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Radioactive Air Emissions Notice of Construction Multi-Function Waste Tank Facility

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Richland, Washington

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Radioactive Air Emissions Notice of Construction Multi-Function Waste Tank Facility

Environmental Services
Westinghouse Hanford Company

Date Published
August 1994

United States
Department of Energy
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Richland, Washington 99352

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LIST OF TERMS

BTU/h	British Thermal Units per hour
CFR	*Code of Federal Regulations*
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
HEPA	high-efficiency particulate air (filter)
km	kilometer
kW	kilowatt
MEI	maximally exposed individual
mrem/yr	millirem per year
MWTF	Multi-Function Waste Tank Facility
NEPA	*National Environmental Policy Act of 1969*
NOC	notice of construction
SEPA	*State Environmental Policy Act of 1971*
WAC	*Washington Administrative Code*

Cross Reference Between Notice of Construction and Appendix A of Washington Administrative Code 246-247

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1	1.2 Facility Identification
2	1.2 Facility Identification
3	1.3 Type of Proposed Action
4	1.4 State Environmental Policy Act Environmental Checklist
5	2.2 Facility Inventory
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RADIOACTIVE AIR EMISSIONS
NOTICE OF CONSTRUCTION
MULTI-FUNCTION WASTE TANK FACILITY

1.0 INTRODUCTION

The mission of the Multi-Function Waste Tank Facility (MWTF) is to provide storage capacity to support retrieval operation from those tanks with safety issues, to provide space for related retrieval demonstrations, and to support the long-term cleanup mission at the Hanford Site. To accomplish this, up to six 1,000,000 gallon, double-shell, high-level waste underground storage tanks and associated facilities are proposed to be constructed. As many as four tanks may be constructed in the 200 East Area and up to two tanks may be constructed in the 200 West Area. All tanks will have associated facilities. The tank farm located in the 200 East Area will be identified as the 241-HN Tank Farm; the 200 West Area tank farm will be identified as the 241-SN Tank Farm. Figure 1 shows the typical MWTF tank. This application addresses the maximum number of tanks proposed to be constructed.

1.1 NOTIFICATION REQUIREMENT AND GUIDANCE

This document serves as a notice of construction (NOC) pursuant to the requirements of *Washington Administrative Code* (WAC) 246-247-060 for the MWTF.

1.2 FACILITY IDENTIFICATION

U.S. Department of Energy, Richland Operations Office
Hanford Site
241-HN Tank Farm
241-SN Tank Farm
Richland, Washington 99352

The MWTF tank farms will be located in the 200 Areas of the Hanford Site. Figures 2 and 3 provide the proposed location of each farm.

Responsible Manager:
Mr. J. E. Rasmussen, Acting Program Manager
Office of Environmental Assurance,
Policy, and Permits
U.S. Department of Energy, Richland Operations Office
P.O. Box 550
Richland, Washington 99352

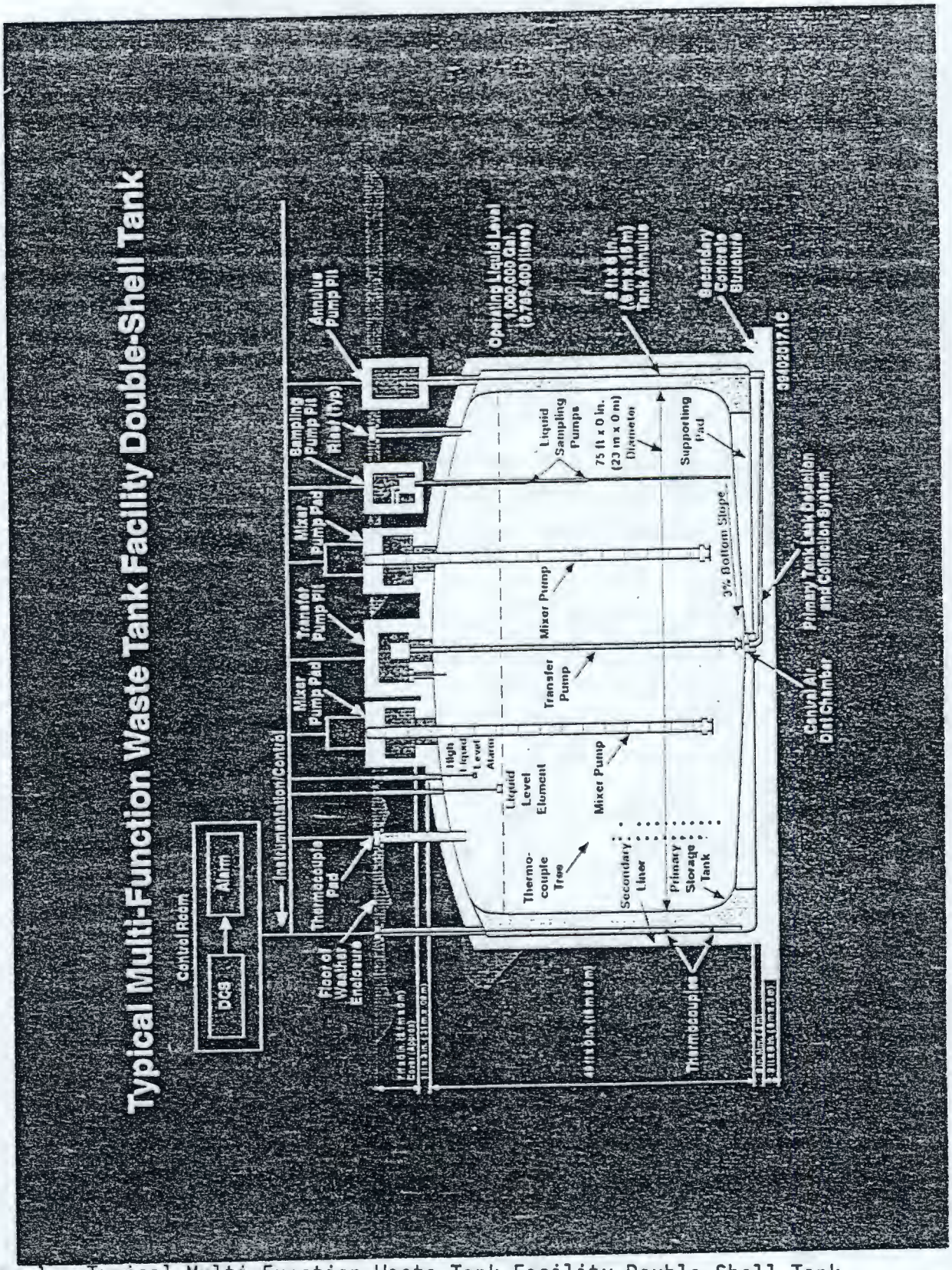

Figure 1. Typical Multi-Function Waste Tank Facility Double-Shell Tank.

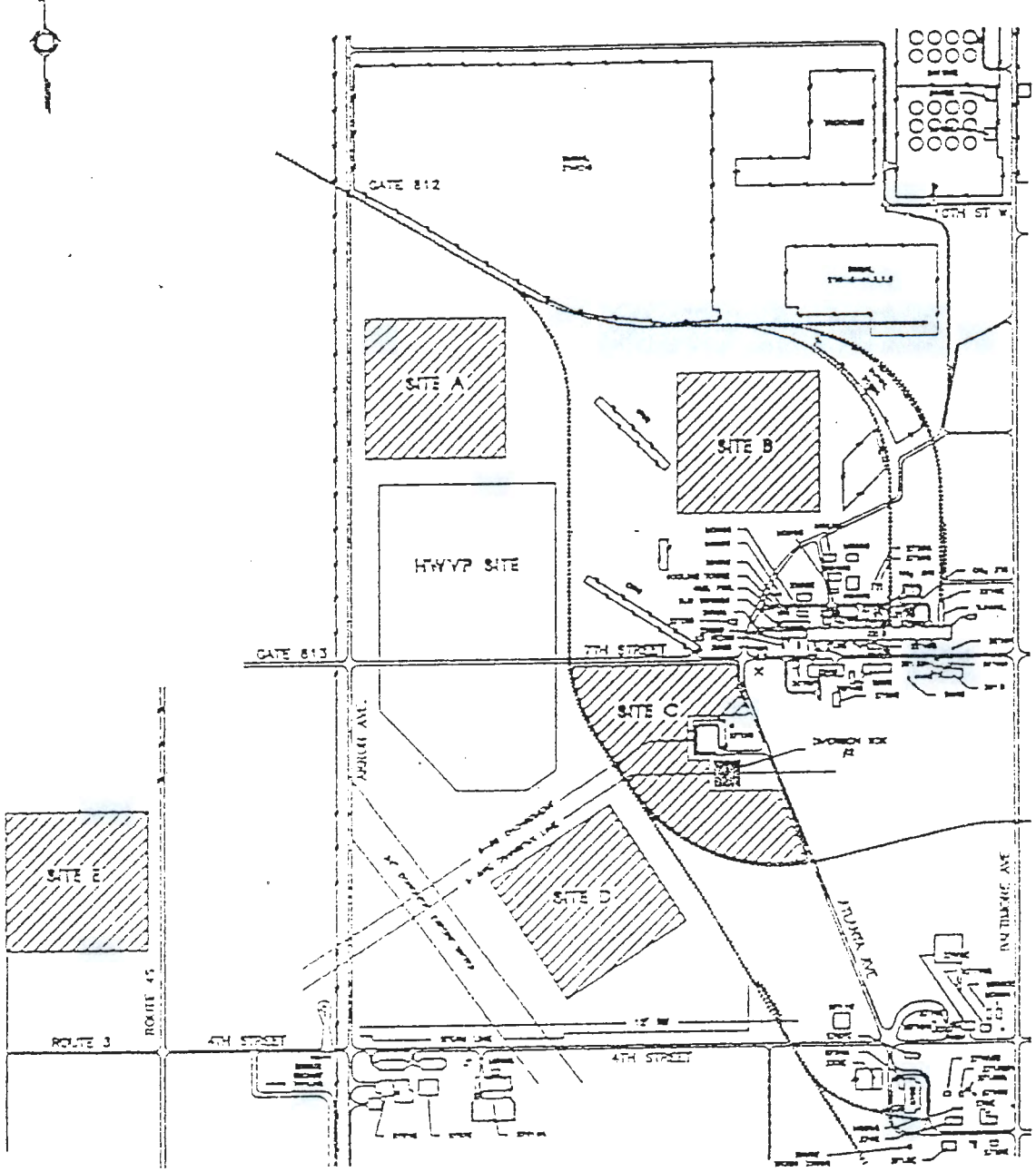

Figure 2. Location of 241-HN Tank Farm.

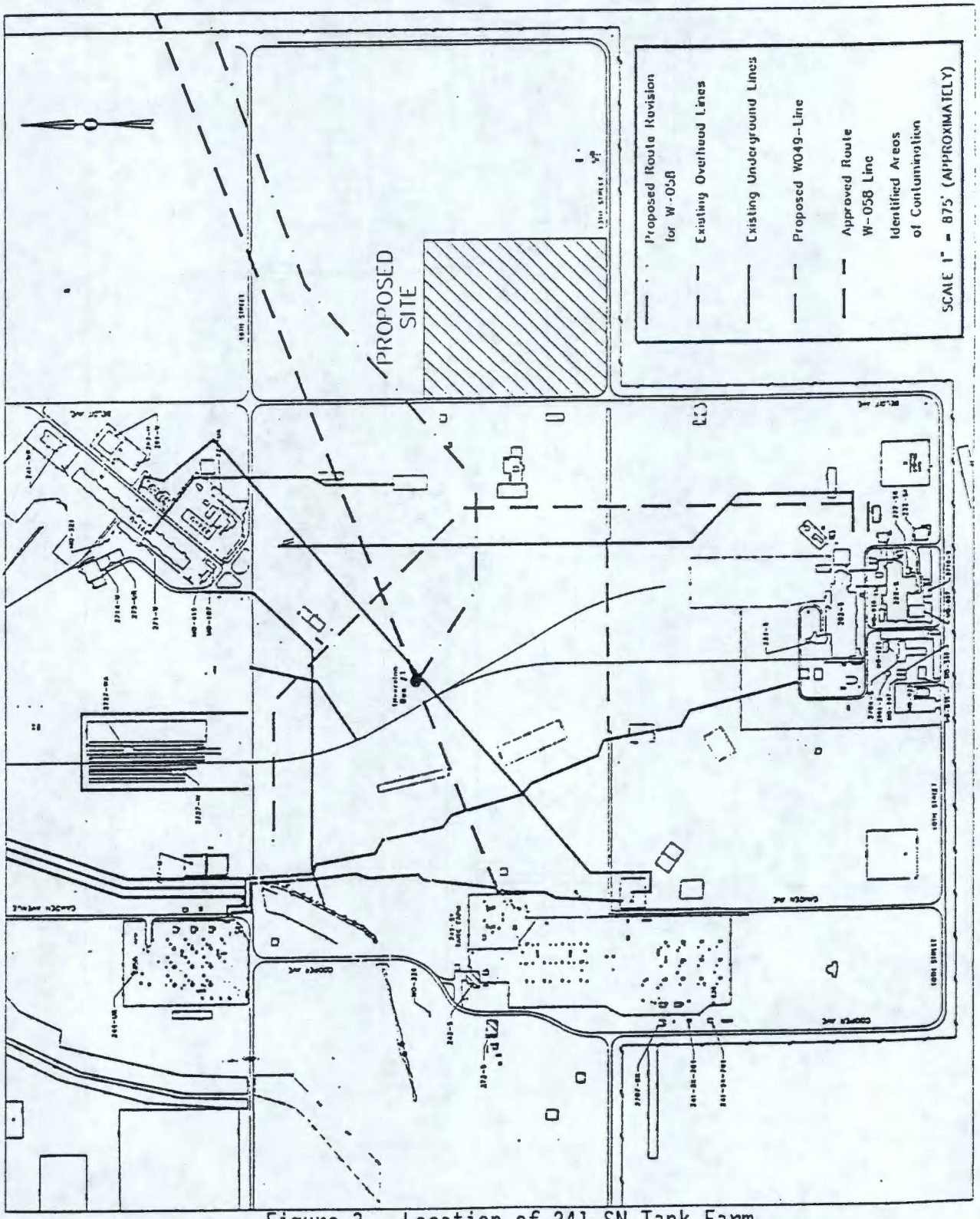

Figure 3. Location of 241-SN Tank Farm.

1.3 TYPE OF PROPOSED ACTION

The MWTF is a new emission unit.

1.4 STATE ENVIRONMENTAL POLICY ACT ENVIRONMENTAL CHECKLIST

The Washington State Department of Ecology (Ecology) is coordinating completion of the *State Environmental Policy Act of 1971* (SEPA) process with the U.S. Department of Energy's (DOE) preparation of a *National Environmental Policy Act of 1969* (NEPA) Environmental Impact Statement (EIS), *Environmental Impact Statement - Safe Interim Storage of Hanford Tank Waste*. For the SEPA process, Ecology is the lead agency. Mr. Geoff Tallent [(206) 407-7112] coordinates all SEPA activities for the Hanford Site.

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2.0 SOURCE INFORMATION

This section provides detailed information regarding the source and quantity of airborne radionuclide emissions resulting from the MWTF.

2.1 PROCESS DESCRIPTION

2.1.1 Overview

The MWTF will provide safe, environmentally acceptable, storage capacity to receive and store waste from single-shell and double-shell tanks supporting the Tank Waste Remediation System activities. The MWTF will consist of two separate sites with similar design. The 241-HN Tank Farm will contain four 1,000,000-gallon (nominal) tanks; the 241-SN Tank Farm will contain two 1,000,000-gallon tanks. Each facility will contain underground carbon steel tanks and associated equipment housed in two main buildings: (1) a support facility that houses the ventilation systems, liquid sampling systems, and control room and (2) a weather enclosure that covers the waste tanks and associated equipment. At the 241-HN Tank Farm only, there will be an administration building for offices, locker rooms, and a lunch room.

Each waste storage tank system will have a ventilation system. The ventilation system for each tank system will be divided into two subsystems: (1) the primary tank ventilation system and (2) the annulus ventilation system. The primary tank ventilation system will maintain the primary tank at a negative pressure to control contamination, remove a portion of the heat, and sweep potentially combustible gases out of the tank. The annulus ventilation system will circulate air around the annular space between the primary and secondary tanks to remove a portion of the mechanically induced (i.e., mixing pump operation) and radioactive decay heat. The ventilation air will be treated before release to the atmosphere to reduce radionuclide and pollutant hazards to acceptable levels. The treatment process is described further in Section 4.1.

