GROUT DISPOSAL FACILITY VAULT EXHAUSTER:
TECHNICAL BACKGROUND DOCUMENT ON DEMONSTRATION
OF BEST AVAILABLE CONTROL TECHNOLOGY FOR TOXICS

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SUMMARY

The Grout Disposal Facility (GDF) is currently operated on the U.S. Department of Energy's Hanford Site. The GDF is located near the east end of the Hanford Site's 200 East operations area, and is used for the treatment and disposal of low-level radioactive liquid wastes. In the grout treatment process, selected radioactive wastes from double-shell tanks are mixed with grout-forming solids; the resulting grout slurry is pumped to near-surface concrete vaults for solidification and permanent disposal. As part of this treatment process, small amounts of toxic particles and volatile organic compounds (VOCs) may be released to the atmosphere through the GDF's exhaust system.

This analysis constitutes a *Best Available Control Technology for Toxics* (T-BACT) study, as required in the Washington Administrative Code (WAC 173-460) to support a Notice of Construction for the operation of the GDF exhaust system at a modified flow rate that exceeds the previously permitted value. This report accomplishes the following:

- assesses the potential emissions from the GDF
- estimates air quality impacts to the public from toxic air pollutants
- identifies control technologies that could reduce GDF emissions
- evaluates impacts of the control technologies
- recommends appropriate emissions controls.

The preliminary assessment of air quality impacts of toxic air pollutants from uncontrolled GDF emissions indicates that pollutant concentrations will be well below Acceptable Source Impact Levels (ASILs) as specified in WAC 173-460. Without emissions controls, the greatest impact of any toxic VOC at the maximum offsite exposure location will be less than 1% of the compound's ASIL standard. Similarly, without emissions controls, the greatest impact of any toxic particle at the maximum offsite exposure location will be less than 10% of the compound's ASIL standard.

Although the air quality impacts will be well below regulatory limits without emissions controls, this report presents a thorough assessment on the emissions control technologies available to further reduce GDF emissions of

toxic VOCs and particles. Each potential control technology is described and evaluated. The evaluation identifies technologies that are technically feasible; sorts the technically feasible technologies by their relative efficiencies; and evaluates the environmental, energy, and economic impacts of each feasible technology.

Based on the evaluations of the available control technologies, a recommendation is made regarding the control technologies to be employed at the GDF. Assessments indicate that all technically feasible control technologies for VOCs have significant environmental, energy, and economic costs. Because of these costs and the low airborne concentrations of toxic VOCs projected for maximum offsite exposure locations when no emissions controls are used, it is concluded that a control technology to limit the emissions of toxic VOCs from the GDF is not warranted. The DOE's policy to have "as low as reasonably achievable" levels of radiological exposure will require the use of High Efficiency Particulate Air (HEPA) filters on the GDF exhaust system. In addition to drastically reducing the emission of radioactive particles from the GDF, this control technology also will produce comparable reductions in the emissions of toxic particles. The application of HEPA filter technology will reduce the maximum concentrations of toxic particles at maximum offsite exposure locations to levels that are substantially less than 1% of any compound's ASIL standard. No further control technologies need to be employed.

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1.0 INTRODUCTION

1.1 THE APPLICANT

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1.2 PURPOSE

This report constitutes the evaluation of the *Best Available Control Technology for Toxics* (T-BACT) required under the Washington Administrative Code (WAC 173-460) in support of a Notice of Construction for the operation of the Grout Disposal Facility (GDF) vault exhausters at a flow rate that exceeds the previously permitted value. The current permit allows a flow rate up to 102 m³/min (3,600 ft³/min); approval is sought for operation at a flow rate up to 127 m³/min (4,500 ft³/min). Under the new permit, exhausters would be operated at a nominal 102 m³/min (3,600 ft³/min) to ensure that normal process fluctuations do not exceed the limit for which approval is sought.

1.3 FACILITY FUNCTION

In the grout treatment process, selected low-radioactivity liquid wastes from double-shell tanks are mixed with grout-forming solids and, if necessary, chemical liquid additives. The resulting grout slurry is pumped to near-surface concrete vaults for solidification and permanent disposal. These vaults and related equipment constitute the GDF. Section 2 provides a more detailed description.

1.4 LOCATION

The Hanford Site is located in Washington state as shown in Figure 1.1. The GDF is part of the Grout Treatment Facility and is located in the east end of the 200 East Area (Figure 1.2), approximately 35 km (22 mi) northwest of Richland. The distance from the GDF to the nearest site boundary location is 14 km (8.7 mi).

FIGURE 1.1. Location of the Hanford Site

FIGURE 1.2. Map of the 200 East Area. The GDF is located near the eastern boundary of the 200 East Area.

1.5 T-BACT EVALUATION PROCEDURE

The procedure used to determine the appropriate T-BACT emissions control technology and its estimated effectiveness is described in this report as outlined below.

- Section 2 presents the design of the GDF. This description emphasizes the GDF's ventilation system.
- Section 3 describes the estimated toxic air pollutant emissions.
- Section 4 presents estimates of the maximum concentration of toxic air pollutants that could occur at or outside the site boundary from uncontrolled emissions by the GDF. The methodology for generating the estimate is presented, and the calculated air concentrations are compared to Acceptable Source Impact Levels (ASILs).
- Section 5 describes potential control technologies.
- Section 6 discusses the technical feasibility of each control technology; technologies are ranked in order of effectiveness.
- Section 7 discusses the environmental, energy, and economic impacts of the ranked control technologies in order to recommend the most effective control device with acceptable impacts as the T-BACT control technology for this application; if no control device has acceptable impacts, a "no control" option may be warranted.
- Section 8 presents the projected air quality impacts from toxic air pollutants with the recommended emissions-control device(s) in place. The method for generating the estimate is presented and calculated air concentrations are compared to ASILs.
- Section 9 presents a summary of conclusions and recommendations.

2.0 DESIGN OF THE GROUT DISPOSAL FACILITY

In this section, the main components of the GDF are described, with emphasis on the ventilation system. The GDF and its permanent storage vaults are part of the Grout Treatment Facility that also comprises the Dry Materials Facility, 241-AP-02D waste-pump pit and transfer piping, and the Grout Processing Facility. Additionally, Tank 241-AP-102 in the nearby 241-AP Tank Farm serves as the waste-feed tank for the Grout Treatment Facility. Wastes destined for the grouting process are first transferred to that tank.

Currently, DOE has approval from the U.S. Environmental Protection Agency (EPA) (November 28, 1986) to fill up to 75 grout vaults on the Hanford Site. Based on projected inventories of double-shell tank wastes, DOE has plans to construct and fill a total of 44 grout vaults. The first completed grout disposal vault, 218-E-16-101, was filled between August 1988 and July 1989 with low-activity phosphate-sulphate waste. This low-level radioactive waste is not dangerous under the Washington Administrative Code (WAC 173-303).

Disposal-vault design has changed significantly since the phosphate-sulphate waste campaign, including the addition of forced ventilation. The current permit for grout vault exhausters would allow them to operate at a flow rate up to $102 \text{ m}^3/\text{min}$ ($3,600 \text{ ft}^3/\text{min}$); however, plans now call for a maximum flow rate of $127 \text{ m}^3/\text{min}$ ($4,500 \text{ ft}^3/\text{min}$). An increase in the maximum exhauster flow rate, and thus a change in operation of the ventilation system, will result in an increase in toxic air pollutant emissions. This T-BACT is required because, from a regulatory standpoint, these additional emissions are considered a new source of toxic air pollutants.

It must be emphasized that this T-BACT analysis is concerned only with emissions to the atmosphere from the permanent storage vaults that are part of the GDF, emissions from other components of the Grout Treatment Facility or other Hanford facilities are not considered in this report.

2.1 GROUT DISPOSAL FACILITY

The GDF is designed to meet the regulatory guidelines of the Resource Conservation and Recovery Act and the *State of Washington Hazardous Waste Management Act of 1976*. Although the design differs significantly in appearance from conventional landfills and surface impoundments, it is intended to meet all requirements for dangerous waste disposal. Design enhancements and modifications were necessary to mitigate the additional hazards associated with radioactive waste. The GDF consists of the following components, which are then briefly described:

- disposal vaults
- vault ventilation system
- piping and decant water removal
- double liner and diffusion barrier
- cover system
- portable instrument house and vault instrumentation
- cathodic protection system.

2.1.1 Disposal Vaults

In addition to the test vault already operating, 43 subsurface vaults are planned to dispose of waste currently designated to be processed by the Grout Treatment Facility. Figure 2.1 illustrates the disposal-vault concept. The vaults are built of cast-in-place reinforced concrete with inside dimensions 37.6 m (123.5 ft) long by 15.4 m (50 ft) wide and 10.4 m (34 ft) deep. The total capacity of the vaults, full to the top, is 6,000 m³ (212,000 ft³) or 6,020,000 L (1,590,000 gal). The vaults are filled to the 9.1-m (30-ft) level with radioactive grout, for a waste volume of 5,300,000 L (1,400,000 gal). After the grout has cured, the void space between the radioactive grout and the vault roof is filled with clean grout to form the "cold cap." The vault roof consists of reinforced concrete panels that have penetrations for grout-distribution piping, excess water removal, level monitors, and vault ventilation.

