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DOE/RL-99-77

Radioactive Air Emissions Notice of Construction for the Magnesium Hydroxide Precipitation Process at the Plutonium Finishing Plant

United States
Department of Energy
Richland, Washington

Approved for Public Release

DOE/RL-99-77
UC-630

Radioactive Air Emissions Notice of Construction for the Magnesium Hydroxide Precipitation Process at the Plutonium Finishing Plant

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METRIC CONVERSION CHART

Into metric units			Out of metric units		
If you know	Multiply by	To get	If you know	Multiply by	To get
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0393	inches
inches	2.54	centimeters	centimeters	0.393	inches
feet	0.3048	meters	meters	3.2808	feet
yards	0.914	meters	meters	1.09	yards
miles	1.609	kilometers	kilometers	0.62	miles
Area			**Area**		
square inches	6.4516	square centimeters	square centimeters	0.155	square inches
square feet	0.092	square meters	square meters	10.7639	square feet
square yards	0.836	square meters	square meters	1.20	square yards
square miles	2.59	square kilometers	square kilometers	0.39	square miles
acres	0.404	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces	28.35	grams	grams	0.0352	ounces
pounds	0.453	kilograms	kilograms	2.2046	pounds
short ton	0.907	metric ton	metric ton	1.10	short ton
Volume			**Volume**		
fluid ounces	29.57	milliliters	milliliters	0.03	fluid ounces
quarts	0.95	liters	liters	1.057	quarts
gallons	3.79	liters	liters	0.26	gallons
cubic feet	0.03	cubic meters	cubic meters	35.3147	cubic feet
cubic yards	0.76456	cubic meters	cubic meters	1.308	cubic yards
Temperature			**Temperature**		
Fahrenheit	subtract 32 then multiply by 5/9ths	Celsius	Celsius	multiply by 9/5ths, then add 32	Fahrenheit
Energy			**Energy**		
kilowatt hour	3,412	British thermal unit	British thermal unit	0.000293	kilowatt hour
kilowatt	0.948	British thermal unit per second	British thermal unit per second	1.055	kilowatt
Force/Pressure			**Force/Pressure**		
pounds per square inch	6.895	kilopascals	kilopascals	0.14504	pounds per square inch

Source: *Engineering Unit Conversions*, M. R. Lindeburg, PE., Second Ed., 1990, Professional Publications, Inc., Belmont, California.

GLOSSARY

BARCT	best available radionuclide control technology
CFR	Code of Federal Regulations
dpm	disintegrations per minute
EPA	U.S. Environmental Protection Agency
HEPA	high-efficiency particulate air
MEI	maximally exposed individual
NOC	Notice of Construction
PFP	Plutonium Finishing Plant
TEDE	total effective dose equivalent
WAC	Washington Administrative Code
WDOH	Washington State Department of Health

NOTICE OF CONSTRUCTION FOR THE MAGNESIUM HYDROXIDE PRECIPITATION PROCESS

1.0 INTRODUCTION

The following description and any attachments and references are provided to the Washington State Department of Health (WDOH), Division of Radiation Protection, Air Emissions & Defense Waste Section as a notice of construction (NOC) in accordance with Washington Administrative Code (WAC) 246-247, Radiation Protection – Air Emissions. The WAC 246-247-060, "Applications, registration, and licensing", states "This section describes the information requirements for approval to construct, modify, and operate an emission unit. Any NOC requires the submittal of information listed in Appendix A." Appendix A (WAC 246-247-110) lists the requirements that must be addressed.

Additionally, the following description, attachments and references are provided to the U.S. Environmental Protection Agency (EPA) as an NOC, in accordance with Title 40, Code of Federal Regulations (CFR), Part 61, "National Emission Standards for Hazardous Air Pollutants." The information required for submittal to the EPA is specified in 40 CFR 61.07. The potential emissions from this activity are estimated to provide greater than 0.1 millirem per year total effective dose equivalent (TEDE) to the hypothetical offsite maximally exposed individual (MEI), and commencement is needed within a short time. Therefore, this application also is intended to provide notification of the anticipated date of initial startup in accordance with the requirement listed in 40 CFR 61.09(a)(1), and it is requested that approval of this application also will constitute EPA acceptance of this initial startup notification. Written notification of the actual date of initial startup, in accordance with the requirement listed in 40 CFR 61.09(a)(2) will be provided at a later date.