The support facilities also will be ventilated and all ventilation systems will be combined for release at the stack for the facility. The primary ventilation system is the only system that will normally discharge radionuclides to the environment. Radionuclides become airborne in the tank by three different means: (1) particulates being entrained in the vapor from the waste, (2) as a gas (I-129), and (3) as vapor in the case of tritiated water.

The tanks are primarily a storage system, and only minor in-tank processing activities to support pretreatment facilities have been proposed at this time. A description of the process operations of the MWTF follows.

2.1.2 Operational Modes

The MWTF will have five operational modes:

- Operation - In this mode, the waste will be stored and transfers to or from the tank will be authorized and may occur.

- Warm standby - In this mode, waste will be stored, but transfers to or from the tank will not be authorized.

- Repair - In this mode, waste will be stored while maintenance or repairs are done. Opening the confinement barriers to the environment will be authorized in the repair mode, but transfers to or from the tank will not be possible and will not be authorized.

- Empty - In this mode, the tank may be completely empty, if it has never been used, or may contain a minimum heel of liquid (either water or waste) below the retrieval capability of the transfer pumps (less than 2%).

- Restricted - This mode is considered an abnormal condition where only certain restricted activities may be performed. Transfers to or from the tank will not be authorized in the restricted mode, except as allowed by an approved recovery plan or as necessary to maintain the MWTF in a stable and safe condition.

2.2 FACILITY INVENTORY

2.2.1 Waste Composition

The composition of the waste to be received by the MWTF tanks will be dependent on what existing tank waste is transferred to the facility; however, the extreme case radiological inventory of the waste is summarized in Table 1. The wastes that the MWTF will accept are those currently stored in other tanks in the area of the 241-HN and 241-SN Tank Farms, and waste from normal operations and cleanout of existing fuel processing facilities.

Table 1 is considered an extreme case and will never actually be seen in the facilities but is instead a bounding case to which the facility was designed. The table was derived by first taking a composite of the five worst tanks onsite. The composite was based solely on concentration and not on total inventory. The highest concentration for each individual radionuclide was then identified, and the concentration was multiplied by the volume available in the MWTF. This is a very conservative method because the high concentrations are not available in quantities to fill even one tank. Additional conservatism in the numbers is introduced because the radionuclides are only decayed to 1991, meanwhile the facility will not come online until 1998. Because this is such a conservative method, other methods were used to determine the stack offgas for the facility in Sections 3.0 and 5.0 and are discussed in those sections.

Table 1. Facility Inventory.

Radionuclide	Physical form	Annual possession quantity (Ci/yr) 241-HN Tank Farm	Annual possession quantity (Ci/yr) 241-SN Tank Farm
H-3	Tritiated water	5.26E+02	2.63E+02
C-14	Particulate	6.14E+03	3.07E+03
Ni-63	Particulate	4.03E+05	2.02E+05
Sr, Y-90	Particulate	2.10E+08	1.05E+08
Zr-93	Particulate	5.09E+02	2.54E+02
I-129	Dissolved gas	2.10E+01	1.05E+01
Cs, mBa-137	Particulate	5.79E+07	2.89E+07
Sm-151	Particulate	3.16E+06	1.58E+06
U-238	Particulate	1.03E+02	5.17E+01
Pu-239	Particulate	3.68E+04	1.84E+04
Pu-240	Particulate	1.35E+04	6.75E+03
Pu-241	Particulate	6.14E+04	3.07E+04
Am-241	Particulate	7.37E+05	3.68E+05

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3.0 UNABATED RELEASE RATES

This section provides information regarding the emission release rates from the MWTF without the emission control system in place. Also included is the effective dose equivalent to the maximally exposed individual (MEI) offsite resulting from unabated emissions. Both a nominal and an extreme operating scenario were developed for the MWTF. For the nominal case, a heat load of approximately 32 kilowatts (kW) [110,000 British Thermal Units per hour (BTU/h)] per tank is assumed; for the extreme case, one tank is assumed to have a heat load of approximately 200 kW (700,000 BTU/h) while the other tanks are operating as in the nominal case.

3.1 UNABATED EMISSIONS

Unabated emissions for the nominal and extreme case from both the 241-HN and 241-SN Tank Farms are provided in Tables 2 and 3. The emissions are based on a number of assumptions and may be found in the *Tank Primary Ventilation System Process Flow Diagram Descriptions* (ICF KH 1994).

Table 2. Unabated Emissions - Nominal Case.

Radionuclide	241-HN Tank Farm		241-SN Tank Farm	
	lb/min	Ci/yr	lb/min	Ci/yr
H-3	2.48E-12	5.71E+00	1.24E-12	2.85E+00
Sr-90	6.40E-08	2.12E+03	3.20E-08	1.06E+03
Y-90	1.60E-11	2.07E+03	8.00E-12	1.04E+03
I-129	1.56E-07	6.58E-03	7.80E-08	3.29E-03
Cs-137	4.00E-09	8.26E+01	2.00E-09	4.13E+01
Ba-137m	6.00E-16	7.70E+01	3.00E-16	3.85E+01
Pu-239	3.40E-08	5.03E-01	1.70E-08	2.51E-01

Table 3. Unabated Emissions - Extreme Case.

Radionuclide	241-HN Tank Farm	241-SN Tank Farm
	Ci/yr	Ci/yr
H-3	6.18E+01	5.89E+01
Sr-90	9.21E+03	8.15E+03
Y-90	8.93E+03	7.90E+03
Ru-106	9.58E-06	9.58E-06
Rh-106	9.34E-06	9.34E-06
Sn-113	1.66E-05	1.66E-05
Sb-125	8.10E-05	8.10E-05
I-129	1.00E-02	6.71E-03
Cs-137	3.10E+02	2.68E+02
Ba-137m	2.89E+02	2.50E+02
Pu-239	7.46E-01	4.95E-01

3.2 UNABATED DOSE

The unabated dose to the MEI, located 16 kilometers (km) east of the 200 East Area, for each of the scenarios is shown in Tables 4 and 5. The unit dose factors included in Tables 4 and 5 were previously submitted to the Washington State Department of Health. The 200 East Area dose factors were used for both tank farms for conservatism. The information required to develop the unit dose factors from the Clean Air Assessment Package 1988 computer code was also included in *Unit Dose Calculation Methods Summary of Facility Effluent Monitoring Plan Determinations* (WHC 1991).

Table 4. Unabated Offsite Dose - Nominal Case.

Radionuclide	Unit Dose Factor	241-HN Tank Farm		241-SN Tank Farm	
	mrem/Ci	Ci/yr	mrem/yr	Ci/yr	mrem/yr
H-3	2.19E-05	5.71E+00	1.25E-04	2.85E+00	6.25E-05
Sr-90	4.38E-02	2.12E+03	9.29E+01	1.06E+03	4.64E+01
Y-90	3.77E-04	2.07E+03	7.81E-01	1.04E+03	3.90E-01
I-129	2.91E-01	6.58E-03	1.92E-03	3.29E-03	9.58E-04
Cs-137	2.39E-02	8.26E+01	1.97E+00	4.13E+01	9.87E-01
Ba-137m	(Including Ba-137m)	7.70E+01		3.85E+01	
Pu-239	8.67E+00	5.03E-01	4.36E+00	2.51E-01	2.18E+00
Total	NA	NA	1.00E+02	NA	5.00E+01

Table 5. Unabated Offsite Dose - Extreme Case.

Radionuclide	Unit Dose Factor	241-HN Tank Farm		241-SN Tank Farm	
	mrem/Ci	Ci/yr	mrem/yr	Ci/yr	mrem/yr
H-3	2.19E-05	6.18E+01	1.35E-03	5.89E+01	1.29E-03
Sr-90	4.38E-02	9.21E+03	4.04E+02	8.15E+03	3.57E+02
Y-90	3.77E-04	8.93E+03	3.37E+00	7.90E+03	2.98E+00
Ru-106	2.09E-02	9.58E-06	2.00E-07	9.58E-06	2.00E-07
Rh-106	(Including Rh-106)	9.34E-06		9.34E-06	
Sn-113	1.18E-03	1.66E-05	1.96E-08	1.66E-05	1.96E-08
Sb-125	4.15E-03	8.10E-05	3.36E-07	8.10E-05	3.36E-07
I-129	2.91E-01	1.00E-02	2.91E-03	6.71E-03	1.95E-03
Cs-137	2.39E-02	3.10E+02	7.40E+00	2.68E+02	6.41E+00
Ba-137m	(Including Ba-137m)	2.89E+02		2.50E+02	
Pu-239	8.67E+00	7.46E-01	6.47E+00	4.95E-01	4.29E+00
Total	NA	NA	4.21E+02	NA	3.71E+02

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4.0 CONTROL AND MONITORING SYSTEMS

This section contains information on both the emission control and the monitoring systems proposed for the MWTF. A detailed discussion of the selection of the emission control system to satisfy the requirement to install best available radionuclide control technology is included as Appendix A.

4.1 CONTROL SYSTEM

4.1.1 Primary Ventilation Control Systems

The ventilation system consists of two portions: the first, called the cell treatment system, consists of a chilled water condenser, a high-efficiency mist eliminator filter, an electric heater, and a high-efficiency metal filter. To provide standby capacity, three cell treatment systems will be built for every two tanks. Consequently, there will be three cell treatment systems in the 241-SN Tank Farm and six cell treatment systems in the 241-HN Tank Farm. However, only one cell treatment system will be in operation at a time for each tank. Following the cell treatment system, the exhaust for all of the tanks in each tank farm will be combined. The combined exhaust will flow through a filter bank consisting of two stages of high-efficiency particulate air (HEPA) filters with a high-efficiency gas adsorption filter between the two HEPA filter stages. The final filtration stage will also have a backup system. Figure 3 shows a schematic of the proposed ventilation system.

The decontamination factors for the various pieces of equipment are listed for each constituent in Table 6. Tritium is in the form of tritiated water and partitions in direct proportion to nonradioactive water. The efficiency of the condenser and the high-efficiency mist eliminator depends on the temperature and humidity of the vapor entering the cell treatment system. The temperature of the vapor exiting the condenser will be approximately 40 degrees Fahrenheit (°F).

4.1.2 Annulus and Building Ventilation Control Systems

All annulus and building ventilation systems use a dual HEPA filter to prevent release of particulate radionuclides to the atmosphere under accident conditions. There are no planned emissions from these sources.

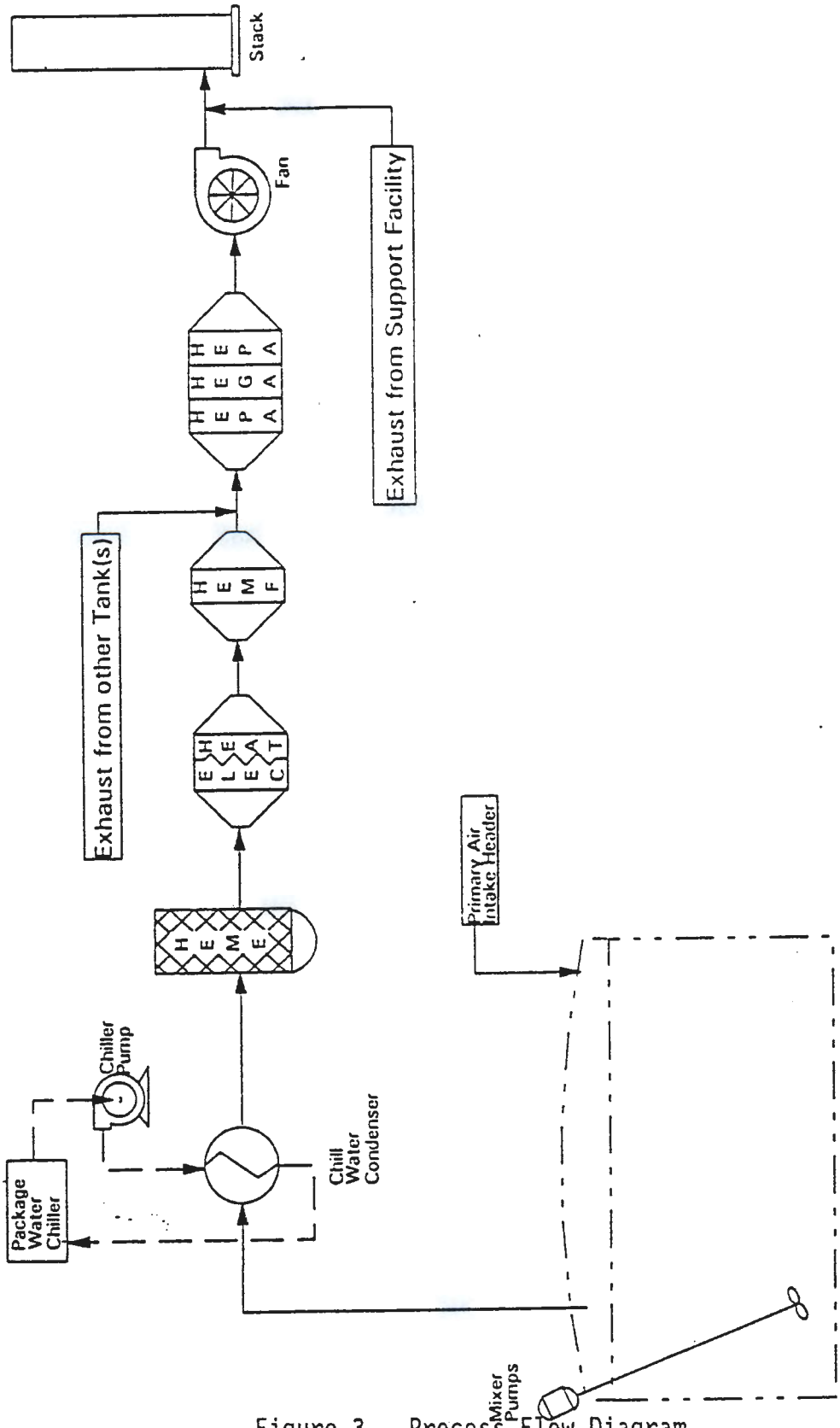

Figure 3. Process Flow Diagram.

Table 6. Decontamination Factors.

Radionuclide	Condenser	HEME	HEMF	HEPAs/HEGA
H-3	At least 2.8	At least 1.5	1	1
Sr-90	3.0	15	3000	1E+05
Y-90	3.0	15	3000	1E+05
Ru-106	1.5	1.25	1	2
Rh-106	1.5	1.25	1	2
Sn-113	1.5	1.25	1	2
Sb-125	1.5	1.25	1	2
I-129	1.5	1.25	1	50
Cs-137	4.0	15	3000	1E+05
Ba-137m	4.0	15	3000	1E+05
Pu-239	3.0	15	3000	1E+05

HEME = high-efficiency mist eliminator.
HEMF = high-efficiency metal filter.
HEGA = high-efficiency gas adsorption.
HEPA = high-efficiency particulate air.

4.2 MONITORING SYSTEM

The primary emission monitoring system will comply with 40 *Code of Federal Regulations* (CFR) 61, Subpart H and referenced requirements, and will consist of a near isokinetic sampling probe in accordance with ANSI N13.1 with an air particulate record sampler, an iodine sampler (I-129), and a tritium sampler. Additionally, an $\alpha/\beta/\gamma$ monitor will be installed for process information. The primary ventilation system effluent flow rate shall be monitored by using 40 CFR 60, Appendix A, Method 2 compliant instrumentation.

Samples will be removed once a month and sent to the 222-S Laboratories in the 200 West Area and will be analyzed by using 40 CFR 61, Subpart H, Method 114 compliant methods. The primary emission monitoring system will be located in the ductwork before the addition of the support facility exhaust. An additional particulate record sampler will be installed in the stack itself.

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5.0 ABATED RELEASE RATES

This section provides information regarding the emission release rates from the MWTF with the emission control system in place. Also included is the effective dose equivalent to the MEI offsite resulting from abated emissions.

5.1 ABATED EMISSIONS

Abated emissions, calculated using the decontamination factors shown in Table 6, are provided in Tables 7 and 8 for the nominal and extreme cases, respectively.

Table 7. Abated Emissions - Nominal Case.

Radionuclide	241-HN Tank Farm	241-SN Tank Farm
	Ci/yr	Ci/yr
H-3	1.40E+00	7.13E-01
Sr-90	1.59E-07	7.95E-08
Y-90	1.55E-07	7.77E-08
I-129	7.17E-05	3.54E-05
Cs-137	4.54E-09	2.27E-09
Ba-137m	4.36E-09	2.18E-09
Pu-239	3.70E-11	1.92E-11

Table 8. Abated Emissions - Extreme Case.