2.1.2 Vault Ventilation System

The vault ventilation system will control airborne emissions from the vault and remove the heat generated by the grout during curing. An exhaust

FIGURE 2.1. Disposal Vault Concept. The vaults are displayed after vault exhausting is completed, vents are sealed, backfilling is completed, and a protective barrier has been placed above the vaults.

fan will draw filtered ambient air into the vault's interior. It has been determined and approved that an airflow of between 85 and 102 m³/min (3,000 and 3,600 ft³/min) should be adequate for cooling the grout during the curing process (Bagaasen 1993).

The pressure within each vault would be maintained between 0.8 and 12.7 cm (0.3 and 5.0 in.) water gage below atmospheric pressure. The maximum design capacity for each vault exhaustor is 130 m³/min (4,500 ft³/min) for each vault, but administrative or engineered controls would be used to maintain flow rates in the operating range noted previously. The exhaustor is designed to provide airflow through two adjacent vaults simultaneously, and each vault will have separate make-up air filter units. The exhaustor and make-up air units will be portable, so they can be relocated to another vault after grout curing and cold-capping operations have been completed. Figure 2.2 shows the configuration of the exhaustor and make-up air units over a pair of vaults. Each exhaustor will be equipped for the monitoring of airborne radionuclide emissions in compliance with applicable regulations.

2.1.3 Piping and Decant Liquid Removal

An encased grout-filling pipe runs underground from the Grout Processing Facility to the center of the vault roof, where it penetrates into the vault. The grout surface will generally slope from the vault center downward, forming a mound. Excess liquid (phase separation liquid) will drain down to the corners of the vault, where sump pits are located. Pumps in the sump pits will transport the liquid back to the GDF via an encased 5.1-cm (2-in.) pipe.

2.1.4 Double Liner and Diffusion Barrier

The vault construction provides a double liner at the bottom of the structure: the composite of coated concrete at the vault bottom on top of a lined catch basin (see Figure 2.1) that is equipped with perforated leachate collection piping, a sump pump, and a liquid detection system to collect, monitor, and remove any liquid that may exit the vault. Any collected liquid will be recycled through the grout process or stored in a double-shell tank for future processing. After the grout cures and the vault is closed, the detection system will discover any leachate.

Figure 2.1 also shows that each vault will be encased in a thick asphalt diffusion barrier to reduce the rate at which contaminants or vapor may diffuse into or out of the disposal system. The top of the asphalt-pavement

FIGURE 2.2. Vault Ventilation Configuration

diffusion barrier also serves as a radiation shield and the operations cover. A permanent protective barrier will be placed over each pair of vaults at closure.

2.1.5 Cover System

After the grout cures for a minimum of 28 days, grout quality-verification samples will be taken as necessary. The void space between the grout and the concrete cover blocks will be filled with a nonradioactive cement mixture (cold grout). The penetrations through the cover blocks also will be filled, completely filling and sealing the surface of the radioactive grout.

2.1.6 Portable Instrument House and Vault Instrumentation

A portable instrument house will transmit monitoring information to the GDF from each active vault. The instrumentation will include level-, temperature-, and pressure-measuring elements. A continuous-air monitor and an area-radiation monitor is used during the vault-filling and cold-capping operations. After completing the vault-filling operation, the air and radiation monitor can be moved to the next active vault and similarly placed.

2.1.7 Cathodic Protection System

An impressed-current cathodic protection system shields the grout-distribution piping, the excess-water-removal piping, and the leak-detection instrumentation. The system has a design life of approximately 20 years to correspond with the active life of the piping systems.

3.0 FACILITY EMISSIONS

This section briefly describes the sources of toxic air pollutant emissions and provides estimates of release rates.

3.1 SOURCES OF EMISSIONS

The vault exhauster is the only point at which emissions occur. Emissions may be generated by the following mechanisms:

- particles and vapors produced from the falling column of grout between the fill-pipe discharge and the impact point on the grout pool's surface
- particles and vapors produced by the flow of grout over the grout pool's irregular surface
- particles and vapors produced by evaporation at the pool surface and cracks, or from bubbles rising to the surface
- particles penetrating the make-up air filters and adsorbing or nucleating vapor from the vault head space.

Emissions from these sources will be drawn out of the vault head space by the airflow from the filtered make-up intake to the exhauster.

3.2 TOXIC POLLUTANT EMISSION RATES

During actual GDF operations, emissions of air pollutants will vary greatly depending on the waste being processed at any given time. Emission rates will also vary greatly during the process of vault filling, curing, and cold capping, with the peak emissions expected during the filling process. Conservative estimates of emission rates for the uncontrolled toxic air pollutants that could be released to the atmosphere during GDF operations are presented in Table 3.1. These emission rates are from Gretsinger (1993) who based his estimates on the methodology of Hendrickson (1990, 1992) and Ballinger (1993).

Some of the emission rates are extrapolated from samples of the Grout Treatment Facility's potential feed materials. Such values represent the 95% confidence mean for each pollutant's emission rate; that is, given a range of potential emission rates for a specific pollutant, the emission rate presented

TABLE 3.1. Estimated Potential Airborne Emissions

Contaminant	ASIL Class	Short-Term Maximum Emission			Annual Average Emission		
		Particles lb/hr	Vapor lb/hr	Total lb/hr	Particles lb/year	Vapor lb/year	Total lb/year
Methyltoluidine [Xylidine]	B	3.21e-06	2.05e-04	2.08e-04	1.08e-03	9.90e-01	9.91e-01
C3-alkylbenzene	B	2.90e-04	3.94e-01	3.94e-01	9.74e-02	1.91e+03	1.91e+03
Trimethylbenzene	B	7.24e-05	5.85e-02	5.86e-02	2.43e-02	2.83e+02	2.83e+02
Diethylphthalates	B	9.06e-06	4.91e-06	1.40e-05	3.04e-03	2.38e-02	2.68e-02
Unknown phthalates (A: Dibutyl)	B	1.89e-05	5.57e-06	2.45e-05	6.34e-03	2.70e-02	3.33e-02
Dioctylphthalate	A	2.18e-05	9.16e-07	2.27e-05	7.30e-03	4.44e-03	1.17e-02
Ethanedioic Acid	B	3.82e-03	1.03e-04	3.93e-03	1.28e+00	4.98e-01	1.78e+00
Tri-n-butyl phosphate	B	3.80e-05	1.10e-05	4.90e-05	1.28e-02	5.30e-02	6.58e-02
Methylene Chloride	A	3.92e-05	4.38e+00	4.38e+00	1.32e-02	2.63e+02	2.63e+02
Trichloroethane, 1,1,1-	B	1.00e-05	4.01e-01	4.01e-01	3.35e-03	6.70e+01	6.70e+01
Acetone	B	3.18e-04	8.26e+00	8.26e+00	1.07e-01	2.13e+03	2.13e+03
Methyl Isobutyl Ketone	B	7.93e-05	3.08e-01	3.08e-01	2.66e-02	5.30e+02	5.30e+02
Butyl alcohol, n-	B	6.38e-06	1.67e-02	1.67e-02	2.14e-03	4.28e+01	4.28e+01
Methyl Ethyl Ketone	B	8.02e-05	9.91e-01	9.91e-01	2.69e-02	5.35e+02	5.35e+02
Dichloroethylene, 1,1-	B	9.44e-07	4.27e-02	4.27e-02	3.17e-04	8.90e+00	8.90e+00
Nitrobenzene	B	3.54e-06	2.51e-04	2.54e-04	1.19e-03	1.22e+00	1.22e+00
Trichloroethylene	A	7.75e-07	1.60e-02	1.60e-02	2.60e-04	7.30e+00	7.30e+00
Toluene	B	1.37e-07	6.98e-04	6.98e-04	4.59e-05	1.29e+00	1.29e+00
Phenol	B	1.77e-07	2.97e-05	2.99e-05	5.93e-05	1.44e-01	1.44e-01
Cresol	B	1.39e-05	2.32e-03	2.33e-03	4.67e-03	1.13e+01	1.13e+01
Ag metal	B	1.99e-08	-1.6e-27	1.99e-08	6.69e-06	0.00	6.69e-06
Soluble Ag compounds	B	1.99e-05	1.65e-24	1.99e-05	6.69e-03	0.00	6.69e-03
Alkyl Al	B	4.58e-04	2.65e-23	4.58e-04	1.54e-01	0.00	1.54e-01

TABLE 3.1. (contd)