This NOC covers the activities associated with the construction and operation activities involving the magnesium hydroxide precipitation process of plutonium solutions within the Plutonium Finishing Plant (PFP).

For the activities covered under this NOC, the unabated and abated TEDE to the hypothetical MEI is 2.19 E+02 and 1.01 E-01 millirem per year, respectively.

2.0 FACILITY LOCATION (REQUIREMENT 1)

U. S. Department of Energy, Richland Operations Office
825 Jadwin Avenue
P.O. Box 550
Richland, Washington 99352-3562

The coordinates for the 291-Z-1 Stack are as follows:
Latitude: 46° 32′ 58.9″ N
Longitude: 119° 37′ 58.7″ W

3.0 RESPONSIBLE MANAGER (REQUIREMENT 2)

The responsible manager for the activities described under this NOC is as follows:

Mr. L. D. Romine, Director
Transition Program Division
U.S. Department of Energy,
P.O. Box 550
Richland, Washington 99352
(509) 376-4747

4.0 TYPE OF PROPOSED ACTION (REQUIREMENT 3)

The proposed action results in a modification of an existing emission unit (291-Z-1 Stack). The proposed action is a significant modification to an emissions unit that is subject to applicable continuous emissions measurement requirements (40 CFR 61.93).

5.0 STATE ENVIRONMENTAL POLICY ACT (REQUIREMENT 4)

The proposed action is categorically exempt from the requirements of the State Environmental Policy Act under WAC 197-11-845.

6.0 PROCESS DESCRIPTION (REQUIREMENT 5)

PFP must process, stabilize, and package, for interim storage, a liquid plutonium nitrate solution to satisfy a portion of the Defense Nuclear Facilities Safety Board's recommendation 94-1. Stabilization of the solution will be accomplished by the combination of a new precipitation process and the existing muffle furnaces. The new process is the magnesium hydroxide ($Mg(OH)_2$) precipitation process. The magnesium hydroxide precipitation process currently is operated at the Rocky Flats Environmental Technology Site in Colorado. PFP will copy the process to the maximum extent possible.

The magnesium hydroxide precipitation process (Figure 1) will remove, by precipitation, plutonium that is contained in various nitric acid solutions. The nitric acid solutions will be neutralized by the addition of magnesium hydroxide. A weak nitric acid stream (0.35 Molar) will dilute the solutions as stored to a maximum acid strength of 3.0 Molar in existing facilities within PFP (feed makeup tank).

The diluted solutions will be fed to the three precipitation vessels where the magnesium hydroxide powder will be added manually. After the magnesium hydroxide addition, the vessels will be agitated by sparging air up through the vessels by pulling a vacuum on the precipitation vessels. The mixing will ensure complete mixing of the powder into the liquid resulting in a complete reaction.

The magnesium hydroxide precipitation process is extremely effective at removing plutonium from the liquid as the solubility product, K_{sp}, for plutonium hydroxide ($PuOH_4$) is extremely low and is reported to be 7 E-56 (ANS 1990). The solubility product is an equilibrium constant that provides a relationship for the concentration of ionic species remaining in solution. For $PuOH_4$, where the brackets [ ] represent the ionic concentration in moles per liter, the solubility product is expressed as follows (ANS 1990):

$$K_{sp} = [Pu^{+4}][OH^{-}]^{4} = 7\ E\text{-}56.$$

As the concentration of base $[OH^{-}]$ is increased, the concentration of plutonium $[Pu^{+4}]$ remaining in the liquid decreases proportionally by $[OH^{-}]^{-4}$. If operated properly, essentially all of the plutonium in solution will be precipitated in the magnesium hydroxide precipitation process.

After the reaction is complete, the precipitators will be drained by gravity to an open pan filter where the plutonium solids will be collected. The filtrate will be vacuumed into a phase separator for collection. The filtrate will be filtered further in the polishing filters before being pumped to temporary storage in the filtrate tanks. After laboratory analysis confirming satisfactory plutonium removal (less than 0.001 grams per liter), the filtrate will be disposed using existing PFP facilities. Out-of-specification material would be subjected to recycle for plutonium recovery.

The plutonium solids will be transferred to an open metal container and heated on a hot plate to further dry the material within the glovebox. The plutonium will be allowed to cool before being conveyed to muffle furnaces.