Radionuclide	241-HN Tank Farm	241-SN Tank Farm
	Ci/yr	Ci/yr
H-3	2.53E+00	1.77E+00
Sr-90	6.63E-07	5.96E-07
Y-90	6.60E-07	5.83E-07
Ru-106	2.48E-06	2.48E-06
Rh-106	2.46E-06	2.46E-06
Sn-113	4.33E-06	4.45E-06
Sb-125	2.16E-05	2.21E-05
I-129	1.10E-04	7.17E-05
Cs-137	1.73E-08	1.51E-08
Ba-137m	1.67E-08	1.41E-08
Pu-239	5.47E-11	3.70E-11

5.2 ABATED DOSE

The abated dose to the MEI, located 16 km east of the 200 East Area, is shown in Tables 9 and 10. The unit dose factors included in Tables 9 and 10 are described in Section 3.2.

The dose resulting from all Hanford Site operations in 1992 was determined to be 0.004 millirem per year (mrem/yr) for an individual located at Ringold (PNL 1993). The maximum abated emissions resulting from the MWTF (less than 0.00015 mrem/yr), in conjunction with other operations at the Hanford Site, will not result in a violation of the National Emission Standards (40 CFR 61) (10 mrem/yr).

Table 9. Abated Dose - Nominal Case.

Radionuclide	Unit Dose Factor	241-HN Tank Farm		241-SN Tank Farm	
	mrem/Ci	Ci/yr	mrem/yr	Ci/yr	mrem/yr
H-3	2.19E-05	1.40E+00	3.07E-05	7.13E-01	1.56E-05
Sr-90	4.38E-02	1.59E-07	6.97E-09	7.95E-08	3.48E-09
Y-90	3.77E-04	1.55E-07	5.86E-11	7.77E-08	2.93E-11
I-129	2.91E-01	7.17E-05	2.09E-05	3.54E-05	1.03E-05
Cs-137 Ba-137m	2.39E-02 (Including Ba-137m)	4.54E-09 4.36E-09	1.09E-10	2.27E-09 2.18E-09	5.43E-11
Pu-239	8.67E+00	3.70E-11	3.20E-10	1.92E-11	1.67E-10
Total	NA	NA	5.16E-05	NA	2.59E-05

Table 10. Abated Dose - Extreme Case.

Radionuclide	Unit Dose Factor	241-HN Tank Farm		241-SN Tank Farm	
	mrem/Ci	Ci/yr	mrem/yr	Ci/yr	mrem/yr
H-3	2.19E-05	2.53E+00	5.54E-05	1.77E+00	3.88E-05
Sr-90	4.38E-02	6.63E-07	2.90E-08	5.96E-07	2.61E-08
Y-90	3.77E-04	6.60E-07	2.49E-10	5.83E-07	2.20E-10
Ru-106 Rh-106	2.09E-02 (Including Rh-106)	2.48E-06 2.46E-06	5.17E-08	2.48E-06 2.46E-06	5.17E-08
Sn-113	1.18E-03	4.33E-06	5.11E-09	4.45E-06	5.26E-09
Sb-125	4.15E-03	2.16E-05	8.97E-08	2.21E-05	9.17E-08
I-129	2.91E-01	1.10E-04	3.19E-05	7.17E-05	2.09E-05
Cs-137 Ba-137m	2.39E-02 (Including Ba-137m)	1.73E-08 1.67E-08	4.14E-10	1.51E-08 1.41E-08	3.60E-10
Pu-239	8.67E+00	5.47E-11	4.74E-10	3.70E-11	3.20E-10
Total	NA	NA	8.75E-05	NA	5.98E-05

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6.0 REFERENCES

40 CFR 60, "Standards of Performance for New Stationary Sources," *Code of Federal Regulations*, as amended.

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APPENDIX A

BARCT DISCUSSION

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Project W-236A
Multi-Function Waste Tank Facility
Best Available Radionuclide Control Technology Assessment

Submitted To:

Westinghouse Hanford Company
Purchase Order No. MJK-SVV-296951, Task No. 16

Prepared By:

CH2M HILL/IT CORPORATION

July 1994

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List of Acronyms

μm	micrometers
^{3}H	tritium
^{90}Sr	strontium
^{90}Y	yttrium-90
^{106}Rh	rhodium-106
^{106}Ru	ruthenium-106
^{113}Sn	tin-113
^{125}Sb	antimony-125
^{129}I	iodine-129
^{137}Cs	cesium-137
^{137m}Ba	barium-137m
^{239}Pu	plutonium-239
^{240}Pu	plutonium-240
ALARA	as low as reasonably achievable
ASME	American Society of Mechanical Engineers
BACT	best available control technology
BARCT	Best Available Radionuclide Control Technology
Btu/hr	British thermal unit per hour
CAP	Clean Air Assessment Package
CEDE	committed effective dose equivalent
Ci/yr	curies per year
CRF	Capital Recovery Factor
DCG	derived concentration guidelines
DF	decontamination factor
DOE	U.S. Department of Energy
DOH	Department of Health
DOP	dioctylphthalate
DST	double shell tanks
ESP	electrostatic precipitator
EPA	U.S. Environmental Protection Agency
EVS	ejector venturi scrubber
ft^3	cubic feet
HEGA	high-efficiency gas absorption
HEME	high-efficiency mist eliminator

List of Acronyms (Continued)

HEMF	high-efficiency metal fiber
HEPA	high-efficiency particulate air
in. H_2O	inches of water
km	kilometers
kWh	kilowatts per hour
kWh/yr	kilowatts per hour per year
LAER	lowest achievable emission rate
m	meter
m/s	meters per second
MEI	maximally exposed individual
mrem/yr	millirem per year
MWTF	Multi-Function Waste Tank Facility
NCAW	neutralized current acid waste
NESHAP	National Emission Standards for Hazardous Air Pollutants
NOC	notice of construction
NTIS	National Technical Information Service
PM	particulate matter
PUREX	plutonium uranium extraction
SST	single shell tanks
TWRS	Tank Waste Retrieval System
ULPA	ultra low penetration air
VLSI	very large scale integration
WAC	Washington Administrative Code

1.0 Executive Summary

This document has been prepared to report the determinations of best available radionuclide control technology (BARCT), as defined by Chapter 246-247 of the Washington Administrative Code, for the reduction of emissions resulting from Project W-236A, Multi-Function Waste Tank Facility (MWTF) at the U.S. Department of Energy's (DOE) Hanford Site.

DOE's Hanford Site is located approximately 20 miles (32 kilometers) northwest of Richland, Washington. The MWTF will be located near the center of the Hanford Site and comprises six 1-million gallon (nominal) underground waste storage tanks and two separate support systems in the 200 East and 200 West Areas. Two of the tanks will be installed in the 200 West Area, and four in the 200 East Area. The tanks will be designed to contain radioactive mixed wastes which have been generated by various production processes at the Site.

The Hanford Site is currently working to resolve major tank waste safety and environmental issues. A major priority of the MWTF is to allow environmentally safe transfer and storage of waste from aging single shell tanks (SST) to facilitate removal of the SST from service and storage of waste from specific double shell tanks (DST) designated as "watchlist" tanks. The MWTF will be utilized in conjunction with other planned waste handling activities by the Tank Waste Retrieval System (TWRS) organization.

The nature of the waste to be stored in the MWTF is such that air pollutant emissions are expected, including various radionuclide, organic, and inorganic compounds. The exhaust stream from the tank is anticipated to be a mixture of solid and liquid particulate matter (aerosol) and vapors. Emission estimates have been developed for the MWTF based upon characterizations of waste which could potentially be stored in the MWTF.

Estimates for emissions of the uncontrolled airstream from the MWTF have been developed based on the radionuclide content of the waste in tank 241-AZ-101 (101-AZ) located in the AZ tank farm of TWRS and engineering judgement. 101-AZ contains neutralized current acid waste (NCAW) solutions from the plutonium uranium extraction (PUREX) plant. These NCAW wastes are known to contain greater than 99 percent of waste fission products from past PUREX operations and are some of the most radioactive slurries contained in Hanford Site tanks.

The majority of the radionuclide emissions are expected to be particulate matter (PM), although tritium (^{3}H), iodine-129 (^{129}I), ruthenium-106 (^{106}Ru), rhodium-106 (^{106}Rh), antimony-125 (^{125}Sb), and tin-113 (^{113}Sn) are expected to be present in the tank headspace as radioactive gases. ^{3}H, ^{129}I, and the other gaseous radionuclides will contribute less than 0.001 percent of the total uncontrolled committed effective dose equivalent (CEDE) to the maximally exposed individual (MEI); thus, only particulate radionuclides will be evaluated for BARCT.

Although not cost-effective, a complex particulate emissions control system will be utilized for the MWTF. The economic analysis of the control system revealed an economic impact of $392,660 per person-rem reduced for 200 East and $419,405 for 200 West; however, given the uncertainty of the emissions characterization and the Hanford Site goal of meeting the derived concentration guidelines (DCG), the control system will be utilized for this project. The emission control system will consist of chilled water condenser, a high-efficiency mist eliminator (HEME), a high efficiency metal fiber (HEMF) filter, and a high efficiency particulate air (HEPA) filter.

After the control system decontamination factor was applied, the CEDE to the MEI was calculated. The controlled total CEDE to the MEI for 200 East was 8.75 E-05 millirem per year (mrem/yr) and 3.27 E-05 for 200 West. The controlled CEDE to the MEI for both the 200 East and 200 West MWTF is significantly below the applicable U. S. Environmental Protection Agency (EPA) guidelines for the Hanford Site.

2.0 Introduction

The objective of this document is to report the determinations of best available radionuclide control technology (BARCT) for Project W-236A, Multi-Function Waste Tank Facility (MWTF) at the U.S. Department of Energy's (DOE) Hanford Site. The BARCT will support the notice of construction (NOC) that must be submitted before Project W-236A can proceed.

The U.S. DOE's Hanford Site covers approximately 560 square miles of semi-arid land in southeastern Washington, northwest of Richland. The MWTF will be located in both the 200 East and 200 West Areas near the center of the Hanford site. Figure 2-1 shows the geographical location of the Hanford Site and identifies the 200 East and 200 West Areas within the Hanford Site boundary.

2.1 Background

Current waste volume projections indicate a need for additional tank space on a priority basis. To satisfy retrieval needs, two million gallons of tank space is needed in the 200 West Area and four million gallons of tank space is needed in the 200 East Area. The additional waste storage tanks will provide safe, environmentally acceptable storage capacity to handle wastes from single shell tanks (SST) and double shell tanks (DST) safety issues and mitigation, and remediation activities. In addition to having space for resolution of safety issues, space is needed for related retrieval demonstrations, and to support the long-term cleanup mission at the Hanford Site.

2.2 Scope of the BARCT Analysis

The Washington Department of Health (DOH) in accordance with the Washington Administrative Code (WAC) 246-247, *Radioactive Air Emission Regulations (Amended)*, has informed DOE that a permit application will be required for Project W-236A, including a BARCT analysis. BARCT is defined by the regulations as "technology which 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 the control radionuclide emissions" (DOH, 1994).

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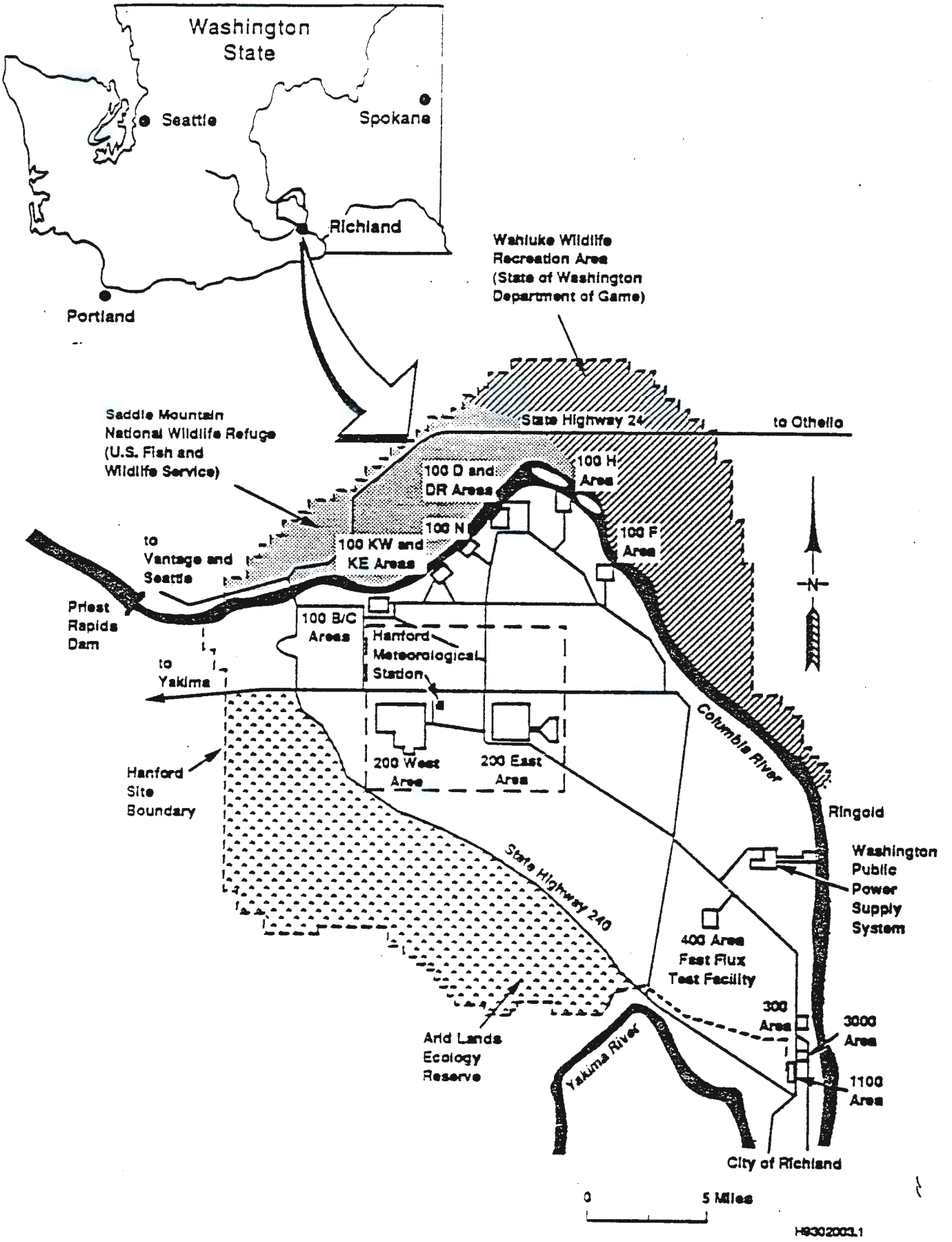

Figure 2-1. Location of the Hanford Site and the 200 Area

2.2.1 Identification of Control Options

A thorough review of available control technologies for radionuclide air emissions was performed. Included in this review were literature searches, previous BARCT determinations, regulatory agency information, vendor information, and other control information as available.

2.2.2 Technical Feasibility

Evaluation for technical feasibility of the various control technologies involved considering the expected conditions of the MWTF, its planned activities, space limitations, capabilities of the technologies, and other technical characteristics. Each conceptual control option was evaluated for technical feasibility. Options which are not feasible were then eliminated from further development.

2.2.3 Economic, Environmental, Energy, and Other Impacts

For each technically feasible option considered, a thorough determination of economic, environmental, energy, and other impacts was completed. Economic impacts involved developing an expected reduction in the committed effective dose equivalent (CEDE) to the maximally exposed individual (MEI) expressed in dollars/person-rem based on annualized capital and operating costs. Environmental impacts included waste generation and disposal, and other impacts which affect the Hanford Site workers and the public. Additional impacts specific to the MWTF were also considered.

2.2.4 BARCT Selection Process

Each technically feasible control option was ranked according to control efficiency. The control option exhibiting no significant adverse economic, environmental, or other impact was selected as BARCT.

3.0 Description of the Multi-Function Waste Tank Facility

3.1 General Facility Description and Layout

The MWTF comprises the 200 East and 200 West Areas as shown in Figure 3-1. The facility will be used to store radioactive mixed waste from other tanks in the Tank Waste Retrieval System (TWRS).

The expected radiolytic heat generation rate in the MWTF will range up to 770,000 British Thermal Units per hour (Btu/hr) with an expected nominal value of 110,000 Btu/hr. Radionuclides present in the tank include strontium-90 (^{90}Sr), yttrium-90 (^{90}Y), cesium-137 (^{137}Cs), barium-137m (^{137m}Ba), tritium (^{3}H), antimony-125 (^{125}Sb), rhodium-106 (^{106}Ru), plutonium-239 (^{239}Pu), plutonium-240 (^{240}Pu), rhodium-106 (^{106}Rh), tin-113 (^{113}Sn), and iodine-129 (^{129}I).