Contaminant	ASIL Class	Short-Term Maximum Emission			Annual Average Emission		
		Particles lb/hr	Vapor lb/hr	Total lb/hr	Particles lb/year	Vapor lb/year	Total lb/year
Al metal dust	B	4.58e-05	0.00	4.58e-05	1.54e-02	0.00	1.54e-02
Soluble Al salts	B	4.58e-02	6.78e-21	4.58e-02	1.54e+01	0.00	1.54e+01
As	A	1.69e-04	0.00	1.69e-04	5.66e-02	0.00	5.66e-02
Soluble Ba compounds	B	1.78e-05	0.00	1.78e-05	5.95e-03	0.00	5.95e-03
Be	A	1.92e-05	0.00	1.92e-05	6.43e-03	0.00	6.43e-03
Ca cyanamide	B	1.61e-06	0.00	1.61e-06	5.40e-04	0.00	5.40e-04
Ca hydroxide	B	8.05e-05	0.00	8.05e-05	2.70e-02	0.00	2.70e-02
Cd	A	7.61e-05	0.00	7.61e-05	2.55e-02	0.00	2.55e-02
Ce hydroxide	B	5.90e-05	0.00	5.90e-05	1.98e-02	0.00	1.98e-02
CN (total)	B	1.28e-04	0.00	1.28e-04	4.29e-02	0.00	4.29e-02
Cr VI	A	1.54e-05	0.00	1.54e-05	5.18e-03	0.00	5.18e-03
Cr II	B	1.54e-04	-1.3e-23	1.54e-04	5.18e-02	0.00	5.18e-02
Cr III	B	1.54e-03	0.00	1.54e-03	5.18e-01	0.00	5.18e-01
Cr metal	B	1.54e-06	0.00	1.54e-06	5.18e-04	0.00	5.18e-04
Cu dusts and mists	B	1.75e-07	1.29e-26	1.75e-07	5.88e-05	0.00	5.88e-05
F	B	2.02e-03	-2.12e-22	2.02e-03	6.79e-01	0.00	6.79e-01
Soluble Fe salts	B	6.34e-05	-6.62e-24	6.34e-05	2.13e-02	0.00	2.13e-02
Inorganic Hg compounds	B	1.92e-05	0.00	1.92e-05	6.43e-03	0.00	6.43e-03
Alkyl Hg compounds	B	1.92e-07	2.58e-26	1.92e-07	6.43e-05	0.00	6.43e-05
K hydroxide	B	2.68e-02	-3.39e-21	2.68e-02	8.98e+00	0.00	8.98e+00
Mn dust and compounds	B	4.10e-05	0.00	4.10e-05	1.38e-02	0.00	1.38e-02
Soluble Mo compounds	B	6.94e-05	-6.62e-24	6.94e-05	2.33e-02	0.00	2.33e-02
Insoluble Mo compounds	B	6.94e-06	4.14e-25	6.94e-06	2.33e-03	0.00	2.33e-03

TABLE 3.1. (contd)

Contaminant	ASIL Class	Short-Term Maximum Emission			Annual Average Emission		
		Particles lb/hr	Vapor lb/hr	Total lb/hr	Particles lb/year	Vapor lb/year	Total lb/year
Na fluoroacetate	B	2.79e-03	-6.35e-22	2.79e-03	9.37e-01	0.00	9.37e-01
Na hydroxide	B	1.40e-01	-1.36e-20	1.40e-01	4.68e+01	0.00	4.68e+01
Ni	A	1.36e-04	-1.32e-23	1.36e-04	4.57e-02	0.00	4.57e-02
Pb acetate	A	4.38e-06	0.00	4.38e-06	1.47e-03	0.00	1.47e-03
Pb phosphate	A	4.38e-06	0.00	4.38e-06	1.47e-03	0.00	1.47e-03
Pb arsenate	B	4.38e-06	0.00	4.38e-06	1.47e-03	0.00	1.47e-03
Pb chromate	B	4.38e-06	0.00	4.38e-06	1.47e-03	0.00	1.47e-03
Sb compounds	B	1.92e-04	-1.3e-23	1.92e-04	6.43e-02	0.00	6.43e-02
Se compounds	B	1.89e-04	2.65e-23	1.89e-04	6.34e-02	0.00	6.34e-02
Ta metal/oxide dusts	B	4.22e-04	2.65e-23	4.22e-04	1.42e-01	0.00	1.42e-01
U	B	1.35e-04	-1.3e-23	1.35e-04	4.53e-02	0.00	4.53e-02
V 205	B	1.92e-07	0.00	1.92e-07	6.43e-05	0.00	6.43e-05
Insoluble W compounds	B	1.68e-05	0.00	1.68e-05	5.64e-03	0.00	5.64e-03
Soluble W compounds	B	1.68e-04	0.00	1.68e-04	5.64e-02	0.00	5.64e-02
Zn chromates	B	3.88e-07	0.00	3.88e-07	1.30e-04	0.00	1.30e-04
Zr	B	2.75e-04	2.65e-23	2.75e-04	9.23e-02	0.00	9.23e-02
TOTAL		2.26e-01	1.49e+01	1.51e+01	7.60e+01	5.79e+03	5.86e+03

in Table 3.1 is larger than 95% of all of the other potential emission rates for that pollutant (or smaller than only 5% of the pollutant's other potential emission rates). Extrapolations from sampling data were not possible for all compounds. In these cases (e.g., acetone and methylene chloride) the estimates were based on the maximum content permissible under land disposal regulations.

The hourly uncontrolled emission rates represent conservative values for vault-filling operations. The annual uncontrolled emission rates are not simply scaled from the hourly values, but are conservative estimates of the average emissions expected during the entire cycle of filling and curing two vaults vented by a single exhauster--from the beginning of emissions until the time the two vaults are cold capped and emissions end.

Summing the emission rate values in Table 3.1 gives a maximum annual emission of 2,600 kg/yr (5790 lb/yr) for vapor phase toxics and only 34.5 kg/yr (76 lb/yr) for the particulate toxics. The emission control devices to be considered later in this report must be sized to accommodate the combined toxic and non-toxic emissions. Because the emission rate for toxic vapors was so conservatively estimated, the total value from the table will be used for sizing vapor control equipment. It is expected that non-toxic particle emissions will be significant. The total uncontrolled emissions for all particles (toxic and nontoxic) is estimated by Grötsinger (1993) to be less than 290 kg/yr (640 lb/yr), which value will be used for equipment sizing.

4.0 THE IMPACT OF UNCONTROLLED EMISSIONS ON AIR QUALITY

This section presents the assessment of the maximum short-term and long-term air quality impacts to the public that could result when the GDF is operated without emissions-control equipment. To estimate air quality impacts, information is required on the emission rates of toxic pollutants and atmospheric transport characteristics. The required data on uncontrolled emission rates were presented in Section 3; Section 4 includes information on local atmospheric dispersion characteristics and how these data are used to estimate air quality impacts.

4.1 METEOROLOGY GOVERNING DISPERSION FROM THE GROUT FACILITY

Information on Hanford's climate and atmospheric dispersion characteristics are collected by the Hanford Meteorology Monitoring Program (Stone et al. 1983, Glantz et al. 1990). Meteorological measurements are made at the Hanford Meteorology Station (HMS) (located outside the northeast corner of the 200 West Area) and at more than 26 automated monitoring stations located within and near the Hanford Site.

Because of its proximity to the grout complex, the automated 200 East station's meteorological measurements are most representative of the atmospheric conditions governing the initial atmospheric dispersion of the grout facility's airborne emissions. This station is located approximately 0.7 km (0.4 mi) north of the PUREX Plant (Glantz and Islam 1988) (Figure 1.2). Wind observations at this station are made at 9 m (30 ft) above ground level and temperature observations are made at 1.5 m (5 ft) above ground level.

Table 4.1 presents the frequency distribution of the wind direction and wind speed monitored at the 200 East station. The prevailing wind direction at this station is from the west-northwest (wind directions are given according to the sector from which the wind is blowing). The wind blows from the west-northwest about 20% of the time, and from either the west, west-northwest, or northwest about 43% of the time. The frequency with which the winds blow out of each of the other 13 directional sectors varies from between 3 and 8%.

TABLE 4.1. The Joint Frequency Distribution of Wind Direction and Wind Speed at the 200 East Meteorology Monitoring Site.

STATION: 6 200 EAST AREA
SEASON: ALL TIME OF DAY: ALL

DATA SUMMARY -- DATA FOR THIS STATION BEGIN: 1/ 1/82 AT 0100 PST
DATA FOR THIS STATION END: 12/31/89 AT 2400 PST
TOTAL NUMBER OF HOURS OF ANALYZED DATA: 99119.
FREQUENCY DISTRIBUTION OF WIND DIRECTION AND WIND SPEED

WIND DIRECTION SECTOR (FROM WHICH THE WIND IS BLOWING)	WIND SPEED CLASS (MPH)							
	1 - 3	4 - 7	8 - 12	13 - 18	19 - 24	25 - 31	32 - 38	>38
NORTH	0.00879	0.02244	0.00837	0.00242	0.00020	0.00002	0.00000	0.00000
NORTH-NORTHEAST	0.00837	0.02090	0.00895	0.00306	0.00117	0.00016	0.00000	0.00000
NORTHEAST	0.00823	0.01885	0.00395	0.00172	0.00056	0.00022	0.00003	0.00000
EAST-NORTHEAST	0.00991	0.01848	0.00202	0.00030	0.00009	0.00004	0.00001	0.00000
EAST	0.00962	0.02307	0.00337	0.00014	0.00005	0.00000	0.00000	0.00000
EAST-SOUTHEAST	0.00966	0.02957	0.00596	0.00033	0.00003	0.00000	0.00000	0.00000
SOUTHEAST	0.00766	0.03368	0.01123	0.00110	0.00001	0.00000	0.00000	0.00000
SOUTH-SOUTHEAST	0.00644	0.02634	0.01423	0.00310	0.00023	0.00001	0.00000	0.00000
SOUTH	0.00565	0.01680	0.00824	0.00258	0.00048	0.00005	0.00000	0.00000
SOUTH-SOUTHWEST	0.00486	0.01324	0.00586	0.00335	0.00164	0.00064	0.00006	0.00001
SOUTHWEST	0.00588	0.01535	0.01023	0.00790	0.00500	0.00190	0.00024	0.00000
WEST-SOUTHWEST	0.00589	0.02272	0.02239	0.01433	0.00749	0.00220	0.00020	0.00000
WEST	0.00753	0.03605	0.04425	0.01488	0.00237	0.00063	0.00000	0.00000
WEST-NORTHWEST	0.00920	0.05556	0.08571	0.03853	0.01160	0.00183	0.00003	0.00000
NORTHWEST	0.01043	0.04636	0.03645	0.01698	0.00821	0.00236	0.00016	0.00000
NORTH-NORTHWEST	0.01006	0.02932	0.00941	0.00152	0.00026	0.00001	0.00001	0.00000
TOTAL:	0.12819	0.42872	0.28061	0.11224	0.03940	0.01009	0.00074	0.00002