Final stabilization of the precipitate will be performed in the existing muffle furnaces to convert the dried plutonium hydroxide to plutonium oxide (PuO_2). Operation of the existing muffle furnaces is covered under another NOC (DOE/RL-96-79).

The feed makeup tank to the magnesium hydroxide precipitation process is located in an existing glovebox within Room 227. The feed line from the feed makeup tank never has been used and currently is capped. Construction activities proposed for Room 227 involve the installation of wall and ceiling mounts, as necessary, to secure the glovebox in case of a seismic event. Additionally, decontamination activities might be performed if necessary.

Most of the construction activities and process activities will occur in Room 230C. Construction activities within Room 230C will include the following:

- Decontaminate and/or stabilize any contaminated areas as necessary
- Install two new gloveboxes to house the process equipment (e.g., precipitators, phase separator, polishing filters, filtrate tanks, and hot plate)
- Anchor the two new gloveboxes to the floor
- Install wall and ceiling mounts, as necessary, to secure the gloveboxes in case of a seismic event
- Install drain lines from the new gloveboxes to a clean section of an existing drain line
- Connect the two new gloveboxes to the existing E-4 ventilation header
- Route feed, return, and spare lines that originate from Room 227 to the new gloveboxes
- Install new wall section in conveyor transport to connect to the new gloveboxes
- Cut a hole, with the dimension approximating by a 4-foot diameter semicircle, into the wall between Rooms 230C and 230B to allow access to a glovebox port
- Remove/relocate electrical power conditioner
- Relocate current safety shower and eye wash station
- Install a new electrical control panel
- Install a wash water tank and run lines to two new gloveboxes.

7.0 ANNUAL POSSESSION QUANTITY AND PHYSICAL FORM (REQUIREMENTS 8, 10, AND 11)

A summary of the annual possession quantity for routine operations, construction, and decontamination operations has been provided in Attachment A. The annual possession quantity for routine operations was based on processing solution containing less than 0.4 metric ton of plutonium (less than 400 kilograms). For conservatism, the plutonium is considered to consist entirely of plutonium-239. For conservatism, the total amount of americium was assumed to be 25 percent of the total plutonium curie inventory based on core samples obtained from the Z-12 Crib (HNF-SD-WM-ETP-208). The annual possession quantity for processing is based on a conservative estimate for the maximum amount of material that could be stabilized in a year.

For construction and decontamination activities, the annual possession quantity assumes an average smearable contamination level of 1,000,000 disintegrations per minute (dpm) per 100 square centimeters (cm^2) on all ceiling, floor, wall, and equipment surfaces originating from americium-241. The assumption of 1,000,000 dpm/100 cm^2 was used based on the historical knowledge that the floors were tiled instead of using paint as a fixative because the floor was highly contaminated. As shown in Attachment A, the total estimated surface area to be disturbed assumes decontamination activities will occur in an area 30 by 50 feet. Up to 100, nominal ½-inch diameter ceiling, floor, and wall bolts will be installed to support the gloveboxes, and a 4-foot diameter semicircle will be cut into a wall.

The physical form of all radionuclides encountered during the construction and processing activities is expected to be dry particulates and particulates in solutions. The physical form of all radionuclides emitted is expected to be particulate.

Radionuclides that are expected to be encountered during the construction and processing activities include: uranium-235, uranium-238, plutonium-238, plutonium-239, plutonium-240, plutonium-241, plutonium-242, americium-241, and americium-243.

8.0 ABATEMENT TECHNOLOGY AND CONCEPTUAL DRAWING(S) (REQUIREMENT 6 AND 7)

Figure 2 contains a schematic of ventilation systems for the 291-Z-1 Stack. Work performed within Rooms 227 and 230C will be exhausted out the E-3 Ventilation System, which contains one stage of HEPA filtration with a minimum efficiency of 99.95 percent for particles with a median diameter of 0.3 micron. The magnesium hydroxide precipitation process located within gloveboxes in Rooms 227 and 230C will be exhausted out the E-4 Ventilation System, which contains two stages of high-efficiency particulate air (HEPA) filtration (credit taken for only one stage) with a minimum efficiency of 99.95 percent for particles with a median diameter of 0.3 micron. The maximum flowrate from the 291-Z-1 Stack is 137 cubic meters per second (290,000 cubic feet per minute).

9.0 MONITORING SYSTEM (REQUIREMENT 9)

The291-Z-1 Stack contains a National Emission Standards for Hazardous Air Pollutants (40 CFR 61) compliant sampling and monitoring system. Additionally, the stack monitoring system contains a continuous air monitor (alpha radionuclides) with alarm capability.