Each underground tank is to consist of two concentric structures. The outer structure shall consist of steel-lined reinforced concrete, and is referred to as the secondary confinement structure. The reinforced concrete will be designed to sustain all soil loadings, dead loads, live loads, seismic loads, and loads caused by temperature gradients between the radioactive wastes confined within the primary storage tank and the outside soil.

The secondary liner will be carbon steel extending along the bottom, sides and upper haunch of the reinforced concrete just beyond the upper knuckle of the primary storage tank. The secondary confinement structure and supporting systems shall provide the secondary confinement as defined by the DOE Order 6430.1A. The inner, completely enclosed, carbon steel primary storage tank shall be located within the secondary confinement structure and shall be separated from the secondary confinement structure by an annular space.

The primary storage tank is designed to confine the radioactive mixed waste, while the secondary confinement structure will safely confine any leakage from the primary storage tank.

3.1.1 Primary Storage Tank

The primary storage tanks design will be per the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III, and shall comply with all applicable Federal and State Codes and Hanford Plant Standards.

Provisions are to be made for inspection and corrosion monitoring to assess primary storage tank integrity during the design life of the tank, and for flushing, decontaminating, and cleaning of

the tanks, as required, to avoid mixing of different waste contents. In addition, the design will enable pumpout of the primary storage tank to within 2 percent of the nominal tank capacity (maximum tank heel). To minimize the buildup of solids at the tank bottom and to enhance heat transfer, the primary storage tanks are designed to accept a waste-mixing system.

3.1.2 Secondary Confinement

Reinforced concrete will be used to support the bottom and walls of the secondary liner and support the primary storage tank and its contents. During design, the effect of thermal transients on the reinforced concrete induced by the primary storage tank liquids level cycling will be evaluated. The ventilation systems are designed to limit the temperature of the secondary confinement structure to the design temperatures.

The annular space between the primary storage tank and secondary confinement structure shall be of sufficient width to allow penetrations from the top for inserting liquid level and leak detection devices; equipment for 100 percent visual inspection of the primary storage tank exterior cylindrical wall and the inner wall surface of the secondary liner; equipment for ultrasonic inspection of selected areas of the primary tank exterior wall and secondary liner inner wall; ventilation air supply; and pumping equipment to remove leaked material from the annular space. The secondary liner shall be designed to confine the radioactive liquids in the event of a leak or failure of the primary storage tank until the liquids are removed to another tank.

3.1.3 Instrumentation and Control

Integral wall, dome, haunch, and base temperature sensing devices (redundant or replaceable) will be installed in the concrete to aid administrative control of thermal gradients in the secondary confinement structure resulting from processing and storage operations. Temperature sensing devices located in the supporting pad will provide similar control.

Temperature sensing devices, redundant liquid level measuring devices, sampling devices, sludge level measuring devices, and high liquid level alarm devices shall be installed to monitor the contents of the primary storage tanks.

Liquid detectors in the annulus space and radiation air monitors in the annulus shall be installed to detect leaks from the primary storage tank. Leak detectors and/or radiation monitors shall be installed in the MWTF cells, pits, and rooms subject to leakage of radioactive and/or hazardous materials.

Effluent air monitors and air samplers will be installed on the ventilation systems to detect and measure radioactive and toxic material releases to the atmosphere. Alarms shall be provided for low flow and loss of sample airflow to the monitors. This alarm will be separate and distinct from that for high radiation. Continuous particulate matter sampling will be provided by the near-isokinetic air sampling system.

A device to measure concentration of ignitable and hazardous gases in the vapor space within each tank shall be provided. The device shall be able to detect the presence of and continuously measure hydrogen, carbon monoxide, hydrogen sulfide, carbon disulfide, nitrous oxide, ammonia and organic gases which might be generated by the waste stored in the tank.

3.2 Primary Ventilation and Heat Removal System

Anticipating the potential for radionuclide air emissions, preliminary design considerations for the MWTF included the development of a multistage emission control system. Each waste storage tank shall be provided with a primary ventilation and heat removal system. To provide for operational flexibility and separation of dissimilar waste forms, each primary ventilation system shall be designed so that vapor condensate can be returned to its tank of origin. The primary ventilation system equipment shall be contained in a building (Support Facility) and be connected via encased underground stainless steel ductwork to dedicated risers on the primary storage tanks.

Recirculation of the exhaust stream for cooling purposes has not been included in the MWTF exhaust system design. Heat loading estimates for the tanks have shown that appropriate cooling levels can be maintained by the normal operation of the ventilation system and inlet air flow system.

Considering the potential emissions from the MWTF and the nature of the exhaust stream, a combination of particulate matter controls were selected for the base case emissions control system. The system will consist of a vapor condensing system, high-efficiency mist eliminator (HEME), high-efficiency metal fiber (HEMF), and high-efficiency particulate air (HEPA) particulate filtration. In addition, organics present in the exhaust stream warrant use of a high efficiency gas adsorption (HEGA) system. A set of exhaust fans will be provided to discharge filtered air to the ventilation stack. Each waste storage tank system shall also be provided with an air intake system equipped with HEPA filters to provide adequate supply of air into the tank vapor areas for operation of the primary ventilation system within the range or tank pressure specified. All heaters, condensers, moisture eliminator equipment, HEPA filters, and exhaust fans

will be located in concrete shells or enclosures for confinement of radioactivity and for shielding. Schematics of the base case control system are shown in Figures 3-2 and 3-3 for the 200 East and 200 West MWTF.

Each tank in the MWTF will initially be exhausted through a "treatment cell" consisting of the condenser, HEME, heater, and HEMF. A condenser cooling system will be utilized to cool and remove vapors from the ventilation air stream. Vapors in the ventilation stream are condensed on the shell side of the condenser by a chilled water system. The condenser system will reduce the exhaust stream temperature of 200°F to 40°F. The chiller units will be designed to remove 0.5 million British thermal units per hour per tank (MBtu/hr/tank) at a ventilation flow rate of 500 ft^3/min. The chilled water system design will allow operation at a pressure higher than the pressure in the primary tank ventilation system to prevent contamination of the cooling water system in the event of a leak in the condenser.

Following the condenser, the HEME will be installed to provide complete fog removal. A cleaning water spray will operate as needed to maintain the removal efficiency of the HEME. The air downstream of the HEME is to be heated to prevent moisture accumulation on the HEPAs in the air filter train. The heater will be designed to increase the temperature from 40°F to 52°F.

The HEMF filters shall be installed to remove radioactive and other particulate contaminants and to minimize contaminant buildup on the HEPA filters. The HEMFs shall be provided with a remotely operated backwash system to prevent plugging and for decontamination.

Before passing through the HEPA and HEGA filtration systems, the individual tank exhaust will be combined; thus, in the 200 East MWTF, four tanks will be combined into one exhaust stream, while in the 200 West MWTF, two tanks will be combined prior to final filtration.

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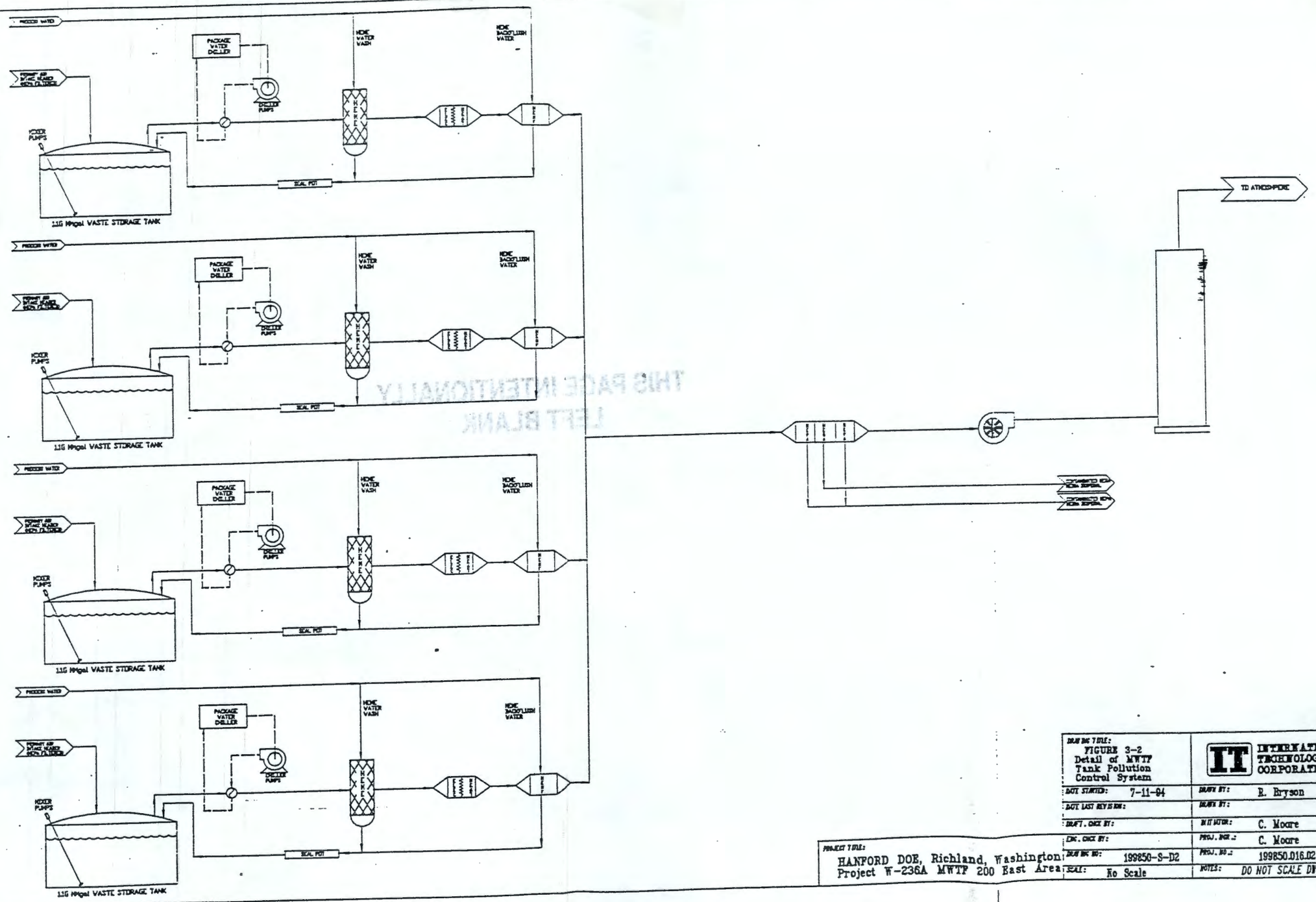

DRAWING TITLE: FIGURE 3-2 Detail of MWTF Tank Pollution Control System	INTERNATIONAL TECHNOLOGY CORPORATION
DATE STARTED: 7-11-94	DRAWN BY: R. Bryson
DATE LAST REVISION:	DRAWN BY:
DRAFT. CHCK BY:	DWG MANAGER: C. Moore
ENG. CHCK BY:	PROJ. ENGR.: C. Moore
DRAWING NO: 199850-S-D2	PROJ. NO.: 199850.016.02
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PROJECT TITLE:
HANFORD DOE, Richland, Washington
Project W-236A MWTP 200 East Area

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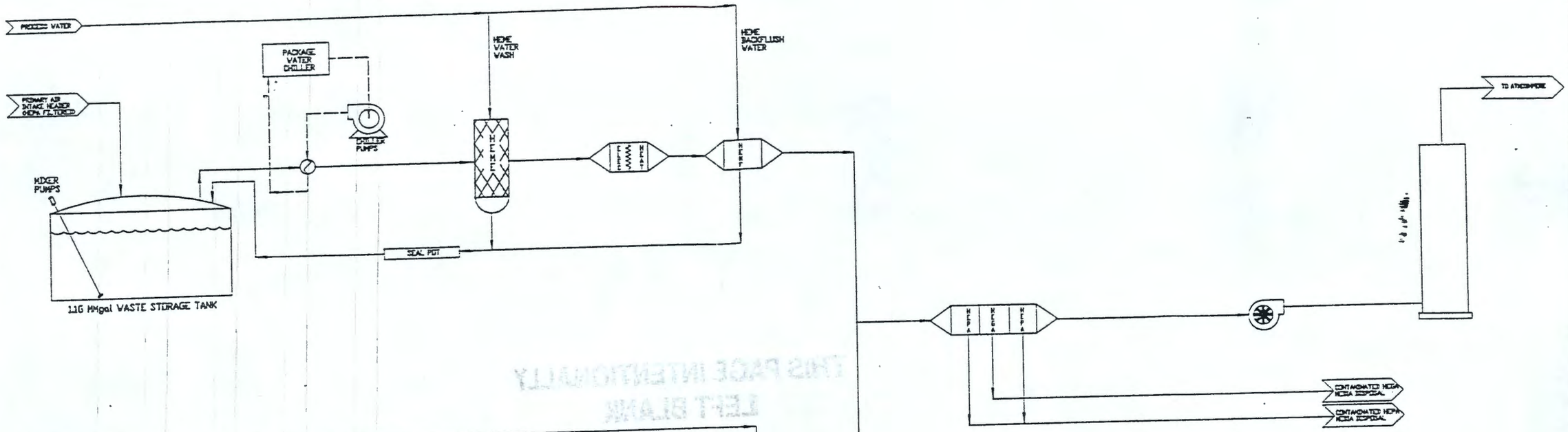

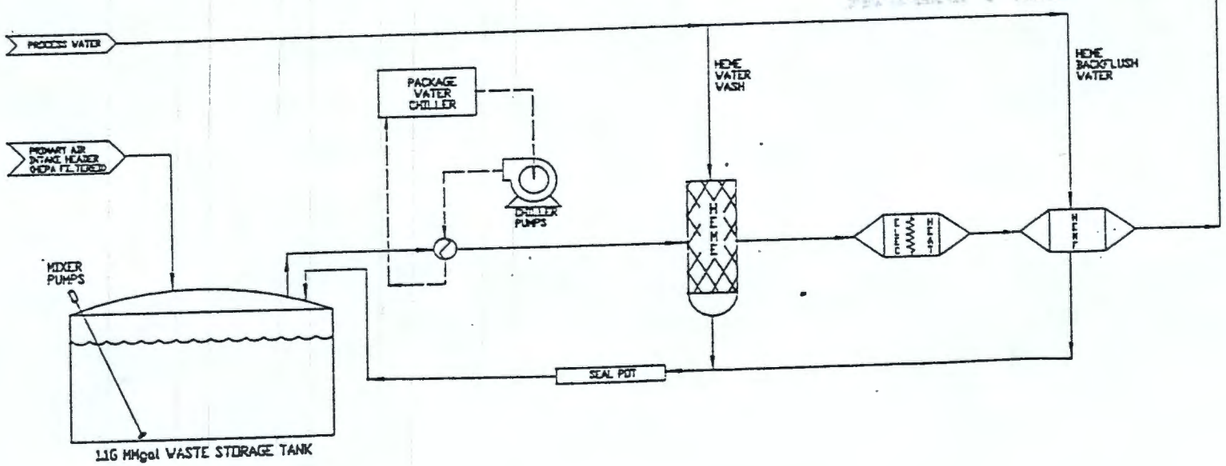

DRAWING TITLE: FIGURE 3-3 Detail of MWTP Tank Pollution Control System	INTERNATIONAL TECHNOLOGY CORPORATION
DATE STARTED: 7-11-94	DRAWN BY: R. Bryson
DATE LAST REVISION:	DRAWN BY:
DRAFT. CHCK BY:	INITIATOR: C. Moore
ENG. CHCK BY:	PROJ. MGR.: C. Moore
DRAWING NO: 199850-S-D1	PROJ. NO.: 199850.016.02
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HANFORD DOE, Richland, Washington
Project W-236A MWTP 200 West Area

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4.0 Uncontrolled Radionuclide Air Emissions

MWTF operations will involve the storage of waste from various tanks at the Hanford Site. Precise characterizations for the waste to be stored in the MWTF are unavailable given the uncertainty of retrieval operations and the contents of the existing tanks. However, radionuclide emission estimates have been developed from other waste tank characterizations for two emission cases: extreme and nominal.

4.1 Extreme and Nominal Cases

Within the storage tanks, the combination of sludge, waste liquid, and heat result in a moisture laden headspace; thus, exhaust from the waste tanks will be in the form of an aerosol, which is defined as a dispersion of microscopic solid and liquid particles in a gas phase (Wark and Warner, 1981). The exhaust stream characteristics differ significantly for the extreme and nominal case. Table 4-1 is a comparison of exhaust stream characteristics. As shown, the heat load of the extreme case is approximately seven times greater than the nominal case. Subsequently, the extreme case exhaust has a much higher humidity and temperature.

