) of the affected component would have been transferred to a hopper or tank.

331.3 (4.2.13) Discuss the expected service life of the charcoal adsorbers and HEPA filters. Describe the design features of the gas filter assembly that are incorporated to maintain personnel doses ALARA during element changeout. Address your conformance with the guidelines of 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", or give suitable alternatives.

RESPONSE:

The charcoal adsorber is designed to have 0.75 seconds gas residence time. The total quantity of KI/TEDA impregnated charcoal is about 400 pounds and the maximum quantity of acid gases is 0.5 ppm or about 10^{-3} lbs/hr. Assuming one-half of the charcoal can be used to collect the acid gases and using the results of SO_2 insult on charcoal from the data in NUREG/CR-2112, Sept. 1981, the expected charcoal life is about 3600 hrs of operations.

The HEPA filter life is expected to be about 4000 hrs of operation based on: DF of 5×10^4 before the HEPA filter, 4 pound filter capacity (6 pound rating), and 50 pounds per hour production rate. The units are bag-in/bag-out type and 2 units are provided in parallel with each unit capable of total flow. When one unit requires servicing, the gas flow is valved through the other unit. Positive seal remote operated valves are used to direct the flow and isolate the spent unit. After 90 days decay time, the HEPA filter and charcoal adsorber are packaged in plastic bags for removal. The decay time and the bag-in/bag-out features are incorporated to minimize personnel exposure.

The housings are designed for the maximum pressure attainable and in accordance with ASME B&PV Code, Section VIII, Division I. The filter cartridges, charcoal adsorber and the housing cartridge supports and sealing provisions are in accordance with ANSI/ASME N509-80. Field testing is in accordance with ANSI/ASME N510-80. AECC believes these requirements meet the intent of Regulatory Guide 1.140.

331.4 (8.4.3) Based on the operating experience of the AECC VR System, provide a realistic estimate of the downtime associated with operation of this system at a utility where the system operator will have had no prior experience with the operation of such a volume reduction system. Provide an estimate of the annual man-rem that will be associated with each of the following functions: operation, maintenance, and in-service inspection. Include in your response: (1) the expected radiation fields (R/hr) associated with all components and cubicles of the radwaste system where personnel may require access to perform the above mentioned functions, (2) the occupancy times (hrs/yr) required in each of these locations, and (3) the exposure (man-rem/yr) received for each function and/or location. Supply this information for all segments of the radwaste system, including the off-gas cleanup system.

RESPONSE:

During the past 3 years, the AECC VR System full-scale prototype located in Sacramento, California has operated in a reliable manner while processing several thousand gallons of simulated evaporator concentrates and tons of dry wastes. Maintenance during this period has been routine and performed principally on mechanical components such as pumps and the shredder, and has consumed only a few % of the total hours available per year for operation of the system.

For system operation at a utility, AECC will provide an operations and maintenance manual in sufficient detail so that a utility operator with no prior experience will be able to operate the system. Furthermore, AECC will provide sufficient operator training prior to system operation. Required system maintenance will be conducted during the scheduled annual two-week maintenance period and at other times as required. A realistic estimate of the expected annual downtime of the VR System is 4 weeks -- two weeks for scheduled maintenance and two weeks for unscheduled activity.

An estimate of the annual man-rem received during system operation is provided in Table 38, while an estimate of the annual man-rem received during maintenance and in-service inspection is provided in Table 39. Annual dose due to normal system operation is estimated to be less than 2.31 man-rem, and annual dose due to maintenance operations and in-service inspection is 0.972 man-rem.

331.4 Response (cont.)

TABLE 38

ANNUAL DOSE FROM AECC VR SYSTEM NORMAL OPERATION

Operation	Location	Radiation Level	Hours/ Year	No. of Persons	Annual Dose, Man-Rem
Startup/shutdown	Control Room	<0.001 R/hour	120	1	<0.12
Steady-state operation	Control Room	<0.001 R/hour	4380	1*	<2.19
			Total Annual Dose		<2.31

*1 Person required half-time.