In accordance with WAC 246-247-075(11), there are no accident scenarios with a probability of occurrence during the expected life time of the proposed project of greater than 1 percent.

10.0 RELEASE RATES (REQUIREMENTS 12 AND 13)

For processing activities, the annual possession quantity shown in Attachment A was multiplied by the conservative 40 CFR 61, Appendix D, release factor of 1.0 E-03 for particulates and solutions. Although the furnace(s) will operate at temperatures near 300°C, the boiling point temperature of plutonium, americium, and uranium oxides and metals is well above 300°C. At high temperatures, the oxides will undergo transformation to a pure metal state. For americium, plutonium, and uranium oxide, the transformation begins to occur at a temperature of approximately 1,150°C, 1,500°C and 2,800°C, respectively. The boiling point of metallic americium, plutonium and uranium occurs at 2,607°C, 3,232°C and 3,818°C, respectively.

For construction and decontamination activities, the annual possession quantity in Attachment A was multiplied by the conservative 40 CFR 61, Appendix D, release factor of 1.0 for gases. A release fraction of 1.0 was used because the construction and decontamination activities could be performed using a HEPA vacuum or some other similar type of equipment.

The 296-Z-1 Stack exhaust will be operated in a continuous mode. Emissions for calendar year 1998 (DOE/RL-99-41) are shown in Table 1.

Table 1. 296-Z-1 Stack Emissions for Calendar Year 1998.

Radioisotopes	Annual emission (curies)	Effective dose equivalent for maximally exposed individual (millirem per year)
Pu-238	3.4 E-06	3.3 E-06
Pu-239,240	1.6 E-04	1.7 E-04
Pu-241	4.4 E-05	7.2 E-07
Am-241	3.0 E-05	4.7 E-05

11.0 OFFSITE IMPACT (REQUIREMENTS 14 AND 15)

A summary of the abated and unabated TEDE to the MEI is provided in Attachment A. The TEDE to the MEI was calculated using CAP88-PC (HNF-3602). The modeling was done based on an effective stack height of less than 40 meters and the MEI being located 22,000 meters southeast of the REDOX Facility in the 200 West Area on the Hanford Site.

12.0 COST FACTORS AND FACILITY LIFETIME (REQUIREMENTS 16 AND 17)

Requirement 16 is not applicable because a best available radionuclide control technology (BARCT) demonstration is provided (Attachment B).

The maximum design life of the magnesium hydroxide precipitation process is approximately 11 years (completion on or before October 1, 2010).

13.0 TECHNOLOGY STANDARDS (REQUIREMENT 18)

The 291-Z-1 Stack is a registered emissions unit with WDOH. The emissions unit design and operation will not be modified for the magnesium hydroxide precipitation process.

The EPA was requested to approve the 291-Z-1 Stack sampling/monitoring system as compliant with 40 CFR 61 Subpart H, on September 8, 1995 (DOE-RL 1995a). On September 19, 1995, EPA approved the 291-Z-1 Stack to be in compliance with the requirements of 40 CFR Part 61 Subpart H (DOE-RL 1995b). Therefore, the control technology standards listed in WAC 246-247-110(18) are being met by this system.

14.0 REFERENCES

AIR 92-107, Letter, A. W. Conklin, Washington State Department of Health, to J. D. Bauer, U.S. Department of Energy, Richland Operations Office, no subject, October 5, 1992.

ANS 1990, *Plutonium Handbook A Guide to The Technology – Volumes 1 and 2*, American Nuclear Society, LeGrange Park, Illinois.

DOE-RL, 1995a, Letter, *Request for Approval for the 291-Z-1 Stack Sampling/Monitoring System*, dated September 8, 1995, U.S. Department of Energy Richland Operations Office, Richland, Washington.

DOE-RL, 1995b, Letter Richard W. Poeton, EPA, to James E. Rasmussen, RL, dated September 18, 1995, Letter #AT-082, U.S. Environmental Protection Agency, Region 10, Seattle, Washington.

DOE/RL-96-79, *Radioactive Air Emissions Notice of Construction for Stabilization of Plutonium Metal and Oxides in the Muffle Furnaces at the Plutonium Finishing Plant*, October 1996, Richland, Washington.