Estimates for the extreme case emissions of the uncontrolled airstream from the MWTF have been developed based on the radionuclide content of the waste in 241-AZ-101 (101-AZ) located in the AZ tank farm of TWRS. 101-AZ contains neutralized current acid waste (NCAW) solutions from the plutonium uranium extraction (PUREX) reprocessing plant. These NCAW wastes are known to contain greater than 99 percent of waste fission products from past PUREX operations and are some of the most radioactive slurries contained in Hanford Site tanks. Emission estimates assume that this waste will not be diluted upon transfer to a MWTF tank. In addition, it is assumed that neutralization, sludge washing, or other operations that would require chemical additions to the waste do not occur in the MWTF tank when undiluted NCAW waste is present (Meisinger, 1994a,b).

Nominal case emission estimates were developed from engineering judgement and an evaluation of historical records of the Hanford Site's waste tank activities (Meisinger, 1994a,b).

4.2 200 East and 200 West MWTF Uncontrolled Radionuclide Emissions

The MWTF will include two tanks in the 200 West Area and four tanks in the 200 East Area. For the emission estimates, it was assumed that all six tanks will process similar types of waste. To provide an accurate estimate of the emissions for each area while maintaining conservatism, it was assumed that each area would contain one tank representing the extreme case and the

Table 4-1

Comparison of Exhaust Stream Characteristics for Extreme and Nominal Case Emissions

Tank Characteristic	Extreme Case	Nominal Case
Heat Load (BTU/hr)	7.0 E+05	1.1 E+05
Vapor Space Temperature (°F)	177	106
Vapor Space Humidity (lb/lb dry air)	0.211	0.021
Waste Vapor Pressure (inches of mercury)	0.93	N/A

remaining tanks representing nominal conditions. Thus, in the 200 East Area, one tank will represent the extreme case, while three tanks will be nominal; in the 200 West Area, one tank will be extreme and one tank will be nominal. The expected speciation of the exhaust stream for both cases is that all radionuclides would be particulate matter (PM) with the exception of ^{3}H, ^{129}I, ^{106}Ru, ^{106}Rh, ^{113}Sn, and ^{125}Sb.

Tables 4-2 and 4-3 present estimated uncontrolled radionuclide emission rates in curies per year (Ci/yr) in addition to uncontrolled CEDE to the MEI for the 200 East MWTF and the 200 West MWTF, respectively.

For the 200 East Area, the highest radionuclide particulate emission rates are from ^{90}Sr, ^{90}Y, ^{137}Cs, and ^{137m}Ba, with emission rates of 9.06 E+03, 8.95 E+03, 3.12 E+02, and 2.89 E+02 Ci/yr. ^{3}H has the highest gaseous radionuclide emission rate of 6.18 E+01 Ci/hr. Dose conversion calculations resulted in a total uncontrolled CEDE to the MEI of 4.33 E+02 millirem per year (mrem/yr). The percentage of total dose contributed by each of the gaseous radionuclides is less than 0.0007 percent; thus, they will not be evaluated for BARCT (DOH, 1994).

For the 200 West Area, the highest radionuclide particulate emission rates are from ^{90}Sr, ^{90}Y, ^{137}Cs, and ^{137m}Ba with emission rates of 8.01 E+03, 7.91 E+03, 2.70 E+02, and 2.50 E+02 Ci/yr respectively. ^{3}H has the highest gaseous radionuclide emission rate of 5.89 E+00 Ci/yr. Dose conversion calculations resulted in a total uncontrolled CEDE to the MEI of 2.27 E+02 mrem/yr. The percentage of total dose contributed by each of the gaseous radionuclides is less than 0.0005 percent; thus, they will not be evaluated for BARCT (DOH, 1994).

CEDE to the MEI calculations were performed using unit dose conversion factors and methods from *Unit Dose Calculation Methods and Summary of Facility Effluent Monitoring Plan Determinations* (WHC, 1991). In the document, unit dose conversion factors are given in rem or mrem exposure per one curie release for each Site area (200 East, 200 West, etc.) based on modeled atmospheric releases by the U.S. Environmental Protection Agency (EPA) approved Clean Air Assessment Package (CAP)-88 (Beres, 1990). The dose conversion factors were applied to the estimated Ci/yr emission rates to yield the CEDE to the MEI in rem/yr or mrem/yr.

Table 4-2

200 East MWTF Uncontrolled Committed Effective Dose Equivalent to the Maximally Exposed Individual[a]

Radionuclide	Uncontrolled Annual Emissions (Ci/yr)	CAP-88 Dose Conversion Factor[b] (mrem/Ci)	Uncontrolled CEDE to MEI (mrem/yr)	Percent of Total Dose (%)
^{137}mBa[c]	2.89 E+02	2.39 E-02	6.90 E+00	1.596
^{137}Cs	3.12 E+02	2.39 E-02	7.45 E+00	1.721
^{3}H	6.18 E+01	2.19 E-05	1.35 E-03	0.000
^{129}I	9.98 E-03	2.91 E-01	2.90 E-03	0.001
^{239}Pu	7.47 E-01	8.67 E+00	6.48 E+00	1.497
^{240}Pu	1.36 E+00	8.66 E+00	1.18 E+01	2.723
^{106}Rh[d]	9.34 E-06	2.09 E-02	1.95 E-07	0.000
^{106}Ru	9.62 E-06	2.09 E-02	2.01 E-07	0.000
^{125}Sb	8.17 E-05	4.15 E-03	3.39 E-07	0.000
^{113}Sn	1.56 E-05	1.18 E-03	1.85 E-08	0.000
^{90}Sr	9.06 E+03	4.38 E-02	3.97 E+02	91.683
^{90}Y	8.95 E+03	3.77 E-04	3.37 E+00	0.800
Total	**1.87 E+04**		**4.33 E+02**	**100.00**

[a]The maximally exposed individual is located 16 kilometers east of the 200 East Area.
[b]Dose conversion factors are for the 200 East Area.
[c]Dose conversion factor for ^{137}mBa is assumed equivalent to the factor for ^{137}Cs.
[d]Dose conversion factor for ^{106}Rh is assumed equivalent to the factor for ^{106}Ru.

Parameters used in the development of unit dose conversion factors included:

- A release height of 10 meters (m) for the CAP-88 factors
- The maximally exposed individual 16 kilometers (km) (10 miles) east of the 200 East Area and 24 km (15 miles) east of the 200 West Area
- Hanford Site Meteorological Station data and on-site meteorological data obtained from 1983 through 1987.

Table 4-3

200 West MWTF Uncontrolled Committed Effective Dose Equivalent to the Maximally Exposed Individual[a]

Radionuclide	Uncontrolled Annual Emissions (Ci/yr)	CAP-88 Dose Conversion Factor[b] (mrem/Ci)	Uncontrolled CEDE to MEI (mrem/yr)	Percent of Total Dose (%)
^{137}mBa[c]	2.50 E+02	1.42 E-02	3.55 E+00	1.566
^{137}Cs	2.70 E+02	1.42 E-02	3.83 E+00	1.689
^{3}H	5.89 E+01	1.38 E-05	8.13 E-04	0.000
^{129}I	6.70 E-03	1.14 E-01	7.63 E-04	0.000
^{239}Pu	4.96 E-01	5.15 E+00	2.55 E+00	1.124
^{240}Pu	1.36 E+00	5.14 E+00	6.99 E+00	3.080
^{106}Rh[d]	9.34 E-06	1.24 E-02	1.16 E-07	0.000
^{106}Ru	9.62 E-06	1.24 E-02	1.19 E-07	0.000
^{125}Sb	8.17 E-05	2.47 E-03	2.02 E-07	0.000
^{113}Sn	1.56 E-05	7.02 E-04	1.10 E-08	0.000
^{90}Sr	8.01 E+03	2.60 E-02	2.08 E+02	91.768
^{90}Y	7.91 E+03	2.22 E-04	1.76 E+00	0.773
Total	**1.65 E+04**		**2.27 E+02**	**100.00**

[a]The maximally exposed individual is located 16 kilometers east of the 200 East Area.
[b]Dose conversion factors are for the 200 East Area.
[c]Dose conversion factor for ^{137}mBa is assumed equivalent to the factor for ^{137}Cs.
[d]Dose conversion factor for ^{106}Rh is assumed equivalent to the factor for ^{106}Ru.

5.0 Review of Potential Control Technologies

Many technologies exist for the control of particulate radionuclides and gases. The top-down BARCT analysis requires review of control technologies for this source category and for similar source categories. After all potential controls are identified, those controls which would be technically infeasible for this application will be eliminated from further discussion. The proposed base case control system will be included in the technical feasibility evaluation.

5.1 Particulate Radionuclides

Various particulate radionuclides will be emitted from the MWTF. Controls must be evaluated for reduction of particulate matter from the MWTF.

5.1.1 BACT/LAER Clearinghouse Review and Literature Search

EPA's best available control technology (BACT)/lowest achievable emission rate (LAER) Clearinghouse database was reviewed to determine effective particulate matter control systems. Source categories, regulatory basis, and regulatory agency categories were reviewed. Particulate control technologies identified included cyclonic separators, dust collectors, electrostatic precipitators (ESP), fabric filters (baghouse), filters, venturi scrubbers, and wet scrubbers. No specific particulate radionuclide control systems were identified.

Additional control technologies specific to the nuclear industry were determined through the use of the National Technical Information Service (NTIS), air pollution control equipment periodicals, and other literature. In addition, previous BARCT analysis for particulate radionuclides were used to obtain descriptions of technologies identified for past projects. Appendix A contains a thorough listing of all resources utilized in the search.

5.1.2 Description of Control Technologies

This section describes the available particulate and aerosol control technologies that may be employed to control emissions from the facility. Technical feasibility of the control technologies is evaluated in Section 5.1.3.

High-Efficiency Metal Fiber Filter. The HEMF filter is composed of fine stainless steel (less than 5 micrometers [μm] in diameter) fibers sintered together into a mat. This construction gives the filter high holding capacity, a high degree of strength, and low pressure drop (approximately 3 inches of water (in. H_2O). HEMF filters can be removed and cleaned repeatedly and could last

the life of the facility without being replaced. In addition, remote cleaning of the filters is currently being practiced. The time between cleanings depends upon the particle loading and the number of filters used. Cleaning solutions for the HEMF filters will become a liquid waste.

Free liquids with dissolved acid gases can cause corrosion and failure if contacted with the filter; however, failure can be prevented by cleaning the filters after exposure to acid gases. HEMF filters are less likely than other filters to fail during plant upsets. The primary suppliers of HEMF filters, the Pall Corporation, guarantees a removal efficiency of greater than 99.99 percent for particles larger than 0.1 µm in a single HEMF filter stage, although efficiencies as high as 99.99999 have been demonstrated in some applications (Moore, M., 1993). Copies of personal communications are located in Appendix B.

Ultra Low Penetration Air/Very Large Scale Integration Filter. The physical characteristics of the ultra low penetration air (ULPA)/very large scale integration (VLSI) filters are similar to the HEPA filters, but have higher particle removal efficiencies (99.995 to 99.99999 percent) due to the smaller diameter media used in the filter. The filters at the low end of this removal efficiency range are known as ULPA filters, while the filters at the high end of this range are referred to as VLSI filters. The ULPA/VLSI filters have a higher pressure drop as a result of the higher efficiency. ULPA/VLSI filters are composed of a collection of randomly oriented fibers of varying diameters and lengths compressed together as mats. The filter is usually 10 to 20 millimeters thick and is pleated with separators between the folds so that a large filtering area can be placed into a relatively small module (Donovan et al., 1987).

High-Efficiency Particulate Air Filter. HEPA filters are commonly used for the removal of submicron particles in the nuclear industry. They are disposable, extended-medium, dry filters with a rigid casing enclosing the full depth of the pleats. They have a minimum particle removal efficiency of 99.97 percent for 0.3 µm thermally-generated, monodisperse dioctylphthalate (DOP) particles, and a maximum pressure drop of 1 in. H_2O when clean and operated at rated airflow capacity. The core of the HEPA is generally made by pleating a continuous web of fiberglass paper back and forth over corrugated separators that add strength to the core and provide air passages between the pleats. The core is then sealed in a wood or metal casing (frame). The filter paper itself is composed of very fine (submicron) glass fibers in a matrix of larger (1 to 4 µm) fibers and held with an organic binder (Burchsted et al., 1976).

Filters are usually removed and replaced when the pressure drop across the filter reaches twice the clean filter pressure drop. The service life of a HEPA filter depends on the amount of PM

in the offgas, and can be extended by removing larger PM in upstream emissions controls. HEPA filter failure can occur if exposed to high temperatures and pressures (EPA, 1991). Excessive amounts of moisture, either from airborne droplets or condensation on the element, can completely plug the filter and result in failure by overpressure (Allen et al., 1989).

Deep Bed Sand Filter. Sand filters are deep beds (several feet thick) consisting of rock, gravel, and sand constructed in layers with approximately 2-to-1 grain size ratio from layer to layer. The flow is upward through the bed, with the granules/packing decreasing in size in the flow direction. Hollow tiles placed below the sand bed distribute the gas evenly throughout the bed. The larger granules remove most of the large particles, while the layers of finer sands provide high efficiency removal. Deep bed sand filters can remove 99.95 percent of 0.3 µm particles.

Deep Bed Glass Fiber Filter. Deep bed glass fiber filters are 0.2- to 2.1-m deep beds of compacted fiberglass insulating wool contained in stainless steel boxes with perforated screens at the top and bottom. Different packing densities are used for each stage of the deep bed filter, with the low density packing stage at the gas inlet and the high density packing stage at the exit. Gas flows upward with the larger particles being removed in the low density stage and the smaller particles in the high density stage (Battelle, 1984). Removal efficiency of deep bed glass fiber filters is 99.9 percent for 0.3 µm particles.

Fabric Filter (Baghouse). A fabric filter collector is composed of many fabric filter bags that collect entrained particles. Particle-laden gas is introduced into the baghouse and is directed through the cylindrical filter bag. The particles form a cake on the bags, which enhances removal efficiency. The bags are rapped or blown clean at predetermined intervals or when the pressure drop increases significantly. The particles are deposited in a hopper at the bottom of the unit. Filter bags must be changed periodically and would require remote changing because the fabric will be contaminated with radionuclides.

Baghouses are commonly used for removing fine dry particles. They are not suitable for applications in moist or wet environments (wet aerosols will clog the filter fabric). If fiberglass is used as the bag material, the maximum operating temperature for baghouses is 550°F. Efficiencies of greater than 99.5 percent are dependent upon particle size distribution.

Electrostatic Precipitator. The ESP uses energized discharge electrodes that produce a high voltage electric field between the discharge electrodes and grounded collection plates. Particles

entering the ESP acquire a charge and migrate to the collecting plates. In a wet ESP, the particles are captured in a liquid state, then flow down the plates and are collected at the bottom. Particles can be removed by automatically rapping the plates (Battelle, 1984). ESPs are extremely effective at removing fine particles and aerosols. Removal efficiencies of 99 percent and greater can be achieved for particles down to 0.1 μm. However, their use in the nuclear industry is limited, because if a failure occurs, the gas stream travels completely through without removal of the radionuclide particles.

Hydrosonic Scrubbers. Hydrosonic atomized scrubbers are wet scrubbing systems in which the energy for cleaning and pumping the dirty gases is provided by the flow of steam or air from a supersonic ejector nozzle. The contaminated gas stream is drawn into the device by the ejector nozzle, which is fitted with a water injection ring. The steam or air jet causes a violent shattering of water droplets and subsequent turbulent mixing of the gas and water in a converging section of piping. Extremely fine particles are captured on the water droplets. The gas then flows through a mixing tube where the drops agglomerate. Separation of the cleaned gas from the entrained liquid is accomplished in a cyclone. A particulate removal efficiency of approximately 99 percent is achieved for 0.1- to 10-μm particles.

Packed Bed Scrubbers. Packed bed scrubbers are made up of vertical towers filled with packing to provide a large surface area for the off-gas to contact the scrubbing solution. In countercurrent scrubbers, the scrubbing solution flows down from the top of the tower through the packing, while the off-gas moves up through the tower. Bed depth in packed countercurrent scrubbers is typically 0.6 to 1.8 m. Gas velocities typically range between 0.9 and 1.8 meters per second (m/s). These scrubbers are not capable of achieving a sufficiently high gas velocity to effectively remove smaller particles; however, a particulate removal efficiency of 99 percent for particles larger than 2 μm is achievable.