4.2 MODELING METHODS

An EPA-approved atmospheric dispersion model is used to conservatively estimate the maximum short-term air quality impacts for each pollutant identified in the effluent from the GDF. The maximally exposed member of the public is assumed to be located at the site boundary^(a). The following three-step method was adopted to compute air quality impacts:

1. Assuming a unit release rate for a generic, nonreactive, nondepositing pollutant, use the EPA-approved SCREEN model (EPA 1988) to compute the

(a) For pollutants emitted by the GDF exhauster, the highest ground-level air concentrations projected by the EPA models for an off-site location will occur at the site boundary. Elevated release assumptions will not affect this result because of the large distances (a minimum of 14 km [8.7 miles]) from the GDF to the site boundary.

short-term air quality impact for the maximally exposed individual in each of the 16 direction sectors. The air quality impact computed using a unit release rate is called an "atmospheric dispersion factor" and is equivalent to a pollutant concentration at a certain distance from the source divided by the pollutant release rate at the source.

2. From among the values computed in Step 1, select the largest short-term atmospheric dispersion factor for the site boundary.
3. For each toxic pollutant, multiply the maximum atmospheric dispersion factor for a unit release by the projected release rate (short term maximum) for that pollutant. This calculation provides a conservative estimate of the maximum short-term air concentration for the pollutant being assessed.

For maximum annual air quality impacts, this process is repeated using the EPA-approved ISCLT2 model (EPA 1992a,b).

Emission characteristics used in the SCREEN and ISCLT2 are presented in Table 4.2. The SCREEN program computed an effective stack height of 33.7 m (110.6 ft) for the GDF due to buoyant plume rise. Trial runs of SCREEN indicated that for short-term maximums, releases under stable conditions (stability class F) with a wind speed of 1 m/s (2.2 mph) produced the greatest air quality impacts to the public. Joint frequency distribution data from meteorological observations at the 200 East monitoring station were used in ISCLT2 modeling to represent long-term atmospheric dispersion conditions.

TABLE 4.2. Inputs for the SCREEN and ISCLT2 Programs

Release Location	Processing	Disposal Area
Stack Height, m	7.62 (25 ft)	6.40 (21 ft)
Stack Diameter, m	0.3048 (1 ft)	0.6096 (2 ft)
Exhaust Flow Rate, m ³ /s	0.3351 (710 ft ³ /min)	3.398 (7200 ft ³ /min)
Exhaust Speed, m/sec	4.59 (10.3 mph)	11.64 (26.0 mph)
Exhaust Temperature, °K	318 (113°F)	336 (145°F)

4.3 CALCULATED DISPERSION FACTORS

Using the method described in Section 4.2, atmospheric dispersion factors for a generic release from the GDF were computed and are provided for site boundary locations in Table 4.3. In this table, the first column gives the direction toward which the pollutant is transported; the second column provides the distance to the site boundary in each of the 16 transport sectors. The remaining columns provide atmospheric dispersion factors for short-term and annual impacts. The greatest short-term air pollutant impacts are estimated to occur to the east-northeast of the GDF. The greatest long-term impacts are estimated to occur to the east of the GDF. Detailed output from the SCREEN and ISCLT2 model simulations are presented in Appendix A.

4.4 MODEL RESULTS

Based on the emissions information presented in Section 3 and the atmospheric dispersion factors presented in Table 4.4, estimates of the maximum pollutant concentration for each pollutant can be computed. Table 4.4 presents the following information:

- maximum short-term and annual average emission rates at the GDF for each contaminant (without emissions controls)
- the concentration limit prescribed for each contaminant by WAC 173-460 (*i.e.*, in the form of ASILs)
- maximum and annual average pollutant concentrations at the site boundary.

It is important to note that ASILs for Class B pollutants always represent the maximum allowable 24-h average pollutant concentrations for the public, but ASILs for a Class A pollutant may represent either an annual average value or a maximum 24-h average. For a Class A pollutant with an annual average ASIL, the maximum short-term concentration of the pollutant may exceed the annual average ASIL by a significant amount, but the maximum annual average pollutant concentration may not exceed the ASIL.

TABLE 4.3. Atmospheric Dispersion Factors at Site Boundary Locations for Emissions at the GDF. Dispersion factors are in units of s/m^3 . The largest dispersion factors in each column are marked with an asterisk.

Atmos. Trans. Dir.	Distance to site boundary (km)	Atmos. Dispersion Factors	
		Short Duration from SCREEN	Annual Average from ISCLT2
S	19.7	9.10E-06	1.98E-08
SSW	18.2	9.92E-06	1.20E-08
SW	17.7	1.03E-05	1.04E-08
WSW	22.4	7.91E-06	7.01E-09
W	21.9	8.09E-06	1.17E-08
WNW	22.4	7.89E-06	1.23E-08
NW	21.8	8.16E-06	1.39E-08
NNW	21.9	8.10E-06	1.22E-08
N	25.9	6.72E-06	1.29E-08
NNE	21.8	8.13E-06	1.28E-08
NE	16.4	1.11E-05	2.42E-08
ENE	14.0	1.33E-05*	4.47E-08
E	15.3	1.20E-05	6.96E-08*
ESE	18.8	9.61E-06	5.35E-08
SE	22.9	7.73E-06	3.23E-08
SSE	19.5	9.21E-06	2.29E-08

Results indicate that even without emissions controls, none of the contaminants projected to be emitted from the GDF (as presented in Table 4.4) will be emitted at a high enough rate to exceed the appropriate ASIL at the site boundary. The pollutants that come closest to their ASILs are sodium hydroxide (maximum concentration reaches $0.23/6.7 = 3.4\%$ of 24-h ASIL), sodium fluoroacetate ($4.7 \text{ E-}3/0.2 = 2.4\%$ of 24-h ASIL), soluble aluminum salts ($0.077/6.7 = 1.2\%$ of 24-h ASIL), and potassium hydroxide ($0.045/6.7 = 1\%$ of the 24-h ASIL). For VOCs, acetone and ethanedioic acid have concentrations that come closest to their ASILs; however, the maximum concentration of each pollutant is less than 0.5% of their respective 24-h ASILs.

TABLE 4.4. Estimates of Unabated Emission Rates and Site Boundary Concentrations

Contaminant	ASIL Class	Maximum total Emission lb/hr	Annual Average Emission lb/year	Annual Average Emission $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
VAPORS:									
Methyltoluidine (Xylidine)	B	2.1e-04	9.9e-01	1.4e+01	9.9e-07	2.8e+01	3.6e-04	3.3e+01	S
C3-alkylbenzene	B	3.9e-01	1.9e+03	2.7e+04	1.9e-03	6.0e+04	6.6e-01	8.2e+02	A
Trimethylbenzene	B	6.9e-02	2.8e+02	4.1e+03	2.8e-04	7.4e+03	9.8e-02	4.2e+02	S
Diethylphthalates	B	1.4e-05	2.7e-02	3.9e-01	2.7e-08	1.8e+00	2.3e-05	1.7e+01	S
Unknown phthalates (A: Dibutyl)	B	2.4e-05	3.3e-02	4.8e-01	3.3e-08	3.1e+00	4.1e-05	1.7e+01	S
Diethylphthalate	A	2.3e-05	1.2e-02	1.7e-01	1.2e-08	2.8e+00	3.8e-05	2.0e-03	A
Ethanedioic Acid	B	3.9e-03	1.8e+00	2.6e+01	1.8e-08	6.0e+02	6.6e-03	3.3e+00	A
Tri-n-butyl phosphate	B	4.9e-05	6.6e-02	9.4e-01	6.6e-08	6.2e+00	8.2e-05	2.7e+02	A
Methylene Chloride	A	4.4e+00	2.6e+02	3.8e+03	2.6e-04	6.6e+05	7.4e+00	2.0e+00	A
Trichloroethane, 1,1,1-	B	4.0e-01	6.7e+01	9.8e+02	6.7e-05	6.1e+04	6.7e-01	6.3e+03	A
Acetone	B	8.3e+00	2.1e+03	3.1e+04	2.1e-03	1.0e+08	1.4e+01	6.9e+03	S
Methyl Isobutyl Ketone	B	3.1e-01	6.3e+02	7.6e+03	6.3e-04	3.9e+04	6.2e-01	6.8e+02	S
Butyl alcohol, n-	B	1.7e-02	4.3e+01	6.1e+02	4.3e-05	2.1e+03	2.8e-02	6.0e+02	S
Methyl Ethyl Ketone	B	9.9e-01	6.4e+02	7.7e+03	6.3e-04	1.3e+05	1.7e+00	2.0e+03	S
Dichloroethylene, 1,1-	B	4.3e-02	8.9e+00	1.3e+02	8.9e-08	6.4e+03	7.2e-02	6.7e+01	A
Nitrobenzene	B	2.6e-04	1.2e+00	1.7e+01	1.2e-08	3.2e+01	4.3e-04	1.7e+01	S
Trichloroethylene	A	1.6e-02	7.3e+00	1.0e+02	7.3e-08	2.0e+03	2.7e-02	8.0e-01	A
Toluene	B	7.0e-04	1.3e+00	1.9e+01	1.3e-08	8.8e+01	1.2e-03	1.2e+03	S
Phenol	B	3.0e-05	1.4e-01	2.1e+00	1.4e-07	3.8e+00	6.0e-05	6.3e+01	S
Cresol	B	2.3e-03	1.1e+01	1.6e+02	1.1e-05	2.9e+02	3.9e-03	7.3e+01	S
PARTICLES:									
Ag metal	B	2.0e-08	6.7e-08	9.6e-05	6.7e-12	2.6e-03	3.3e-08	3.0e-01	S
Soluble Ag compounds	B	2.0e-05	6.7e-03	9.6e-02	6.7e-08	2.6e+00	3.3e-05	3.0e-02	S