DOE/RL-99-41, *Radionuclide Air Emissions Report for the Hanford Site Calendar Year 1998*, June 1999, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

HNF-SD-WM-ETP-208, *Engineering Task Plan Cleanup of Miscellaneous Underground Storage Tank 241-Z-361*, Rev. 1, 1997, SG Eurisys Services Corporation, Richland, Washington.

HNF-3602, *Volume 1: Calculating Potential to Emit Releases and Doses for FEMPS and NOCs*, July 1999, Fluor Daniel Hanford, Inc., Richland, Washington.

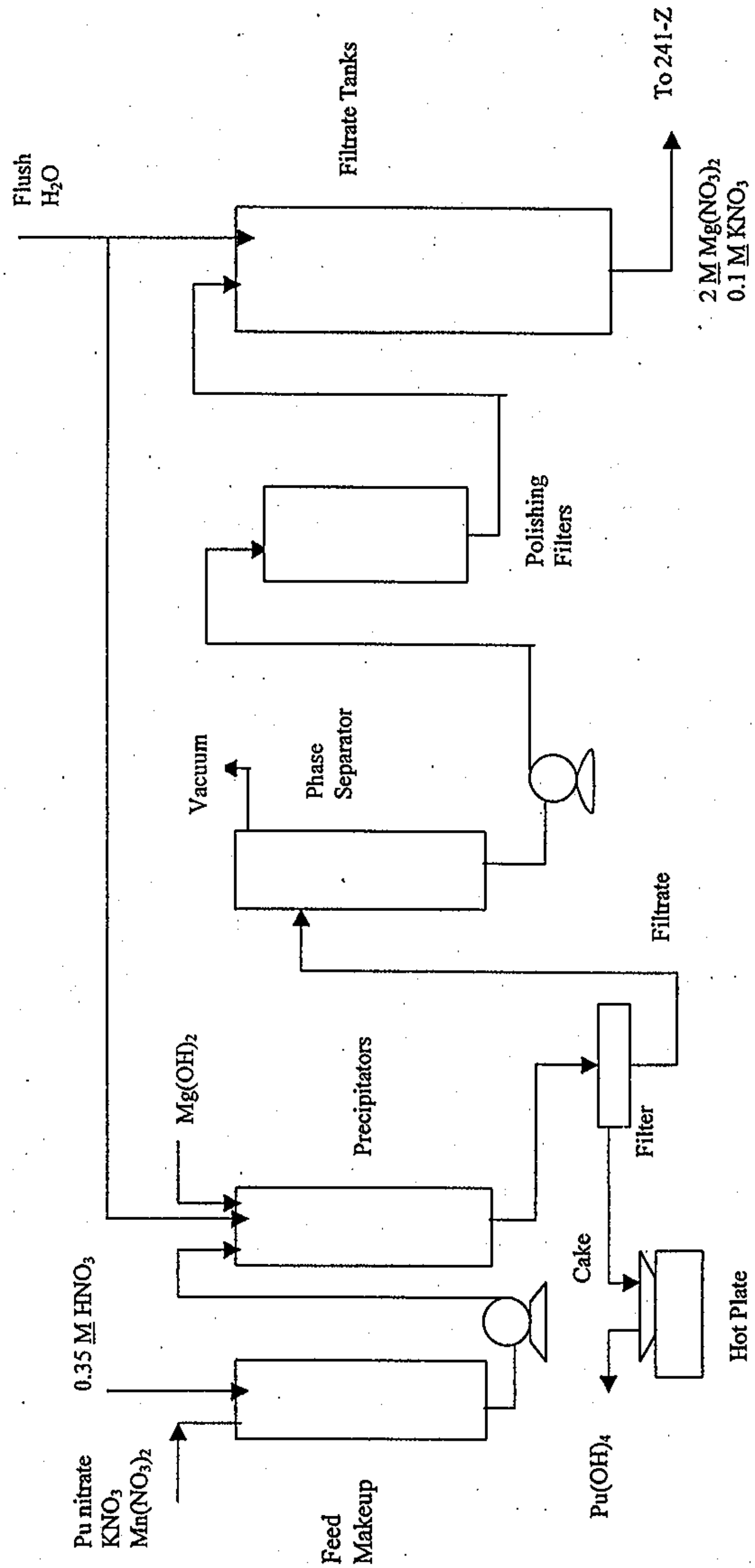

Figure 1. Simplified $Mg(OH)_2$ Process.