The size of the packing material influences its ability to remove contaminants. Coarsely packed beds can remove dusts and mists (10 μm and larger). Finely packed beds can remove smaller sized contaminants, but because of pressure drop considerations, the velocity throughout the bed must be kept below 0.3 m/s. The finely packed beds have a greater tendency to plug, so their applications are generally limited to gas streams with low grain loadings (Buonicore and Davis, 1992).

Perforated Plate Mist Eliminator. Perforated plate mist eliminators consist of two perforated metal sheets welded together and uniformly spaced a few thousandths of an inch apart. The

perforations in the adjacent plate are offset so that the air entering the holes must make two 90° turns before it can exit. Moisture is removed by impingement of droplets on the water film flowing down between the plates and on the face of the first plate. Regular cleaning is required to maintain the unit's performance (Battelle, 1984). The perforated plate mist eliminator can achieve a particulate removal efficiency of 99 percent for particles between 1 and 10 µm and is effective for aerosol removal. The perforated plate mist eliminator must be cleaned regularly to prevent fouling of the device.

High-Efficiency Mist Eliminator. The HEME is composed of regenerable deep-bed fiber filters configured in an annular shape to remove submicron aerosols. Gas may flow either from the outside to the inside hollow core or from the inside to the outside, from which the clean gas exits at the top and the collected liquid exits at the sealed bottom in a drain pipe. Various fibers and other materials of construction can be selected for their resistance to gas constituents. The HEMEs can be operated wet to allow simultaneous removal of both liquid and solid aerosols. Soluble particles become part of the liquid film and drop to the drain, while the insoluble particles impact the fiber and become physically bonded. Continuous or intermittent water spraying of the filter elements has been used to wash down and cleanse accumulated debris to extend the service life of the HEMES; however, soluble particles can migrate through the filter and become reentrained (Battelle, 1984).

HEMEs are commonly used to remove fine aerosols and exhibit removal efficiencies of up to 99 percent for aerosols smaller than 3 µm. They are passive devices with low maintenance requirements and high reliability. Potential disadvantages of the HEME include production of liquid wastes, production of solid waste (the spent demister material), potential upsets if air flow rates vary significantly, and high pressure drops.

Tray Tower. Tray towers utilize perforated plates with an impingement baffle over each perforation. Gas enters at the bottom of the tower and must pass through perforations in each plate before exiting from the top. Conceptually, the tray tower expands the surface area of the liquid by utilizing the gas stream's kinetic energy. The gas flowing upward is divided into many small jets by the orifices and can reach velocities of 4.6 to 6.1 m/s. Each jet aspirates liquid from the blanket and creates a wetted surface on the baffle, located at the point of maximum jet velocity. The directed impingement on a wetted target dynamically precipitates particles and entraps them in the scrubbing liquid. Upon impingement, each jet forms minute gas bubbles which rise through and create turbulence in the liquid blanket. This provides extremely close gas-liquid contact for maximum cleaning. Continuous violent agitation of the blanket by the

bubbles prevents settling of entrapped particles and flushes them away in the scrubbing liquid (Buonicore and Davis, 1992). Overall collection efficiencies for a single plate ranges from 90 to 98 percent for 1 µm particles and low inlet loadings. Pressure drops of 1 to 4 in. H_2O per plate are typical. Water requirements usually range from 3 to 5 gallons per 1,000 cubic feet (ft^3) of gas (Buonicore and Davis, 1992).

Ejector Venturi Scrubber. The ejector venturi scrubber (EVS) (also called a jet or eductor scrubber) utilizes a high-pressure spray nozzle to atomize scrubbing liquid into droplets. The EVS introduces the scrubbing water into the rear of the converging section of the venturi. The velocity of the sprayed water droplets creates a draft that draws the dirty gas into the body of the scrubber. The water-laden gas is then accelerated through the throat section of the venturi and into the diverging section, where the majority of the particle capture takes place. Although the contact time is quite short, the extreme turbulence in the venturi enhances particle-water contact. The gases are separated from the liquid in the separator located at the end of the diverging section. A particulate removal efficiency of 90 percent is achieved for particles larger than 2 µm and low inlet loadings. The device is compact and requires little space, is easy to operate, and has few vulnerable internal components. These units have a large water consumption compared to other scrubbers (50 to 100 gallons per 1,000 ft^3 of gas handled). An advantage of the EVS is that it can accommodate wide variations in inlet gas volume, temperature, and composition.

Impingement and Entrainment Scrubbers. In these orifice-type scrubbers, the gas stream comes into contact with a pool of liquid at the entrance to a constriction. Liquid is entrained and carried into the restriction, where greater liquid-particle interaction occurs. This results in a high frequency of particle impaction on the droplets. Most of the water droplets are separated by gravity upon leaving the restriction since the gas velocity is reduced. Smaller droplets are removed by centrifugal force and impingement on baffles located in the upper part of the unit. Pressure drop typically ranges from 3 to 10 in. H_2O; collection efficiencies usually range from 90 to 95 percent. The main advantage of orifice-type systems is their ability to handle high dust concentration and high solid slurries.

Multiple Cyclones. A multiple cyclone separator consists of a number of small-diameter cyclones that have a common gas inlet and outlet. The flow pattern differs from that in a conventional cyclone in that the gas enters at the top of the collecting tube and has a swirling action imparted to it by a stationary vane positioned in its path. The diameters of the collecting

tubes usually range from 0.03 to 0.6 m. A particle removal efficiency of 90 percent is achieved for particles in the 5 to 10 μm range.

Spray Towers. Spray towers are devices that collect particles on liquid droplets. A scrubbing liquid is sprayed into the chamber or tower. Spray nozzles are used to atomize the liquid into small droplets. As the droplets fall to the bottom of the chamber, they collect particles from the gas, which enters the tower from the bottom and is scrubbed by the liquid drops as it flows upward. Particle collection is primarily by impaction on water droplets. Spray towers, which typically have pressure drops in the range of 1 to 4 in. H_2O, are generally used as a precleaner for the removal of particles larger than 5 μm. The efficiency in removing the larger particles is greater than 90 percent (EPA, 1973).

Cyclonic Scrubber. Cyclonic scrubbers can vary from conventional cyclones equipped with water sprays to specifically designed multi-stage devices. Particle-laden gas and aerosols are introduced into the device where they are contacted by water sprays; the resulting droplets are impacted by centrifugal force onto the cyclone walls. The scrubbing liquid and captured particles run down the walls and out the bottom of the scrubber (Battelle, 1984). Particle removal efficiencies in the range of 80 to 90 percent are achieved for large particles.

Mechanically-Aided Scrubbers. Mechanically-aided scrubbers incorporate a motor-driven device between the inlet and the outlet of the scrubber body. Usually, the motor-driven devices are fan blades used to move the air through the scrubber. Particles are collected by impaction upon the fan blades, while the gas is moved through the system. A liquid is introduced at the base of the rotating fan blades. The liquid runs over the blades and collects the particles, and is then drained to a sump. Usually, the liquid for a mechanically-aided scrubber can be recirculated. The scrubbers require little space and water, although high-energy scrubbing applications usually require a mist eliminator leading to high operating costs. Particle removal efficiency for mechanically-aided scrubbers is good for particles larger than 2 μm in diameter.

Prefilter (Roughing Filter). Prefilters can be classified as either low (Group I), moderate (Group II), or high (Group III) efficiency filters. Group I filters are shallow, tray-like assemblies of coarse fibers or crimped metal mesh enclosed in a steel or cardboard casing. The filter medium is coated with a tacky oil or adhesive to improve retention of trapped particles. Group I panel filters have fairly high dust-holding capacity, high air flow capacity with low resistance, and high removal efficiency for large particles. Group II and III filters are extended medium, dry-type units. The medium is pleated or formed as bags to increase surface area. Group II

filters are effective in removing plus 5 μm particles, while Group III filters can filter even small particles. In a nuclear exhaust application, Group I and II panel filters are of limited value as prefilters because of their ineffectiveness against small particles (5 μm and less) and because they are rapidly plugged by lint and other fibrous materials.

Mist Eliminator. Standard mist eliminators use impaction to capture mists and particles. The most common is a wave-plate demister, which consists of a series of corrugated or bent plates through which the gas flows, imparting the droplets onto the plate surfaces. Mist eliminators used for nuclear applications include knitted fabric and nonwoven fiber mat demisters. In these applications, the demisters are usually made up of multiple cells consisting of coalescing layers (mat of knitted fabric) and draining layers (usually wire mesh). All of these devices have increased removal efficiency at higher gas velocities at the expense of increased pressure drop (Battelle, 1984).

5.1.3 Evaluation of Technical Feasibility

The technical feasibility of each of the individual control technologies described previously was evaluated considering availability of the technology, applicability of the technology to the expected emissions, and project specific limitations. The technical feasibility of each control technology is evaluated in Table 5-1.

All of the particulate control devices evaluated were determined to be feasible with the exception of the ULPA/VLSI filter. These filters do not meet the standards specified in the ASME N509 Nuclear Power Plant Air Cleaning Units and Components, Hanford Plant Standards for High Efficiency Particulate Air Filters, and military specification MIL-F-51068 (Moore, G., 1993). Therefore, the ULPA/VLS filter has been dropped from further consideration.

The multiple stages of the proposed base case control system utilize control elements discussed in Section 5.1.2; thus, the proposed base case emissions control system is considered technically feasible.

5.2 Particulate Control Technology Hierarchy

Technically feasible control technologies are ranked in Table 5-2 based upon removal efficiency to determine the hierarchy for emissions control of Project W-236A.

Table 5-1

Radionuclide Particulate Emissions Control Technologies for Project W-236A

(Page 1 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
HEMF Filtration	- Chemical industry - Food industry	- High efficiency - Reusable after cleaning - Moisture resistant - High temperature resistance - Simple design - Low pressure drop	- High cost - Liquid waste generated during cleaning	Yes
ULPA/VLSI Filtration	- Semiconductor and electronic clean rooms - Medical industry	- High efficiency - Low pressure drop - Simple design	- High cost - Spent filters are solid waste - Not moisture resistant - Frequent change-out may be required - Not certified for the nuclear industry	No
HEPA Filtration	- Nuclear industry - Clean rooms	- High efficiency - Low cost - Low pressure drop - Simple design	- Spent filters are solid waste - Low moisture resistance - Frequent change-out may be required	Yes
Deep Bed Sand Filter	- Radiochemical processing facilities	- High efficiency - Low maintenance - High heat capacity - Variable loading capacity - Fire resistant	- High initial cost - Large space requirement - High pressure drop - Spent material becomes solid waste	Yes

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Table 5-1

(Page 2 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
Deep Bed Glass Fiber Filter	- Radiochemical processing facilities	- Simple design - Small space requirement	- Relatively high pressure drop - Spent filters become solid waste	Yes
Fabric Filter (Baghouse)	- Extensive commercial use	- Modular construction - Can handle large gas flow rates	- High initial and operating costs - Frequent bag replacement - Bags become solid waste - Large space required - Flammability hazard - Relatively high pressure drop	Yes
Electrostatic Precipitator (Wet or Dry)	- Extensive commercial use	- Low maintenance - Can accommodate corrosive materials - Can handle large gas flow rates	- High initial cost - Sensitive to varying process conditions - Large space required - Safety concerns regarding high voltages - Wet ESPs produce a liquid waste stream - Not fail-safe	Yes

Table 5-1

(Page 3 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
Hydrosonic Atomized Scrubber	- Hazardous and municipal waste incineration	- Simple design - Can use recycle scrubbing solution - Can be used in series	- Produces liquid waste stream - High solids concentration can cause plugging - High pressure drop	Yes
Packed Bed Scrubber	- Various process applications - Generally used as a precleaner to remove large particles	- Low initial cost - Handles corrosive, high temperature and moisture gases - Simple process design	- Not effective for smaller particles - Plugging may occur - Produces a liquid waste stream - High operating cost	Yes
Perforated Plate Mist Eliminator	- Various chemical processing operations - Radiochemical operations	- Simple design - Service life can be extended by flushing the filter	- Produces solid and liquid wastes - Sensitive to process variations - High pressure drops - Low efficiency for small particles	Yes
High efficiency Mist Eliminator (HEME)	- Acid and caustic mist removal - Radiochemical plant service	- Simple design - Backwashing can extend filter element life	- Produces solid and liquid waste - High pressure drop - Relatively large space required - Sensitive to process variations	Yes

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Table 5-1

(Page 4 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
Tray Tower	- Various process applications - Generally used as a precleaner to remove large particles	- Low initial cost - Simple design - Handles high temperature and moisture gases - Can handle corrosive gases	- Low efficiency - Produces a liquid waste stream - High operating cost	Yes
Ejector Venturi Scrubber	- Various process applications	- Low initial cost - Simple process design - Tolerates variable operating conditions - Can use recycled scrubbing solution	- Low efficiency - Produces a liquid waste stream - Can have abrasion and corrosion problems	Yes
Impingement and Entrainment Scrubber	- Various process applications	- Simple design - Handles high temperature and moisture gases - Can handle corrosive gases	- Low efficiency - High pressure drop - Produces a liquid waste stream - High operating cost	Yes
Multiple Cyclones	- Used where high removal efficiencies are not required - Generally used as a precleaning device	- Simple design - Flow initial cost - Useful for high gas flows	- Low efficiency - High humidity gases can cause plugging	Yes

Table 5-1

(Page 5 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
Spray Towers	- Various process applications - Generally used as a precleaner to remove large particles	- Low initial cost - Simple design - Handles corrosive, high temperature and high moisture gases - Relatively low pressure drop	- Produces a liquid waste stream - High operating cost - Low efficiency - Liquid entrainment at high gas flow rates	Yes
Cyclonic Scrubber	- Various process applications - Generally used as a precleaner to remove large particles	- Low initial cost - Simple design - Handles high temperature and moisture gases - Can be fabricated for corrosive environments	- Low efficiency - Produces a liquid waste stream - Poor submicron particle capture - High pressure drop	Yes
Mechanically-Aided Scrubber	Not-known	- Small space requirement - Minimal water use - High dust load capacity	- High operating and maintenance cost - Usually requires a mist eliminator - Not effective for submicron particles - Low efficiency	Yes
Prefilter (Roughing Filter)	- Heating and ventilation systems - Various air filtering systems	- Low initial cost - Simple design; no moving parts - Easily replaced - High dust loading capacity	- Low efficiency - Relatively high pressure drop - Spent filters become solid waste	Yes

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Table 5-1

(Page 6 of 6)

Control Technology	Current Applications	Advantages	Disadvantages	Technically Feasible
Standard Mist Eliminator	- Various chemical processing operations - Nuclear reactor applications	- Low pressure drop - Simple design; no moving parts	- Spent filters become solid wastes - Low efficiency for small particles	Yes

Table 5-2

Radionuclide Particulate Control Technology Hierarchy for the W-236A MWTF Project

Technology	Removal Efficiency (%)	Lowest Effective Particle Size (µm)
Base Case Control System	>99.9999	0.1
HEMF Filtration	99.99	0.1
HEPA Filtration	99.97	0.3
Deep Bed Sand Filter	99.95	0.3
ESP	<99.9	2
Deep Bed Glass Fiber Filter	99.9	0.3
Hydrosonic Scrubber	99.5	0.1
Fabric Filter (Baghouse)	99.5	1
Packed Bed Scrubber	<99	2
Perforated Plate Mist Eliminator	<99	1
High Efficiency Mist Eliminator	99	3
Tray Tower	95	1
Venturi Scrubber	<95	2
Impingement & Entrianment Scrubber	<90	2
Multiple Cyclones	<90	5
Spray Tower	<90	5
Cyclonic Scrubber	<80	1
Mechanically-aided Scrubber	<80	1
Standard Mist Eliminator	<80	1
Prefilter (Roughing Filter)	<80	5

6.0 Environmental, Energy, and Economic Analysis

To determine BARCT for Project W-236A, an analysis of the energy, environmental, and economic impacts was completed. Technologies were analyzed in the order determined by the control technology hierarchy established in Section 5.1.4 of this report.

Energy impacts focused on direct energy impacts from the installation of emissions control technology (e.g., energy cost required to overcome the pressure drop of a particular control device). Environmental impacts addressed included the generation of solid and/or liquid waste from use of the technology, construction and maintenance hazards, and other health and safety issues.

For the economic analysis, each potential technology was evaluated by considering the total capital investment required and the annual operating cost for the control technology. The estimates provided are rough order of magnitude costs based on vendor-supplied quotes, engineering judgement, and cost estimation methodologies presented in the *Office of Air Quality Planning and Standards (OAQPS) Control Cost Manual* (EPA, 1990a) and in *Plant Design and Economics for Chemical Engineers* (Peters and Timmerhaus, 1980). Vendor equipment quotes are included in Appendix B. These costs should be considered "budgetary" (plus or minus 30 percent).