TABLE 4.4. (contd)

Contaminant	ASIL Class	Maximum total Emission lb/hr	Annual Average Emission lb/year	Annual Average Emission $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
Alkyl Al	B	4.6e-04	1.5e-01	2.2e+00	1.5e-07	5.8e+01	7.7e-04	6.7e+00	S
Al metal dust	B	4.6e-05	1.5e-02	2.2e-01	1.5e-08	5.8e+00	7.7e-05	3.3e+01	S
Soluble Al salts	B	4.6e-02	1.5e+01	2.2e+02	1.5e-05	5.8e+03	7.7e-02	6.7e+00	S
As	A	1.7e-04	5.7e-02	8.1e-01	5.7e-08	2.1e+01	2.8e-04	2.3e-04	A
Soluble Ba compounds	B	1.8e-05	6.0e-03	8.6e-02	6.0e-09	2.2e+00	3.0e-05	1.7e+00	S
Be	A	1.9e-05	6.4e-03	9.2e-02	6.4e-09	2.4e+00	3.2e-05	4.2e-04	A
Ca cyanamide	B	1.6e-08	5.4e-04	7.8e-03	5.4e-10	2.0e-01	2.7e-08	1.7e+00	S
Ca hydroxide	B	8.1e-05	2.7e-02	3.9e-01	2.7e-08	1.0e+01	1.4e-04	1.7e+01	S
Cd	A	7.6e-05	2.6e-02	3.7e-01	2.6e-08	9.6e+00	1.3e-04	5.6e-04	A
Ce hydroxide	B	5.9e-05	2.0e-02	2.8e-01	2.0e-08	7.4e+00	9.9e-05	6.7e+00	S
CN (total)	B	1.3e-04	4.3e-02	6.2e-01	4.3e-08	1.6e+01	2.1e-04	1.7e+01	S
Cr VI	A	1.5e-05	5.2e-03	7.4e-02	5.2e-09	1.8e+00	2.6e-05	8.3e-05	A
Cr II	B	1.5e-04	5.2e-02	7.4e-01	5.2e-08	1.8e+01	2.6e-04	1.7e+00	S
Cr III	B	1.5e-03	5.2e-01	7.4e+00	5.2e-07	1.8e+02	2.6e-03	1.7e+00	S
Cr metal	B	1.5e-08	5.2e-04	7.4e-03	5.2e-10	1.8e-01	2.6e-08	1.7e+00	S
Cu dusts and mists	B	1.8e-07	5.9e-05	8.4e-04	5.9e-11	2.2e-02	2.9e-07	3.3e+00	S
F	B	2.0e-03	6.8e-01	9.8e+00	6.8e-07	2.6e+02	3.4e-03	8.3e+00	S
Soluble Fe salts	B	6.3e-05	2.1e-02	3.1e-01	2.1e-08	8.0e+00	1.1e-04	3.3e+00	S
Inorganic Hg compounds	B	1.9e-05	6.4e-03	9.2e-02	6.4e-09	2.4e+00	3.2e-05	3.0e-01	S
Alkyl Hg compounds	B	1.9e-07	6.4e-05	9.2e-04	6.4e-11	2.4e-02	3.2e-07	3.0e-02	S
K hydroxide	B	2.7e-02	9.0e+00	1.3e+02	9.0e-06	3.4e+03	4.5e-02	6.7e+00	S
Mn dust and compounds	B	4.1e-05	1.4e-02	2.0e-01	1.4e-08	5.2e+00	6.9e-05	1.7e+01	S
Soluble Mo compounds	B	6.9e-05	2.3e-02	3.3e-01	2.3e-08	8.7e+00	1.2e-04	1.7e+01	S
Insoluble Mo compounds	B	6.9e-06	2.3e-03	3.3e-02	2.3e-09	8.7e-01	1.2e-05	3.3e+01	S
Na fluoroacetate	B	2.8e-03	9.4e-01	1.3e+01	9.4e-07	3.5e+02	4.7e-03	2.0e-01	S

TABLE 4.4. (contd)

Contaminant	ASIL Class	Maximum total Emission lb/hr	Annual Average Emission lb/year	Annual Average Emission $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
Na hydroxide	B	1.4e-01	4.7e+01	6.7e+02	4.7e-05	1.8e+04	2.3e-01	6.7e+00	S
Ni	A	1.4e-04	4.6e-02	6.6e-01	4.6e-08	1.7e+01	2.3e-04	3.3e+00	S
Pb acetate	A	4.4e-08	1.5e-03	2.1e-02	1.5e-09	5.5e-01	7.3e-08	8.3e-05	A
Pb phosphate	A	4.4e-08	1.5e-03	2.1e-02	1.5e-09	5.5e-01	7.3e-08	8.3e-05	A
Pb arsenate	B	4.4e-08	1.5e-03	2.1e-02	1.5e-09	5.5e-01	7.3e-08	5.0e-01	S
Pb chromate	B	4.4e-08	1.5e-03	2.1e-02	1.5e-09	5.5e-01	7.3e-08	2.0e-01	S
Sb compounds	B	1.9e-04	6.4e-02	9.2e-01	6.4e-08	2.4e+01	3.2e-04	1.7e+00	S
Se compounds	B	1.8e-04	6.3e-02	9.1e-01	6.3e-08	2.4e+01	3.2e-04	7.0e-01	S
Te metal/oxide dusts	B	4.2e-04	1.4e-01	2.0e+00	1.4e-07	5.3e+01	7.1e-04	1.7e+01	S
U	B	1.4e-04	4.5e-02	6.5e-01	4.5e-08	1.7e+01	2.3e-04	7.0e-01	S
V 205	B	1.8e-07	6.4e-05	9.2e-04	6.4e-11	2.4e-02	3.2e-07	2.0e-01	S
Insoluble W compounds	B	1.7e-05	5.6e-03	8.1e-02	5.6e-08	2.1e+00	2.8e-05	1.7e+01	S
Soluble W compounds	B	1.7e-04	5.6e-02	8.1e-01	5.6e-08	2.1e+01	2.8e-04	3.3e+00	S
Zn chromates	B	3.9e-07	1.3e-04	1.8e-03	1.3e-10	4.9e-02	6.5e-07	3.0e-02	S
Zr	B	2.8e-04	9.2e-02	1.3e+00	9.2e-08	3.5e+01	4.6e-04	1.7e+01	S
X/Q s/m3 assumed -->					6.98e-08		1.33e-05		

5.0 CONTROL ALTERNATIVES

This section identifies and describes all available control options for reducing toxic air pollutant emissions. The potential control technologies include equipment to remove toxic air pollutants and measures to prevent or reduce emissions. Sections 5.1 and 5.2 describe the available control technologies for VOCs and particles, respectively.

5.1. VOLATILE ORGANIC COMPOUNDS

Some of the toxic air pollutants emitted from the GDF will be in the form of VOCs, so this T-BACT analysis considers control technologies designed to destroy or capture VOCs. A review was conducted of EPA's BACT/LAER Clearinghouse data base to collect information on pollution control equipment for VOCs. Several "source type" classifications were searched due to the lack of a specific classification for nuclear-waste disposal facilities. Other literature searches were conducted to find information on VOC control devices, including the Compendex, Toxline, Pollution Abstracts, and National Technical Information Service data bases. The VOC control technologies identified include various types of thermal oxidation, catalytic oxidation, adsorption, absorption, and condensation devices. These devices will be described in the following subsections.

5.1.1 Thermal Oxidation

In thermal oxidation, the pollutants are brought into direct contact with a high-temperature combustion flame to oxidize the pollutants into harmless compounds (mostly water). The pollutant stream is mixed thoroughly with a burner fuel (usually natural gas or distillate oil), if needed, and passed through a combustion zone. Combustion temperatures range from 870 to 1200°C (1,600 to 2,200°F) with destruction efficiencies of 90 to 99% (EPA 1992c). Thermal oxidizers are widely used in industry, and the various types are distinguished by what use is made of the hot exhaust gases.

Thermal-oxidizer design parameters include temperature, oxygen availability, retention time, and turbulence. One parameter value can be increased while decreasing another to maximize the destruction efficiency for

a given compound. Halogenated organic compounds require more residence time and higher temperatures to achieve the same destruction efficiency as nonhalogenated organic compounds (EPA 1992c). Also, depending on the content of halogenated pollutants, offgas quenchers and scrubbers may be required to remove the resultant HCl in the offgas.