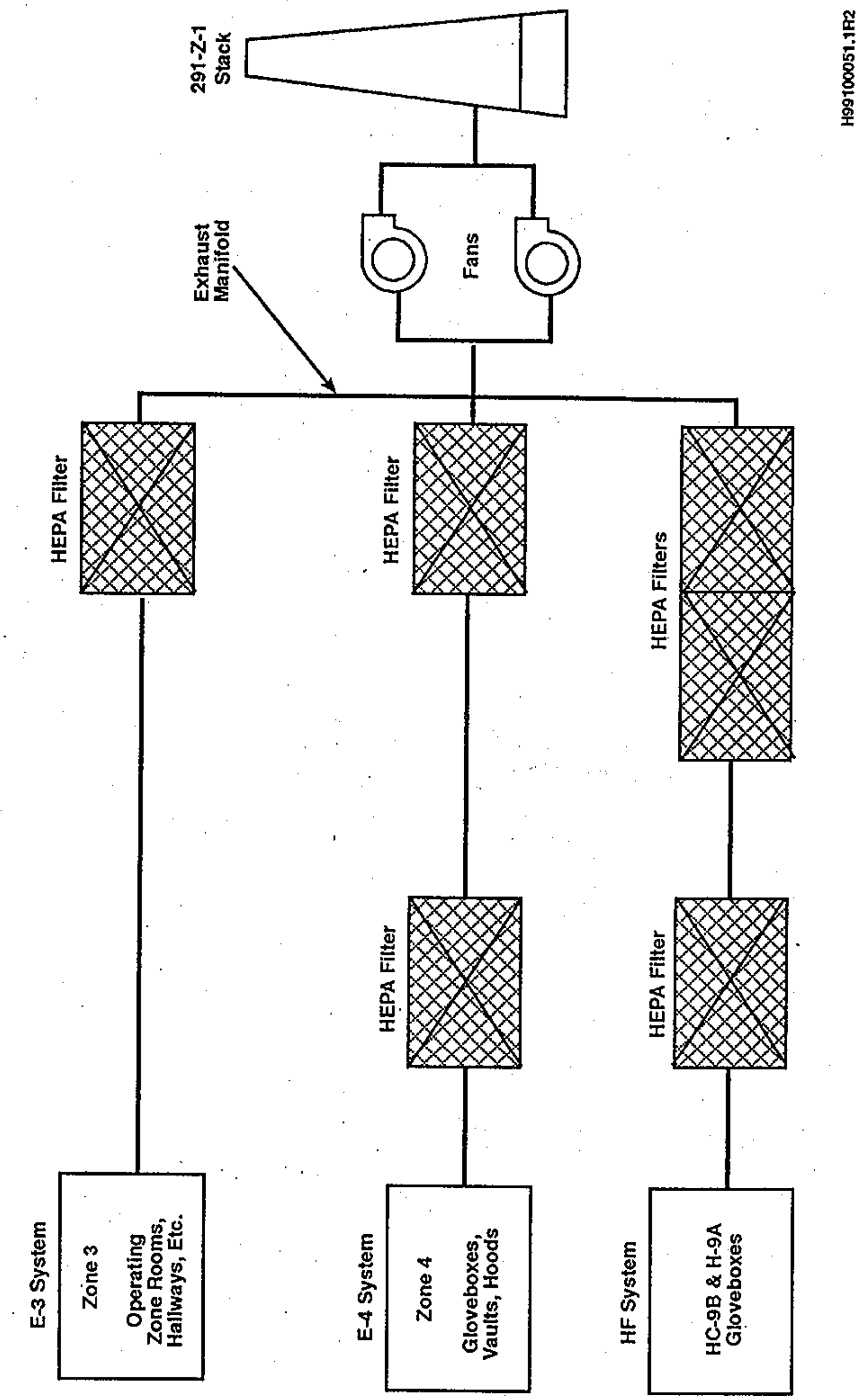

Figure 2. Schematic of Ventilation System.