331.4 Response (cont.)

TABLE 39

ANNUAL DOSE FROM MAINTENANCE AND IN-SERVICE INSPECTION

Component	Service/Inspection Operation	Frequency	Units	Total Man-Hours Required	Average Radiation Level, R/Hour	Annual Dose, Man-Rem
Total System	Decontamination	1/Year	1	60	0.002	0.120
Centrifugal Pumps P-1, P-3, P-5, & P-8	Check shaft runout		5	10	0.005	0.05
	Change oil		5			
	Check seals		5			
	Check alignment		5			
	Inspect impeller		5			
Progressing Cavity Pumps P-2 & P-4	Replace rotor & stator	1/Year	2	4	0.005	0.02
Diaphragm Pumps P-6	Change oil	1/Year	2	2	0.002	0.004
Gear Pump P-9	None required	—	1	—	---	---
Air Blowers C-2 & C-3	Check & lubricate bearings, seals, & drive coupling. Adjust packing	1/Year	2	1	0.005	0.005
HEPA Filters F-1A, F-1B, & F-4	Inspect gaskets, seals & valves per RG 1.140.	1/Year	2	1	0.002	0.002
	Change HEPA filters F-1A/B	2/Year	2	6	0.02	0.12
	Change HEPA filter F-4	4/Year	1	8	0.02	0.16
Charcoal Adsorbers D-1A & D-1B	Inspect gaskets, seals, & valves.	1/Year	2	1	0.002	0.002
	Change charcoal adsorber media.	2/Year		4	0.02	0.08
Air Heaters E-1, E-2 & E-4	Check elements & controls.	1/Year	3	1	0.005	0.005

331.4 Response (cont.)

TABLE 39 (cont.)

ANNUAL DOSE FROM MAINTENANCE AND IN-SERVICE INSPECTION

Component	Service/Inspection Operation	Frequency	Units	Total Man-Hours Required	Average Radiation Level, R/Hour	Annual Dose, Man-Rem
Process Vessels R-1 & R-3	Inspect vessel & nozzles.	1/Year	2	1	0.03	0.03
Product Conveyor R-2	Inspect & service drive motor & shaft seals.	1/Year	1	1	0.03	0.03
Off-Gas cleanup system components S-1, S-2, S-3 & S-4	Inspect vessel & nozzles.	1/Year	4	2	0.02	0.04
Hoppers H-1, H-2, H-3A, H-3B, H-4 & H-5	Inspect & service valves, drive motors, & seals.	1/Year	6	20	0.01	0.20
Trash Shredder G-2	Inspect & service per manufacturer's schedule.	1/Year	1	160	0.0005	0.08
Trash Elevator G-1	Inspect & service per manufacturer's schedule.	1/Year	1	4	0.0005	0.002
Metal Detector/Trash Conveyor XJ-101 & G-3	Inspect & service per manufacturer's schedule	1/Year	1	4	0.0005	0.002
Control Panels CP-1, CP-2, & CP-3	Inspect & calibrate.	1/Year	3	40	0.0005	0.02
					Total Annual Dose	0.972 Man-Rem

331.5 (8.4.3) The following design features are intended to minimize the deposition and accumulation of radioactive materials in the components of waste processing systems. Describe how your system design reflects consideration of these features to maintain occupational radiation exposures ALARA:

(1) Reducing the length of piping runs.

(2) Avoiding low points and dead legs in piping.

(3) Using larger diameter piping to minimize plugging.

RESPONSE:

AECC does not perform the piping analysis or laycut but does approve the piping layout. The equipment is located in individual cubicles (ALARA) and all effort is made to locate the equipment adjacent to the next processing vessel in order. Lines containing dust laden gases are routed as short as possible with minimum bends. Lines containing dry solids are always vertical lines to a maximum of 30° from vertical with no bends. For these types of pipe runs, there are no loops or dead legs permitted.

Piping carrying liquids is routed to provide adequate personnel shielding. However, drain valves are provided at the low points, and dead legs are avoided. In the event that dead legs are unavoidable, they are flushed with water and secured at both ends. Equipment and piping is designed to avoid crud traps or buildup of contaminated solids.

Pipe diameters are selected based on the particular use. Piping carrying solids is limited to 2" minimum size for solids smaller than 500 micron diameter. Gas piping carrying dust is sized by velocity and pressure drop restraints but in no case is smaller than 4-inch. Liquid piping is sized to maintain a minimum velocity to keep all suspended solids from settling out in lines which can result in plugging. In general, the waste feed lines to scrubber/preconcentrator and fluid bed dryer must be sized to prevent settling. The flowrates vary between 15 to 100 gph which may require pipelines to be less than 3/4" to provide adequate velocity. All other piping is designed to maximize size consistent with the required velocity.

REFERENCES

5.* "A Waste Inventory Report for Reactor and Fuel-Fabrication Facility Wastes", J. Phillips, F. Feizollahi, R. Martineit, W. Bell, R. Stouky, ONWI-20, NUS-3314, NUS Corporation, March 1979.

6. Draft Environmental Impact Statement on 10CFR61, "Licensing Requirements for Land Disposal of Radioactive Waste", U.S. NRC, NUREG-0782, September 1981.

7. NRC Working Paper, "LWR Solid Waste Generation", Revision 2, U.S. NRC, ETSB, June 1981.

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*References 1 through 4 are contained in the Topical Reports No. AECC-2-NP and No. AECC-2-P.