In the **afterburner** type of thermal oxidizer, there is no preheating of the inlet pollutant gas stream. This type is frequently used where the inlet stream has some fuel content of its own, but its use is not limited to such cases. The afterburner type is characterized by low initial cost, compact size, and high use of supplemental fuel. The high cost of the quencher and HCl scrubber may partially offset any cost advantage.

In the **recuperative** type of thermal oxidizer, the inlet pollutant stream is preheated by the hot exhaust gases in a tube-and-shell heat exchanger. This preheat promotes better combustion and destruction efficiency, and reduces the supplementary fuel requirement considerably. The initial cost is higher than a simple afterburner. The lower offgas temperature requires a smaller quencher than the afterburner type.

The **regenerative** type of thermal oxidizer preheats the inlet pollutant gases with extremely high-efficiency heat-exchange beds filled with ceramic stoneware or rocks. As one bed gives up its heat to the incoming air stream, another bed is heated up or regenerated by the exhausting air stream. Periodically, the valving system switches so that the hot exhausting bed changes and becomes the inlet heat bed, and so on. These systems are able to recover as much as 95% of the exhaust temperature energy, thereby greatly reducing the system's operating costs. The regenerative thermal oxidizer is the largest and most expensive.

5.1.2 Catalytic Oxidizer

A catalytic oxidizer is a variation on thermal oxidation in which a catalyst is used to lower the oxidation-activation energy, allowing combustion to occur at a much lower temperature than in the thermal types. In this application, the pollutant gas may be preheated with a supplemental fuel or in a heat exchanger to raise its temperature before it enters the combustor. The gas is then ignited in the combustor with additional fuel and passed through a

fixed or fluidized catalyst bed, where VOCs are destroyed by oxidation. Flue gas exits the combustor, passes through a heat exchanger to preheat the incoming gas stream, and discharges to the stack.

Catalyst beds are manufactured from compounds such as platinum, palladium, and certain metal oxides, depending on the specific VOCs to be removed. The catalyst compounds are coated on the surfaces and in the pores of high-temperature ceramic substrates that are either monolithic (porous blocks containing parallel channels), or beds of spheres or pellets. Catalyst beds will have a short life if the pollutant stream contains catalyst-poisoning constituents such as lead, arsenic, phosphorous, and chlorinated and sulphur-containing compounds together in the same stream. Destruction efficiencies range from 90 to 99% (EPA 1992c).

5.1.3 Adsorption

Adsorption occurs when a gas or vapor is brought into contact with a solid substance, resulting in the gas or vapor being collected on the surface of the solid. The process results from the forces acting on the collection surface, gases, vapors, and dispersed material. The magnitude of these forces depends upon the nature of the solid surface and the types of molecules in the fluid. The adsorbing solid, or adsorbent, is generally an extremely porous material with large internal surfaces. The common adsorbents are activated carbon, chemically impregnated alumina, and resin-coated beads. The carbon and alumina adsorbents can be used in either disposable or regenerative equipment configurations. The equipment descriptions that follow assume the use of activated carbon; however, systems using alumina are essentially the same. The resin beads have been used mostly in air-cleaning applications in a regenerative configuration.

5.1.3.1. Disposable Activated Carbon

Activated carbon is a versatile solid adsorbent. For physical adsorption, activated carbon is limited to high molecular weight and nonpolar adsorbates. However, activated carbon can be chemically treated to enhance the adsorption capability for polar and low molecular weight gases or vapors. The carbon is contained in disposable or refillable canisters. Particle filters are used usually before and after to prolong the life of the carbon

and control the emission of adsorbed compounds on carbon dust. Such systems using high efficiency particulate (HEPA) air filters are commonly used in the nuclear power industry to control radioiodine emissions. Power costs are minimal and a high VOC removal efficiency, 95 to 99% (EPA 1992c), can be attained with low inlet concentrations.

5.1.3.2 Regenerative Activated Carbon

Activated carbon can be re-used through regeneration, either in place or at another location. Steam or hot gases (air or nitrogen) are frequently used for regeneration. Continuous offgas treatment is provided in a system with multiple carbon beds, one in use while the other is being regenerated. The offgas is passed through a condenser for collection of the VOCs as liquid. This liquid waste may be either reclaimed if it has some value, recycled to the grout treatment process if the land disposal acceptance criteria are met, stored, or disposed of according to some possible future regulated procedures. The VOC removal efficiency is the same as for disposable activated carbon. Energy costs are higher than for the disposable carbon systems, and the initial cost is considerably greater; however, the volume of wastes requiring disposal is significantly less.

5.1.3.3 Regenerative Resin Beds

This approach is similar to activated carbon, except that instead of carbon, proprietary resin-coated polymer beads are arranged in two parallel packed beds, one adsorbing (treating the pollutant stream) while the other is desorbing (regenerating by removing adsorbed VOCs). Regeneration is accomplished with heated inert gas, from which the desorbed compounds are condensed. The desorbed compounds may be reclaimed if they have some value, recycled to the grout treatment process if the land disposal acceptance criteria are met, stored, or disposed of according to some possible future regulated procedures. The VOC removal efficiency is generally around 99% (personal communication with Gerald Facino, Purus Inc., April 5, 1993), as is desorption efficiency. The resin beds have a life span sufficient for the scheduled grout-pouring operations. This process has been used at a variety of environmental restoration sites, but mostly for liquid stream treatment.

5.1.4 Absorption

In the process of gas absorption, the effluent gases are brought into contact with a liquid in which the gaseous contaminants will dissolve. This mass-transfer device is usually referred to as a scrubber. The packed bed scrubber is most commonly used. Design parameters include the choice of liquid, the liquid recirculation rate, the liquid flow path (parallel or countercurrent flow), the liquid/gas contacting method, and the amount of liquid surface exposed. The VOC removal efficiencies typically range from 85 to 95%, but can reach 99% (EPA 1992c). In this application, the design for a wide variety of VOCs is complicated by the lack of vapor equilibrium data for many compounds, and a design with good performance for one compound may perform badly for many other compounds.

5.1.5 Condensation

This process uses the principle of cooling to condense vapor into liquid, which is then captured and rerouted through a liquid treatment scheme or captured in a particle-collection device. For the low concentrations of VOCs in this application, the efficiency of this technology ranges from only 75 to 85% (EPA 1992c).

5.2 PARTICLES

Because some of the toxics the GDF emits will be as particles or aerosols, particle controls are considered in this T-BACT analysis. Searches of the EPA's BACT/LAER Clearinghouse and the Compendex, Toxline, Pollution Abstracts, and National Technical Information Service data bases identified several technologies that may be applicable for removing particles from the GDF. These include many kinds of filters, scrubbers, electrostatic precipitators, cyclones, and mist eliminators. This section describes each available particle control technology.

5.2.1 High Efficiency Metal Fiber Filter

The High Efficiency Metal Fiber (HEMF) filter comprises fine stainless-steel fibers (less than 8 μm diameter) sintered together and formed into a cylindrical shape. Cylinder length and number are varied to achieve the

desired capacity. High removal efficiency (greater than 99.99999% at 0.12 μm) (Fluor, Inc. 1991), high strength, high holding capacity, and low pressure drop characterize this filter. In addition, it would likely last through the scheduled duration of the GDF vault-filling process.

The HEMF filters can be cleaned in place or removed for cleaning. The frequency of cleaning depends on the particle loading and the number of filters used; a time interval of 2 to 4 years between filter cleaning is achievable. The decontamination/cleaning solutions may be recycled back to the feed system of the Grout Treatment Facility provided that the acceptance criteria are met. The process to remotely clean the filters is still experimental. The HEMF filter has been commercially available only since the mid-1980s and has not seen extensive use in nuclear-waste applications.

5.2.2 High Efficiency Particle Air Filter

HEPA filters are commonly used in the nuclear industry to remove radionuclide-bearing particles. An individual HEPA filter has a minimum particle removal efficiency of 99.97% for 0.3- μm particles, and a pressure drop of around 2.5 cm (1 in.) water gage when clean and operated at rated airflow capacity (Burchsted et. al. 1976). The filter element of a typical HEPA is made by pleating a continuous sheet of glass microfiber paper over corrugated separators (the separators add strength to the core and maintain air passages between the pleats; however, separatorless varieties are also available). The filter element is then sealed in a wood or metal casing.

To accommodate large airflows, multiple filters are arranged in banks. Filters are disposable and replaced when the airflow declines or the pressure drop across the filter exceeds some multiple of the clean-filter pressure drop. The service life of a HEPA filter depends on the amount of particles in the offgas. The dry-particle capacity is not more than about 450 g (1 lb) each for the standard 61-by-61-by-29-cm (24-by-24-by-11.5-in) size. The service life usually is extended by the upstream removal of most of the particles using less expensive prefilters or other devices. Moisture in the airstream, either from airborne droplets or condensation on the element, severely shortens the life of HEPA filters. The costs of operating a HEPA

filtration system are affected by energy, replacement filters, and labor for filter replacement.

5.2.3 Ultra Low Penetration Air Filter

Ultra low penetration air (ULPA) filters have thicker filter material than HEPA filters. The two types are similar in most respects, but the ULPA filter has a higher particle removal efficiency (99.995% to 99.99999% at 0.12 μm)--and a higher pressure drop as a result.