ATTACHMENT A

TOTAL ESTIMATED INVENTORY (ANNUAL POSSESSION QUANTITY) AND EMISSIONS

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Estimate of Emissions and Offsite Dose Associated With the Magnesium Hydroxide Precipitation Process									
Maximum Annual Plutonium Throughput (Assume 100% Pu-239)	400	kg	(Less Than 0.4 Metric Tons of Plutonium)						
HEPA Effic.	99.95%								
HEPAs in series	1								
Isotope	**Maximum Annual Throughput, (grams/yr)**	**Specific Activitiy (Ci/gm)**	**Annual Possession Quantitiy (Ci/yr)**	**Particulate Release Factor**	**Unabated Release (Ci/yr)**	**Abated Release (Ci/yr)**	**Unit Dose Factor [HNF-3602] (mrem/Ci)**	**Unabated Dose (mrem/yr)**	**Abated Dose (mrem/yr)**
Pu-239	4.00E+05	6.20E-02	2.48E+04	1.00E-03	2.48E+01	1.24E-02	6.40E+00	1.59E+02	7.94E-02
Am-241	N/A	N/A	6.20E+03	1.00E-03	6.20E+00	3.10E-03	9.80E+00	6.08E+01	3.04E-02
Total			**3.10E+04**		**3.10E+01**	**1.55E-02**		**2.19E+02**	**1.10E-01**
Estimate of Emissions and Offsite Dose Associated With Construction & Decontamination Activities									
Surface Area for Decontamination	1500	ft^2							
Surface Area for Installation of Bolts into Ceilings, Floors & Walls (based on 100 - nominal 0.5 inch diameter holes)	1.64	ft^2							
Surface Area for 4 feet semicircle wall cut	6.28	ft^2							
Total Surface Area	1507.92	ft^2							
Total Surface Area	1400902.99	cm^2							
curie =	2.22E+12	DPM							
Isotope	**Surface Contamination (DPM/100*cm^2)**	**Annual Possession Quantitiy (Ci/yr)**	**Particulate Release Factor**	**Unabated Release (Ci/yr)**	**Abated Release (Ci/yr)**	**Unit Dose Factor (HNF-3602) (mrem/Ci)**	**Unabated Dose (mrem/yr)**	**Abated Dose (mrem/yr)**	
Am-241	1.00E+06	6.31E-03	1.00E+00	6.31E-03	3.16E-06	9.80E+00	6.18E-02	3.09E-05	
Summary of Overall Emissions and Offsite Dose									
Isotope	**Annual *Possession* Quantitiy (Ci/yr)**	**Unabated *Release* (Ci/yr)**	**Abated *Release* (Ci/yr)**	**Unabated *Dose* (mrem/yr)**	**Abated Dose (mrem/yr)**	***% Of Offsite Dose***			
Pu-239	2.48E+04	2.48E+01	1.24E-02	1.59E+02	7.94E-02	72.30%			
Am-241	6.20E+03	6.21E+00	3.10E-03	6.08E+01	3.04E-02	27.70%			
Total	**3.10E+04**	**3.10E+01**	**1.55E-02**	**2.20E+02**	**1.10E-01**	**100.00%**			

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ATTACHMENT B

DISCUSSION OF BEST AVAILABLE RADIONUCLIDE CONTROL TECHNOLOGY

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DISCUSSION OF BEST AVAILABLE RADIONUCLIDE CONTROL TECHNOLOGY
(REQUIREMENT 16)

Pursuant to WAC 246-247-110(16), providing cost factors for construction, operation, and maintenance of the proposed control technology components is not required because the following BARCT discussion is provided. The BARCT is defined by WAC 246-247-030 as follows:

> "Technology that will result in a radionuclide emission limitation based on the maximum degree of reduction for radionuclides from any proposed newly constructed or significantly modified emission units that the licensing authority determines is achievable on a case-by-case basis. A BARCT compliance demonstration must consider energy, environmental, and economic impacts, and other costs through examination of production processes, and available methods, systems and techniques for control of radionuclide emissions. A BARCT compliance demonstration is the conclusion of an evaluative process that results in the selection of the most effective control technology from all know feasible alternatives. In no event shall application of BARCT result in emissions of radionuclides that could exceed the applicable standards of WAC 246-247-040. Control technology that meets BARCT requirements also meets ALARCT requirements."

As stated in WAC 246-247-120, only those radionuclides comprising more than 10 percent of the unabated dose need to be evaluated. All of the dose is due to particulate radionuclides. WDOH has provided guidance that HEPA filters generally are considered BARCT for particulate emissions (AIR 92-207).

It is proposed, pursuant to the quoted citation and the cited WDOH guidance, that the ventilation system described in Section 8.0 and the controls (engineering and administrative) (described in Section 9.0) be approved as BARCT for the proposed activities.

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