Cost effectiveness represents the total dollars required for a certain percentage reduction in the CEDE to the MEI and is equal to the annualized cost of the control technology divided by the difference between the uncontrolled dose and the controlled dose. Annualized cost is equal to the sum of annual direct operating and indirect operating cost. Indirect operating cost includes the capital recovery cost determined by multiplying the total capital investment by a Capital Recovery Factor (CRF). The CRF is calculated using an assumed interest rate and project life (EPA, 1990a).

6.1 Particulate Radionuclides

Energy, environmental, and economic impacts are discussed in this section for potential radionuclide particulate control technologies. Various stages of particulate matter removal will be required for the MWTF exhaust stream. Potential control technologies are evaluated as follows.

6.1.1 Radionuclide Particulate Control Options

6.1.1.1 Base Case

The base case emissions control system as discussed in Section 5.2 is a compilation of gas conditioning and particulate matter control equipment. Major components of the system include a chilled water condenser, HEME, preheater, HEMF, and HEPA filtration. Small amounts of particulate matter removal are expected in the condenser; however, the major removal will occur in the HEME, HEMF, and HEPA stages.

The typical efficiency of the HEME is greater than 99.5 for 3-micron particles. Based on actual test data, the HEME is conservatively assumed to have an overall efficiency of 93 percent (Battelle, 1989). HEMF filters have the highest reported removal efficiency for particulate matter of the potential individual control technologies. Efficiencies as high as 99.99999 percent have been guaranteed by the Pall Corporation, the major manufacturer of HEMF filters.

HEPA filters are widely used for the control of particulate radionuclide emissions in the nuclear industry. A minimum efficiency of 99.95 can be met for 0.3-micron-diameter particles with the standard HEPA filter. HEPA filters meet all applicable nuclear qualification standards.

Energy Impacts. Energy impacts due to installation of the base case control system consist mainly of the energy required to overcome the additional gas pressure drop across the condenser, HEME, HEMF, and HEPA filters, in addition to the energy required to power the preheater. A total of 156,120 kilowatts per hour (kWh) are necessary for the 200 East MWTF representing an annual cost of $9,365, while for 200 West, a total of 60,431 kilowatts per hour per year (kWh/yr) are required equaling an annual cost of $3,626. These incremental energy requirements do not present any adverse impact to the operations of the facility.

Environmental Impacts. Environmental impacts due to the installation of the base case control system include the liquid waste generation from the HEME and HEMF, and solid waste generation from the HEPA filters. Normally, disposal of the liquid generated in backflushing the HEME and HEMF filters would be required. However, in this particular project application, the backflush can be drained into the system. Costs for waste generated by HEPA filter disposal is approximately $9,589 for each MWTF area. No adverse environmental impacts will be encountered with use of the base case control system.

Economic Impacts. The economic impacts due to the base case control system were evaluated by estimating the total installed capital cost and operating cost for implementation. An equivalent amortized capital cost along with the estimated annual operating cost for the base case was then determined. The economic impact to the facility for the base case was defined in terms of total annualized cost to the facility per decrease in CEDE to the MEI. Results of the economic analysis for the base case are given in Table 6-1 for the 200 East MWTF and Table 6-2 for the 200 West MWTF. Appendix C contains vendor quotations for the capital equipment.

The total capital investment for the 200 East MWTF base case control system was $674,100, with an annual operating cost of $98,514. For 200 West, the total capital investment was $362,550, corresponding to an annual operating cost of $56,746. The annual amortized cost was determined to be $170,022 for 200 East yielding a cost effectiveness of $392,660 per person-rem reduction in the CEDE to the MEI. For the 200 West MWTF, the annual amortized cost was determined to be $95,205, yielding a cost effectiveness of $419,405 per person-rem reduction in the CEDE to the MEI.

6.1.2 Selection of BARCT

Although the base case control system is not cost effective, it will be required to maintain emission concentrations below the Hanford Site derived concentration guidelines (DCG). The DCG values are compiled in the Hanford Site *Environmental Compliance Manual* (WHC, 1993). To satisfy the DCGs and to demonstrate consistency with as low as reasonably achievable (ALARA) policy, the base case control system will be necessary. The condenser will provide initial particulate matter removal, followed by the HEME, HEMF, and HEPA. The removal efficiency of the HEME is 93 percent, the efficiency of the HEMF is 99.97, and each stage of the HEPA filter provides a removal efficiency of 99.95 percent, yielding an overall removal efficiency approaching 100 percent. The BARCT analysis is summarized in Tables 6-3 and 6-4.

Table 6-1

200 East MWTF Base Case Emission Control System
Capital and Operating Cost Estimate for Project W-236A

CAPITAL INVESTMENT COSTS	COST
Purchased Equipment	
Chilled Water Condenser	$28,800
High Efficiency Mist Eliminator	$58,900
Electric Preheater	$5,000
High Efficiency Metal Filter & Housing	$120,000
High Efficiency Particulate Air Filter, Prefilter & Housing	$12,000
Total Equipment Cost	$224,700
Installation (50 % of Total Equipment Cost)	$112,350
Piping (30 % of Total Equipment Cost)	$67,410
Instrumentation & Controls (30 % of Total Equipment Cost)	$67,410
Engineering & Supervision (30 % of Total Equipment Cost)	$67,410
Sub-total Equipment & Installation Cost	$539,280
Contingency (15 % of Equipment & Installation Cost)	$80,892
Start-up (10 % of Equipment & Installation Cost)	$53,0928
Total Capital Investment	$674,100
DIRECT ANNUAL OPERATING & MAINTENANCE COSTS	
Replacement of Used Prefilters & HEPA filters	$1,400
Operating Labor (365 Hours @ $20/hr)	$29,200
Supervision of Operating Labor (15% of Operating Labor)	$4,380
Maintenance & Repairs (20% of Total Equipment Cost)	$44,940
Disposal of Used Filters (32 cf @ $299.65/cf)	$9,589
Electricity (35,527 kW-hr @ $.06/kW-hr)	$9,365
Total Annual Direct Operating & Maintenance Cost	$98,514
INDIRECT ANNUAL COST[a]	
Capital Recovery (% of Total Capital Investment = 57.6)[b]	$71,508
Total Annual Indirect Cost	$71,508
TOTAL ANNUALIZED COST	$170,022

[a]Labor overhead costs are included in operating labor; no incremental cost for administrative labor is included.
[b]Capital recovery factor based on 30 year project life; 10% interest rate; no salvage value.

Table 6-2

200 West MWTF Base Case Emission Control System
Capital and Operating Cost Estimate for Project W-236A

CAPITAL INVESTMENT COSTS	COST
Purchased Equipment	
Chilled Water Condenser	$14,400
High Efficiency Mist Eliminator	$29,450
Electric Preheater	$5,000
High Efficiency Metal Filter & Housing	$60,000
High Efficiency Particulate Air Filter, Prefilter & Housing	$12,000
Total Equipment Cost	$120,850
Installation (50 % of Total Equipment Cost)	$60,425
Piping (30 % of Total Equipment Cost)	$36,225
Instrumentation & Controls (30 % of Total Equipment Cost)	$36,225
Engineering & Supervision (30 % of Total Equipment Cost)	$36,225
Sub-total Equipment & Installation Cost	$290,040
Contingency (15 % of Equipment & Installation Cost)	$43,506
Start-up (10 % of Equipment & Installation Cost)	$29,004
Total Capital Investment	$362,550
DIRECT ANNUAL OPERATING & MAINTENANCE COSTS	
Replacement of Used Prefilters & HEPA filters	$1,400
Operating Labor (365 Hours @ $20/hr)	$14,600
Supervision of Operating Labor (15% of Operating Labor)	$2,190
Maintenance & Repairs (20% of Total Equipment Cost)	$24,170
Disposal of Used Filters (32 cf @ $299.65/cf)	$9,589
Electricity (35,527 kW-hr @ $.06/kW-hr)	$5,157
Total Annual Direct Operating & Maintenance Cost	$56,746
INDIRECT ANNUAL COST[a]	
Capital Recovery (% of Total Capital Investment = 57.6)[b]	$38,459
Total Annual Indirect Cost	$38,459
TOTAL ANNUALIZED COST	$95,205

[a]Labor overhead costs are included in operating labor; no incremental cost for administrative labor is included.
[b]Capital recovery factor based on 30 year project life; 10% interest rate; no salvage value.

Table 6-3

Summary of BARCT Analysis for Radionuclide Emissions for the W-236A 200 East Multi-Function Waste Tank Facility

Control Alternative	CEDE Due to Emissions (person-rem/yr)	CEDE Reduction[a] (person-rem/yr)	Total Capital Investment[b]	Economic Impacts			Adverse Environmental Impact (Yes/No)	Adverse Energy Impact (Yes/No)
				Total Annualized Cost ($/yr)	Cost Effectiveness[d] ($/yr)	Adverse Economic Impact (Yes/No)		
Base Case Control System	4.33 E-01	4.33E-01	674,100	170,022	3.93E+05	Yes	No	No
Baseline	4.33E-01		--	--	--	--	--	--

[a]Emissions reduction over baseline level.
[b]Installed capital cost relative to baseline
[c]Includes capital and operating costs. The capital recovery factor was used on a 30-year equipment life and a 10 percent annual interest rate.
[d]Average Cost Effectiveness is total annualized cost for the control option divided by the emissions reductions resulting from the option.

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Table 6-4

Summary of BARCT Analysis for Radionuclide Emissions for the W-236A 200 West Multi-Function Waste Tank Facility

Control Alternative	CEDE Due to Emissions (person-rem/yr)	CEDE Reduction[a] (person-rem/yr)	Total Capital Investment[b]	Economic Impacts			Adverse Environmental Impact (Yes/No)	Adverse Energy Impact (Yes/No)
				Total Annualized Cost ($/yr)	Cost Effectiveness[d] ($/yr)	Adverse Economic Impact (Yes/No)		
Base Case Control System	2.27E-01	2.27E-01	362,550	95,205	4.19E+05	Yes	No	No
Baseline	2.27E-01	--	--	--	--	--	--	--

[a]Emissions reduction over baseline level.
[b]Installed capital cost relative to baseline.
[c]Includes capital and operating costs. The capital recovery factor was used on a 30-year equipment life and a 10 percent annual interest rate.
[d]Average Cost Effectiveness is total annualized cost for the control option divided by the emissions reductions resulting from the option.

7.0 Air Quality Analysis

Emissions from Project W-236A must be in compliance with the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Radionuclides (EPA, 1990b). The present NESHAP for the entire Hanford Site is an effective dose equivalent of 10 mrem/yr.

To determine the impact of the radionuclide emissions from Project W-236A, dose conversion factors based on CAP-88 radionuclide dispersion modeling for the 200 East and 200 West Areas were used as described in Section 3.3. The CEDE to the MEI was calculated by applying the rem/Ci conversion factor to Ci/yr emission estimates.

7.1 Controlled Emission Rates

To insure that the emissions from the MWTF do not adversely affect the off-site population, the estimated CEDE to the MEI must be determined utilizing the recommended BARCT. Controlled emissions based on the BARCT recommendation are included in Table 7-1 for 200 East and 7-2 for 200 West. The decontamination factor (DF) is equivalent to:

$$DF = 1 / [1 - \text{Overall Efficiency}]$$

Based on the overall efficiencies of approximately 100 percent for soluble and insoluble radionuclides respectively, the DF equaled 7.62 E+11 for insoluble radionuclides and 5.77 E+11 for soluble radionuclides.

7.2 Radionuclide Emissions Impact

As shown in Tables 7-1 and 7-2, the total controlled CEDE to the MEI is expected to be 8.75 E-05 mrem/yr for the 200 East MWTF and 3.27 E-05 for the 200 West MWTF. Compared to the Hanford Site NESHAP standard of 10 mrem/yr, these CEDE to the MEIs are insignificant.

Table 7-1

200 East MWTF Controlled Committed Effective Dose Equivalent to the Maximally Exposed Individual[a]

Radionuclide	Uncontrolled Annual Emissions (Ci/yr)	CAP-88 Dose Conversion Factor[b] (mrem/Ci)	Uncontrolled CEDE to MEI (mrem/yr)	Control System DF[c]	Controlled CEDE to MEI (mrem/yr)	Percent of Total Dose (%)
^{137}mBa[d]	2.89 E+02	2.39 E-02	6.90 E+00	7.62 E+11	3.99 E-10	0.000
^{137}Cs	3.12 E+02	2.39 E-02	7.45 E+00	7.62 E+11	4.17 E-10	0.000
^{3}H	6.18 E+01	2.19 E-05	1.35 E-03	N/A	5.54 E-05	63.322
^{129}I	9.98 E-03	2.91 E-01	2.90 E-03	N/A	3.19 E-05	36.414
^{239}Pu	7.47 E-01	8.67 E+00	6.48 E+00	5.77 E+11	4.75 E-10	0.001
^{240}Pu	1.36 E+00	8.66 E+00	1.18 E+01	5.77 E+11	1.74 E-09	0.002
^{106}Rh[e]	9.34 E-06	2.09 E-02	1.95 E-07	7.46 E+06	5.15 E-08	0.059
^{106}Ru	9.62 E-06	2.09 E-02	2.01 E-07	7.46 E+06	5.19 E-08	0.059
^{125}Sb	8.17 E-05	4.15 E-03	3.39 E-07	7.46 E+06	9.05 E-08	0.103
^{113}Sn	1.56 E-05	1.18 E-03	1.85 E-08	7.46 E+06	4.81 E-09	0.006
^{90}Sr	9.06 E+03	4.38 E-02	3.97 E+02	5.77 E+11	2.85 E-08	0.033
^{90}Y	8.95 E+03	3.77 E-04	3.37 E+00	5.77 E+11	2.49 E-10	0.000
Total	**1.87 E+04**		**4.33 E+02**		**8.75 E-05**	**100.00**

[a]The maximally exposed individual is located 16 kilometers east of the 200-East Area.
[b]Dose conversion factors are for the 200 East Area.
[c]Although no DF is given for ^{3}H and ^{129}I, minimal removal is expected in certain parts of the control system.
[d]Dose conversion factor for ^{137}mBa is assumed equivalent to the factor for ^{137}Cs.
[e]Dose conversion factor for ^{106}Rh is assumed equivalent to the factor for ^{106}Ru.

Table 7-2

200 West MWTF Controlled Committed Effective Dose Equivalent to the Maximally Exposed Individual[a]

Radionuclide	Uncontrolled Annual Emissions (Ci/yr)	CAP-88 Dose Conversion Factor[b] (mrem/Ci)	Uncontrolled CEDE to MEI (mrem/yr)	Control System DF[c]	Controlled CEDE to MEI (mrem/yr)	Percent of Total Dose (%)
^{137}mBa[d]	2.50 E+02	1.42 E-02	3.55 E+00	7.62 E+11	2.00 E-10	0.001
^{137}Cs	2.70 E+02	1.42 E-02	3.83 E+00	7.62 E+11	2.15 E-10	0.001
^{3}H	5.89 E+01	1.38 E-05	8.13 E-04	N/A	2.44 E-05	74.654
^{129}I	6.70 E-03	1.14 E-01	7.63 E-04	N/A	8.16 E-06	24.930
^{239}Pu	4.96 E-01	5.15 E+00	2.55 E+00	5.77 E+11	1.90 E-10	0.001
^{240}Pu	1.36 E+00	5.14 E+00	6.99 E+00	5.77 E+11	6.99 E-10	0.002
^{106}Rh[e]	9.34 E-06	1.24 E-02	1.16 E-07	7.46 E+06	3.05 E-08	0.093
^{106}Ru	9.62 E-06	1.24 E-02	1.19 E-07	7.46 E+06	3.08 E-08	0.094
^{125}Sb	8.17 E-05	2.47 E-03	2.02 E-07	7.46 E+06	5.51 E-08	0.168
^{113}Sn	1.56 E-05	7.02 E-04	1.10 E-08	7.46 E+06	2.94 E-09	0.009
^{90}Sr	8.01 E+03	2.60 E-02	2.08 E+02	5.77 E+11	1.52 E-08	0.047
^{90}Y	7.91 E+03	2.22 E-04	1.76 E+00	5.77 E+11	1.30 E-10	0.000
Total	**1.65 E+04**		**2.27 E+02**		**3.27 E-05**	**100.00**

[a]The maximally exposed individual is located 16 kilometers east of the 200-East Area.
[b]Dose conversion factors are for the 200 East Area.
[c]Although no DF is given for ^{3}H and ^{129}I, minimal removal is expected in certain parts of the control system.
[d]Dose conversion factor for ^{137}mBa is assumed equivalent to the factor for ^{137}Cs.
[e]Dose conversion factor for ^{106}Rh is assumed equivalent to the factor for ^{106}Ru.