5.2.4 Deep-Bed Sand Filter

Typical sand filters in the nuclear industry consist of graduated layers of rock, gravel, and sand so that there is about a 2-to-1 variation in granule size from layer to layer. Airflow is upward through the bed and the granules decrease in size in the direction of flow. A plenum beneath the bed assures even distribution of airflow. Larger particles are removed in the bottom of the bed and finer ones in the topmost layers. Tested removal efficiency is slightly less than for HEPA filters and is probably around 99.95% for 0.3- μm particles (Burchsted et. al. 1976).

5.2.5 Deep-Bed Glass-Fiber Filter

Deep-bed glass-fiber filters consist of compacted glass fibers in stainless-steel boxes with perforated screens at the top and bottom. The glass fiber packing density varies through the depth of the filter, with the lowest density packing at the gas inlet and the highest density packing at the gas exit. The low packing density stage removes larger particles while the finer particles are removed at the higher packing density stages. Removal efficiency of the deep-bed glass-fiber filters is about 99.9% for 0.3- μm particles (Moore 1984).

5.2.6 Fabric Filters (Baghouses)

A fabric filter generally consists of fabric elements suspended from a tubesheet that separates the clean-air side from the dirty-air side of the filters. The fabric filter element, or bag, is usually shaped in long cylindrical socks or envelopes, but radially pleated paper or fabric cartridges are also available. Particle-laden gas passes through the bags where the particles are deposited. As the particle deposit thickens to form a

cake, particle removal becomes more efficient. The bags are cleaned at a predetermined time interval or pressure drop by temporarily reversing the direction of the airflow and gently shaking the bags mechanically or sending through pulses of compressed air. The removed particles drop into a hopper at the bottom of the unit.

The filter bags have a long life, but remote changeout (as may be required with radionuclide or toxic contaminants) is technically difficult with the common bag types. The pleated cartridge style of baghouse permits changeout using the bag-in/-out process typical of HEPA filters. Baghouses are not suitable for moist or wet environments, because moisture will quickly reduce the airflow through the bags and make particle removal all but impossible. A removal efficiency of greater than 99.5% for 0.3- μm particles is possible with certain fabrics (Glissmeyer et. al. 1985).

5.2.7 Electrostatic Precipitator

The operating principle of an electrostatic precipitator (ESP) is that a charged particle migrates in an electric field. In an ESP, a high-voltage electric field is produced between discharge electrodes and grounded collection plates. The airborne particles entering the ESP become charged in the vicinity of the discharge electrodes and migrate to the collecting plates. Captured liquid particles flow down the collecting plates to removal channels at the bottom. Solid particles are removed by automatically rapping or washing the collection plates. Removal efficiencies of 99% and greater can be achieved (EPA 1992c). The use of ESPs in the nuclear industry is rare because there is no physical barrier to particle emission if the ESP fails.

5.2.8 Scrubbers

Scrubbers were discussed previously as a tool for VOC removal from air. With specific designs, scrubbers are effective for particle removal; however, a given scrubber design will have a high removal efficiency for both particles and gases at the same time. Scrubbers collect particles by incorporating them into comparatively large water droplets that are easily removed from the airstream. Most scrubbers can be considered as having two zones: a contacting zone where droplets contact particles by interception, impaction, and diffusion mechanisms; and a separation zone where the droplets are separated

from the airstream. Removal efficiency is related to the amount of energy expended by the system in droplet generation and air acceleration (EPA 1981). Scrubbers have the advantages of low initial cost, and tolerance for moist airstreams and widely varying airstream temperatures. A disadvantage is the resulting contaminated liquid stream; however, in the case of the GDF, it may be possible to recycle it back to the Grout Treatment Facility if the land disposal acceptance criteria are met.

There are many different types of scrubbers, distinguished by the method of particle/liquid contacting, and by which stream is used to impart energy into the system. Common types include: tray tower, packed bed, submerged packed bed, swirl orifice, many types of venturists, spray tower, cyclonic, and so on. (See EPA 1981 for a good discussion of the types and operating characteristics.)

5.2.9 Demisters

Demisters (mist eliminators) are used to remove liquid particles (mists) from airstreams. There are several styles, some of which are described in the following paragraphs. These units are considered here because some of the particles in the vault ventilation offgas may be mists formed during the grout-pouring operation.

Standard mist eliminators use impaction to capture mists and particles. The most common is a chevron-plate demister, which consists of a series of corrugated or bent plates through which the gas flows, impacting the droplets onto the plate surfaces. Mist eliminators common in nuclear waste processing use alternating coalescing layers (made of nonwoven fiber mats) and draining layers (usually wire mesh). Mist removal efficiency increases with gas velocity, at the expense of increased pressure drop (Moore 1984).

The **High Efficiency Mist Eliminator (HEME)** is composed of regenerative deep-bed fiber filters configured in an annular shape to remove submicron aerosols. Gas flows from the outside to the inside hollow core, 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 construction materials can be selected for their resistance to attacking 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 lodge on the fiber and become physically bonded. Continuous or intermittent water spraying of the filter elements can be used to wash down and cleanse accumulated debris, thus extending the service life of the devices; however, water-soluble compounds can migrate through the filter and become reentrained.

HEMEs are commonly used to remove fine mists and aerosols, and exhibit removal efficiencies of nearly 99% for aerosols smaller than 3 μm (Moore 1984). They are passive devices with low maintenance requirements and high reliability. Disadvantages of the HEMEs include production of liquid wastes as well as solid waste (the spent demister material), potential upsets if airflow rates vary significantly, and high pressure drops across the HEME.

5.2.10 Cyclones

The principal gas/particle separation mechanism in a cyclone is impaction. Particles enter the cyclone with the flowing gas, which is forced to turn several times. Particles with too much momentum to follow the turning gas impact on the cyclone walls and fall into a hopper. The particle removal efficiency is lower than for the other devices described in this section. To increase the airflow, multiple cyclones, consisting of several small-diameter cyclones that have a common gas inlet and outlet, are used. The flow pattern differs from that of 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 3 to 61 cm (1 to 24 in.). A removal efficiency of 90% is achieved for particles in the 5- to 10- μm range (EPA 1981).

6.0 TECHNICAL FEASIBILITY OF CONTROL TECHNOLOGIES

The previous section described the available technologies for the control of VOCs and particles. This section discusses the technical feasibility of employing these technologies for the GDF exhausters. Those technologies determined to be feasible will be the subject of impact analysis in the following section. Those not determined feasible will not be considered further.

6.1 TECHNICAL FEASIBILITY OF TECHNOLOGIES THAT CONTROL VOC EMISSIONS

The technical feasibility of the previously described control technologies for VOC emissions will be discussed. The feasibility discussion and control device characteristics are summarized in Table 6.1.

6.1.1 Thermal Oxidation

Thermal oxidizers are commercially available as packaged units containing all necessary equipment. A supplemental fuel source would be needed for combustion because the organic loading is too low to support self combustion. Of the three types of thermal oxidizers identified, the afterburner and recuperative types are feasible from the capacity and portability standpoint. The regenerative type is not feasible because it is only suitable for larger flows and fixed sites.

6.1.2 Catalytic Oxidation

As in the case of the thermal oxidizers, a catalytic oxidizer will need a supplemental fuel source for application in GDF. The VOC loading in the GDF effluent airstream is too small for a normal catalyst bed to react with the organics and allow complete combustion. Because the pollutant stream contains many of the common catalyst-poisoning agents, this technology is not feasible in this case.

TABLE 6.1. Summary of VOC Control Options

Control Technology	Advantages	Disadvantages	Technically Feasible
Afterburner and Recuperative Thermal Oxidation	<ul style="list-style-type: none"> High efficiencies Low maintenance requirements 	<ul style="list-style-type: none"> High fuel costs Quencher cooling water required HCl scrubber may be required producing liquid waste (may be recyclable to GDF) 	YES
Regenerative Thermal Oxidation	<ul style="list-style-type: none"> Low energy use Low operating costs 	<ul style="list-style-type: none"> Lower efficiencies than normal thermal oxidation Not portable Scrubber & Quencher may be required Used on very large flow (>35,000 cfm) 	NO
Catalytic Oxidation	<ul style="list-style-type: none"> High efficiencies Low maintenance costs 	<ul style="list-style-type: none"> High capital costs Unable to treat low VOC loadings Catalyst may be poisoned quickly by some of the VOC constituents 	NO
Disposable Activated Carbon Adsorber	<ul style="list-style-type: none"> Inexpensive Simple design High efficiencies 	<ul style="list-style-type: none"> Secondary solid waste Ketones and alcohols not as effectively removed Moisture sensitive Low capacity for acetone and methylene chloride 	NO
Regenerative Activated Carbon Adsorber	<ul style="list-style-type: none"> High removal efficiency High capacity 	<ul style="list-style-type: none"> Produces liquid waste (may be recyclable) Requires desorption and condensation stages 	YES
Regenerative Resin Bed Adsorber	<ul style="list-style-type: none"> High removal efficiency High capacity 	<ul style="list-style-type: none"> Produces liquid waste (may be recyclable) Requires desorption and condensation stages 	YES
Absorption	<ul style="list-style-type: none"> Inexpensive Small space requirements 	<ul style="list-style-type: none"> Liquid waste produced Not useful with many different VOC contaminants 	NO
Condensation	<ul style="list-style-type: none"> Simple design Inexpensive 	<ul style="list-style-type: none"> Liquid waste produced Low efficiency on low inlet VOC concentrations 	NO

6.1.3 Disposable Activated Carbon Adsorber

Because of the activated carbon's low capacity for the principal VOC pollutant constituents (acetone and methylene chloride), breakthrough would

occur after about 20 h^(a). This makes the disposable carbon types unfeasible because of the great amounts of solid wastes and intensive labor in carbon changeout.