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APPENDIX A

BACKGROUND DOCUMENTATION FOR BACT/LAER CLEARINGHOUSE AND LITERATURE SURVEY

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APPENDIX B

RECORD OF PERSONAL COMMUNICATIONS

9413297.0485

Date 12-8-93 Originator CHRIS MOORE Office KNOXVILLE

Project W-320 BARCT Project No. 199850.001

Placed/Received P Conversation With GLENN MOORE

Title _____ Division _____

Organization FLANDERS FILTERS Phone No. 919-946-8081

Subject: USE OF ULPA/VLSI FILTERS W DOE APPLICATIONS

Discussion:

2:15 PM EST

ACCORDING TO MR. MOORE THE ULPA/VLSI (ULTRA LOW PENETRATION AIR / VERY LARGE SCALE INTEGRATION) FILTER IS UNACCEPTABLE FOR DOE USE. IT DOES NOT MEET ASME N509 OR MILITARY SPECIFICATION MIL-F-51068. IN ADDITION, THE FILTER HAS BEEN USED MAINLY FOR SEMICONDUCTOR AND ELECTRONIC CLEAN ROOMS AND IN THE MEDICAL INDUSTRY. NO USE IN DOE APPLICATIONS IS PLANNED OR ANTICIPATED.

cc: _____ _____ _____

TELEPHONE REPORT

Date 12-8-93 Originator CHRIS MOORE Office KNOXVILLE

Project W-320 GARCT Project No. 199850.001

Placed/Received P Conversation With MIKE MOORE

Title _____ Division _____

Organization FLUID FLOW (REPRESENTATIVE OF PALL CORPORATION) Phone No. 615-588-1012

Subject: EFFICIENCY AND COST OF HIGH EFFICIENCY METAL FIBER FILTERS

Discussion:

3:30 PM EST

THE HEMP CAN BE DESIGNED TO MEET THE FOLLOWING SPECIFICATIONS:

ΔP	GUARANTEED EFFICIENCY	COST
3" H_2O	99.99 %	~$130 / CFM
7" H_2O	99.99 %	~$50 / CFM
7" H_2O	99 %	~$30 / CFM

REMOTE CLEANING IS AVAILABLE ON ALL FILTERS.

cc: _____ _____ _____

APPENDIX C

VENDOR COST QUOTATIONS

Peyton L. Morgan Jr. P.E.
George B. Bishop P.E.
Neil D. Kirk
William C. McConnell

ROGERS MORGAN INC.
Manufacturers' Representatives
P.O. Box 10648 Knoxville, TN 37939-0648
(615) 524-1100 FAX (615) 525-2305

PROPOSAL

See below 9.13.94

To: IT CORPORATION
312 DIRECTORS DRIVE
KNOXVILLE, TN. 37923

693-1944 FAX
693-3211

ATTN: CHRISTOPHER MOORE

Date: DECEMBER 1, 1993

Quotation No.:

Reference: DOE HANFORD, WA
W-320 TANK 241-C-106
WASTE REMOVAL

We are pleased to submit the following proposal:

FLANDERS FILTERS:

360 SCFM MAXIMUM

1 EA. E-8 BAG-IN/BAG-OUT HOUSING
SIZE 1 H X 1 W: 304 SST
TEST/HEPA/TEST/HEPA
WITH: 99.97% DOP FILTERS

BUDGET-----$7,100.00

REVISION
9-12-94
2000 cfm
SIZE 1X2
$11,000.00
BUDGET

OPTION:

1 EA. E-8C BAG-IN/BAG-OUT HOUSING
SIZE 1 H X 1 W: 304 SST
WITH: CARBON AND ADSORBERS

BUDGET-----$3,400.00

SIZE 1X2
$5200.00 BUDGET

Shipment: 6 WEEKS A.R.O.
F.O.B.: WASHINGTON, N.C.
Terms: NET 30

Prices do not include Excise, Sale or Use Taxes.
Proposal valid for 30 days unless otherwise noted.

Submitted for:
FLANDERS FILTERS, INC.
c/o ROGERS & MORGAN, INC.

By:

GEORGE B. BISHOP

Peyton L. Morgan Jr. P.E.
George B. Bishop P.E.
Neil D. Kirk
William C. McConnell

ROGERS MORGAN Inc.
Manufacturers' Representatives
P O Box 10846 Knoxville, TN 37939-0846
(615) 524-1100 FAX (615) 525-2305

PROPOSAL

To: IT CORPORATION
312 DIRECTORS DRIVE
KNOXVILLE, TN. 37923

ATTN: CHRISTOPHER MOORE

Date: DECEMBER 1, 1993
Quotation No.:
Reference: DOE HANFORD, WA
W-320 TANK 241-C-106
WASTE REMOVAL

We are pleased to submit the following proposal:

HARTZELL CENTRIFUGAL FAN: K1-1
230 SCFM
MODEL 052-12-MHI3
1-1/2 HP MOTOR, TEFC

Zero off
7-13-94
REVISED
BUDGET
$ 2,000.00

BUDGET-----$1,500.00

HARTZELL CENTRIFUGAL FAN: K2-1
830 SCFM
MODEL 052-12-MHK3
3 HP MOTOR, TEFC

BUDGET-----$1,750.00

NOTES:

1. WITH: WEATHER COVER, DRAIN, V-BELT
2. VARIABLE FREQUENCY DRIVE BY OTHERS

Shipment: 6 WEEKS A.R.O.
PIQUA, OHIO

F. O. B.: NET 30

Terms:

Submitted for: HARTZELL FAN, INC.
c/o ROGERS & MORGAN, INC.

By: GEORGE B. BISHOP

Prices do not include Excise, Sale or Use Taxes.
Proposal valid for 30 days unless otherwise noted.

DOYLE & ROTH
MANUFACTURING CO., INC.

26 BROADWAY NEW YORK, N.Y. 10004
(212) 269-7840 • FAX 212-248-4780

Quotation No.
Please refer to this number on your purchase order. MD-5361

Attn: Russel Bryson
IT Corporation
312 Directors Drive
Knoxville, TN 37923
San Mateo, CA 94402

Date: July 15, 1994

Sheet 1 of 1

Your Ref. Fax

Gentlemen:

We are pleased to offer the following for your approval:

DESCRIPTION

No. of Units	D&R Model No.	Material of Construction	Tubes No.	Tubes O.D.	Tubes BWG	Tubes Length	Approx. Ship Wt. (lbs)ea.	Budget Price (ea)
1	VT86J-14V	316SS shell & tubeside	55	3/4"	18	14'	750	$7,200

QUOTE

Drawings: 1-2 weeks after receipt of purchase order
Shipment: 6-8 weeks after receipt of approved drawings

Notes:
a) Per attached Doyle & Roth TEMA data sheets.
b) Prices are net F.O.B. our plant Simpson, PA
c) Thermal analysis is based on the following:
Composition of Vapor stream:
288 lb/hr acetone
302 lb/hr benzene
85 lb/hr butanol
662 lb/hr carbon tetrachloride
1940 lb/hr air
d) Tema data sheets show two different cases, one with chilled water as the coolant and the other with 40% Propylene Glycol.
e) Unit is quoted as a down flow condenser.

Terms: 1/2% - 10 Days, Net 30

CC: H&M

Sales Representative

By Nino Pava/mc

This quotation is subject to the terms and conditions on the face and the reverse side unless otherwise noted.

PRICES QUOTED ARE FIRM FOR 60 DAYS and do not include any Municipal, County, State or Federal Sales, Excise or Use Taxes.

HEAT EXCHANGER SPECIFICATION SHEET

Doyle and Roth Mfg. Co. Inc.

IT Corporation
Condenser

Size 8-168 Type BEM Ver Connected in 1 Parallel 1 Series
Surf/Unit(Eff) 150 ft2; Shells/Unit 1 Surf/Shell(Eff) 150 ft2

PERFORMANCE OF ONE UNIT

		Shell Side		Tube Side	
Fluid Allocation		40% Propylene Glycol		Process Vapor	
Fluid Name		50000		3277	
Fluid Quantity, Total	lb/h			1337	374
Vapor (In/Out)	lb/h				963
Liquid	lb/h	50000	50000	1940	1940
Noncondensable	lb/h			106.2	40
Temperature (In/Out)	F	30	34.5	106.2	
Dew Point/Bubble Point	F			0.098	68.188
Density	lb/ft3	65.182	65.104	0.009	0.7
Viscosity	cp	12.423	10.93		
Molecular Weight, Vapor				28.96	28.96
Molecular Weight, Noncondensable				0.208	0.344
Specific Heat	BTU/(lb*F)	0.892		0.006	0.075
Thermal Conductivity	BTU/(ft*h*F)	0.239			
Latent Heat	BTU/lb				
Inlet Pressure	psia	65		14.7	
Velocity	ft/s	2.0		73.0	
Pressure Drop, Allow./Calc.	psi	15 / 14.586		10 / 0.47	
Fouling Resist. (Min.)	ft2*h*F/BTU	0.001		0.001	

Heat Exchanged 202891 BTU/h; MTD (Corrected) 33.0 F
Transfer Rate, Service 41 Dirty 43 Clean 47 BTU/(ft2*h*F)

CONSTRUCTION OF ONE SHELL

Sketch

		Shell Side	Tube Side
Design/Test Pressure	psig	100/Code	100/Code
Design Temperature	F	200	200
No. Passes per Shell		1	1
Corrosion Allowance	in	0.0	0.0
Connections In	in/lb	3 / 150	4 / 150
Size & Out	in/lb	3 / 150	4 / 150
Rating		/	1 / 150

Tube No. 55 OD 0.75 ;Thk-Avg 0.049 in;Length 14 ft;Pitch 0.9375 in
Tube Type Plain Material SS316 Pattern 30
Shell SS316 ID 8.407 OD 8.625 in Shell Cover
Channel or Bonnet SS316 Channel Cover
Tubesheet-Stationary SS316 Tubesheet-Floating
Floating Head Cover Impingement Protection None
Baffles-Cross SS316 Type SSEG Cut (%d) 21 H;Spacing: c/c 4.875 in
Baffles-Long Seal Type Inlet 7 in
Supports-Tube U-Bend Type
Bypass Seal Arrangement Tube-Tubesheet Joint Expanded
Expansion Joint Type
Rho*V2-Inlet Nozzle 1230 Bundle Entrance 194 Bundle Exit 194
Gaskets-Shell Side Tube Side
-Floating Head
Code Requirements ASME Code Sec VIII Div 1 TEMA Class C
Weight/Shell 726 Filled with Water 1067 Bundle 349 lb
Remarks

HEAT EXCHANGER SPECIFICATION SHEET

Doyle and Roth Mfg. Co. Inc.

IT Corporation
Condenser

Size 8-168 Type BEM Ver Connected in 1 Parallel 1 Series
Surf/Unit(Eff) 150 ft2; Shells/Unit 1 Surf/Shell(Eff) 150 ft2

PERFORMANCE OF ONE UNIT

Fluid Allocation		Shell Side		Tube Side	
Fluid Name		Cooling Water		Process Vapor	
Fluid Quantity, Total	lb/h	50000		3277	
Vapor (In/Out)	lb/h			1337	377
Liquid	lb/h	50000	50000		960
Noncondensable	lb/h			1940	1940
Temperature (In/Out)	F	34	38	106.2	40
Dew Point/Bubble Point	F			106.2	
Density	lb/ft3	62.257	62.302	0.098	68.115
Viscosity	cp	1.73	1.617	0.009	0.692
Molecular Weight, Vapor				28.96	28.96
Molecular Weight, Noncondensable				0.208	0.344
Specific Heat	BTU/(lb*F)	1.003		0.006	0.074
Thermal Conductivity	BTU/(ft*h*F)	0.33			
Latent Heat	BTU/lb				
Inlet Pressure	psia	65		14.7	
Velocity	ft/s	2.2		73.0	
Pressure Drop, Allow./Calc.	psi	10 / 9.567		10 / 0.474	
Fouling Resist. (Min.)	ft2*h*F/BTU	0.001		0.001	

Heat Exchanged 202517 BTU/h; MTD (Corrected) 27.4 F
Transfer Rate, Service 49 Dirty 50 Clean 56 BTU/(ft2*h*F)

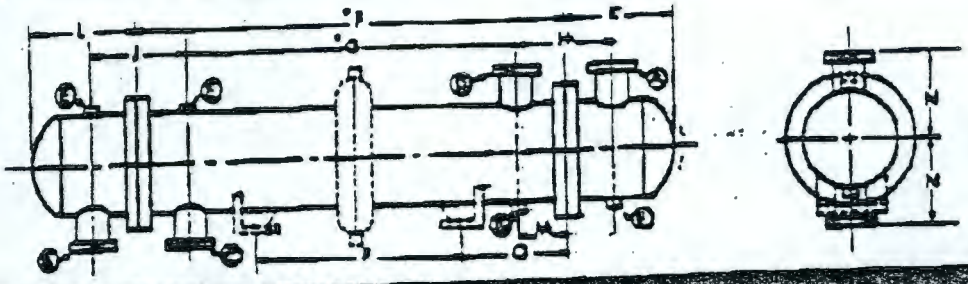
CONSTRUCTION OF ONE SHELL — Sketch

			Shell Side	Tube Side
Design/Test Pressure		psig	100/Code	100/Code
Design Temperature		F	200	200
No. Passes per Shell			1	1
Corrosion Allowance		in	0.0	0.0
Connections	In	in/lb	3 / 150	4 / 150
Size &	Out	in/lb	3 / 150	4 / 150
Rating			/	1 / 150

Tube No. 55 OD 0.75 ;Thk-Avg 0.049 in;Length 14 ft;Pitch 0.9375 in
Tube Type Plain | Material SS316 | Pattern 30
Shell SS316 ID 8.407 OD 8.625 in | Shell Cover
Channel or Bonnet SS316 | Channel Cover
Tubesheet-Stationary SS316 | Tubesheet-Floating
Floating Head Cover | Impingement Protection None
Baffles-Cross SS316 Type SSEG | Cut (%d) 21 H;Spacing: c/c 4.5 in
Baffles-Long | Seal Type | Inlet 7 in
Supports-Tube U-Bend Type
Bypass Seal Arrangement | Tube-Tubesheet Joint Expanded
Expansion Joint | Type
Rho*V2-Inlet Nozzle 1287 Bundle Entrance 203 Bundle Exit 203
Gaskets-Shell Side Tube Side
-Floating Head
Code Requirements ASME Code Sec VIII Div 1 TEMA Class C
Weight/Shell 727 Filled with Water 1068 Bundle 350 lb
Remarks

STANDARD MODEL "VT" CONDENSER — GROUPS 5, 6 & 8

"VT" CONDENSER HORIZONTAL • CONDENSING TUBE SIDE—SINGLE PASS • COOLANT LIQUID SHELL SIDE—BAFFLED



VT CONDENSER HORIZONTAL BAFFLED SHELL SIDE	Shell O. D. (In Inches)	DIMENSIONS (In Inches)						NOZZLES & FITTINGS (In Inches)				
		H	J	K	L	M	N	A	B	C	D	E
	6⅝	10	5⅝	11⅛	9¼	5	8⅝	1	1	2	2	¾
	8⅝	12	10¼	13	10⅞	6	9¾	4	2	3	3	¾
	10¾	14	10¾	17	11⅞	6	10¾	6	2	3	3	¾
	12¾	15	11¾	17¼	11¾	7	11¾	6	2	4	4	¾
	14	18	12¾	22	12¾	8	12	8	3	6	6	¾
	16	18	13¾	22¼	14¼	8	13	8	2	6	6	¾
	18	19	13¾	24¼	15	8	14	8	3	6	6	¾
	20	23	16¾	29	17¼	10	15	10	4	8	8	¾
	22	23	16¾	29¼	17¾	10	16	10	4	8	8	¾
	24	23	16¾	29¾	17¾	10	17	10	4	8	8	¾
	26	27	19¾	35¾	20¾	12	18	12	4	8	8	1
	28	27	19¾	36¾	21¾	12	19	12	4	8	8	1
	30	31	22¾	40	24¾	14	20	14	6	10	10	1
	32	31	22¾	40¾	25¼	14	21	14	6	10	10	1
	34	35	26	44¾	26¾	16	23	16	6	12	12	1
	36	35	26	44¾	27¼	16	24	16	6	12	12	1
	38	38	29	49¾	31¼	17	25	18	8	14	14	1
	40	38	29	49¾	32	17	26	18	8	14	14	1
	42	38	29	50¾	32¾	17	27	18	8	14	14	1

"Dimensions [illegible] (Page 16)

For physical [illegible]

D & R STANDARD "VT"-GROUP ONE PASS TUBE SIDE

SQUARE FEET SURFACE FOR TUBE LENGTH

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