6.1.4 Regenerative Activated Carbon Adsorber

The regenerative carbon adsorber is technically feasible.

6.1.5 Regenerative Resin Bed Adsorber

This technology is feasible for the GDF exhauster application.

6.1.6 Absorption

Packed tower systems are low in capital costs, have small space requirements, and a variety of designs exist; however, they are useful only for removing a specific organic compound or several closely related organic compounds. Because of the great variety of VOCs in the GDF effluent stream, all at relatively low concentrations, a single suitable absorption fluid would not suffice. Several absorption units would probably be required and would render the completed system not portable, and therefore not feasible.

6.1.7 Condensation

Because of the low VOC content and high humidity of the vault air, the VOC removal efficiency of the condensation technique would be negligible (EPA 1992c). This technology would be useful only if the VOC content were much higher, such as in the desorption loop of an adsorption system. Condensation, therefore, is not a feasible control technology for the GDF exhauster.

6.2 TECHNICAL FEASIBILITY OF TECHNOLOGIES THAT CONTROL PARTICLE EMISSIONS

The standards for the technical feasibility of control technologies for particles are more restrictive than those for VOC control technologies, because the requirements of WAC 246-247 and 173-480 also must be met for the particulate radionuclides. To meet these regulations, filtration systems with a removal efficiency equal to or exceeding that of HEPA filters are required. Less efficient devices would be suitable only for pretreatment prior to a

(a) Personal Communication with Kenneth Hefley, Charcoal Service Corporation, April 7, 1993.

stage of HEPA (or better) filters. The feasibility discussion and control device characteristics are summarized in Table 6.2.

6.2.1 HEMF Filters

Although HEMF filters have not seen widespread application in nuclear air cleaning, they are technically feasible for this application. DOE Order 6430.1A requires that final filter elements be certified to meet the HEPA filter specifications (MIL-F-51068). This certification is not yet complete for the HEMF filter type, so it is assumed for this evaluation that HEPA filters are still required as a final filter stage.

6.2.2 HEPA Filters

HEPA filters are technically feasible for the GDF exhauster application; however, solid waste disposal must be considered in the impact analysis.

6.2.3 ULPA Filters

The ULPA filters are not feasible because they do not meet the standards specified in HEPA filter specifications (MIL-F-51068).

6.2.4 Deep-Bed Sand Filter

The deep-bed sand filter is not feasible for this application because it is not portable.

6.2.5 Other Particle Control Devices

The presence of radionuclide pollutants, that are not regulated under WAC 176-460, requires (under DOE Order 6430.1A) that the final filter elements be certified to meet the HEPA filter specifications (MIL-F-51068). The control devices with particle collection efficiencies less than that of HEPA filters (*i.e.*, deep-bed glass-fiber filter, fabric filter, ESP, scrubbers, demisters, multiple cyclones, and prefilters) are not considered feasible as the final control devices in this case.

TABLE 6.2. Summary of Particle Control Technologies

Control Technology	Advantages	Disadvantages	Technically Feasible
High Efficiency Metal Fiber (HEMF) Filter	<ul style="list-style-type: none"> Extremely efficient Can be cleaned instead of disposing Can withstand higher temperatures and moisture Simple design; no moving parts Relatively low pressure drop 	<ul style="list-style-type: none"> Produces liquid waste Very high initial cost Requires additional equipment for filter cleaning Currently would require a final stage of traditional nuclear-grade HEPA filters 	YES
High Efficiency Particulate Air (HEPA) Filter	<ul style="list-style-type: none"> Highly efficient Simple design; no moving parts Low initial cost Handles variable loading Low pressure drop 	<ul style="list-style-type: none"> Spent filters become solid waste Must be kept dry to avoid fouling May require frequent changing of filter media 	YES
Ultra Low Penetration Air (ULPA) Filter	<ul style="list-style-type: none"> Extremely efficient Low pressure drop Simple design; no moving parts More expensive than HEPA filters 	<ul style="list-style-type: none"> Spent filters become solid waste Must be kept dry to avoid fouling May require frequent changing of filter media Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO
Deep-Bed Sand Filter	<ul style="list-style-type: none"> Highly efficient Low maintenance High heat capacity Capable of handling variable loading Fire resistant 	<ul style="list-style-type: none"> High initial cost Large space requirement High pressure drop Spent sands become solid waste Not portable 	NO
Deep-Bed Glass-Fiber Filter	<ul style="list-style-type: none"> Highly efficient Simple design Relatively small space requirements 	<ul style="list-style-type: none"> Relatively high pressure drop Spent filters become solid waste 	NO
Fabric Filter (Baghouse)	<ul style="list-style-type: none"> Highly efficient Modular construction Can handle large gas flow rates 	<ul style="list-style-type: none"> High initial and operating costs Frequent bag replacement Bags become solid waste Large space required Flammability hazard Relatively high pressure drop Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO

Control Technology	Advantages	Disadvantages	Technically Feasible
Electrostatic Precipitator (Wet or Dry)	<ul style="list-style-type: none"> • Highly efficient • Low maintenance; few moving parts • Can accommodate corrosive materials • Can handle large gas flow rates 	<ul style="list-style-type: none"> • High initial cost • Sensitive to varying process conditions • Large space required • Safety concerns regarding high voltages • Wet ESPs produce a liquid waste stream • Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO
Scrubbers	<ul style="list-style-type: none"> • Low initial cost • Handles high temperature and moisture • Can handle corrosive gases 	<ul style="list-style-type: none"> • Produces liquid waste stream • High operating cost • Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO
Demisters	<ul style="list-style-type: none"> • Simple design; no moving parts • Backwashing can extend filter element life 	<ul style="list-style-type: none"> • Produces solid and liquid wastes • Low removal efficiency for fine mists and particles • Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO
Cyclones	<ul style="list-style-type: none"> • Simple design • Low initial cost • Useful for high gas flows 	<ul style="list-style-type: none"> • Low efficiency for fine particles • High humidity gases can cause plugging • Currently would require a final stage of traditional nuclear-grade HEPA filters 	NO

6.3 CONTROL TECHNOLOGY HIERARCHY

The VOC control technologies judged as feasible for this application are listed in Table 6.3, and the feasible particle control technologies are listed in Table 6.4. They are listed in order of declining removal efficiency.

TABLE 6.3. VOC Control Technology Feasible for GDF Vault Exhauster

Control Alternative	Range of Control	Removal Efficiency for Vault Exhauster
Activated Carbon Adsorption	95-99%	97%
UV/Oxidation	95-99%	97%
Thermal Incineration	90-95%	93%

TABLE 6.4. Technically Feasible Particle Removal Technologies

Technology	Range of Control	Removal Efficiency for Vault Exhauster (%)	Particle Size (μm)
HEMF Filter	>99.99999	99.99999	0.12
HEPA Filter	99.95-99.99	99.95	0.3

7.0 ENVIRONMENTAL, ENERGY, AND ECONOMIC ANALYSIS

In this section, the control technologies identified in Section 6 to be technically feasible for the GDF Exhauster are evaluated on the basis of their environmental, energy, and economic impacts. This section then concludes with a recommendation for an appropriate T-BACT for this application.

The environmental impact analysis for a control technology considers the secondary waste production, the construction hazards, and the safety of workers and the public. The secondary wastes to be identified include gaseous discharges, and solid and liquid wastes.

The energy impact analysis for a control technology considers the energy requirements of the control devices. Electrical and other fuel usage is considered, as well as the need for the extension of new utility service.

The economic impact analysis for each control technology explores the cost of control equipment acquisition, installation, and operation. The costs presented are based on informal discussions with vendors, and industry-standard estimating methods such as EPA (1992c) and Peters and Timmerhouse (1990). As such, the cost information presented here represents rough-order-of-magnitude estimates from which actual costs may deviate substantially. Nevertheless, this method generally provides a good indication of the relative costs of different technologies. The cost estimates will be presented in terms of annual cost, net-present-value cost, and cost per unit of pollutant removed. The general assumptions and detailed calculations are included in Appendix B.

7.1 VOLATILE ORGANIC COMPOUNDS

The three VOC control technologies evaluated as technically feasible are considered in the order of decreasing removal effectiveness, as they were listed in Table 6.3. If the impacts of one technology are considered too great, then the next technology will be evaluated, and so on until a technology with reasonable impacts is identified. That technology will then be recommended as the T-BACT for the VOC pollutants.

7.1.1 Regenerative Resin Bed Adsorber

The resin bed adsorber is assumed to use two resin beds, one adsorbs (treating the pollutant stream) while the other desorbs (regenerates by removing the adsorbed VOCs). Condensation of the desorbate is accomplished with a refrigerated chiller. Recycle of the condensate to the feed system of the Grout Treatment Facility is assumed for the economic analysis. If, however, the condensate does not meet the land disposal acceptance criteria, storage or further treatment would be necessary, the cost of which has not been included in the economic impact analysis. Figure 7.1 diagrams the key features of this system.

7.1.1.1 Environmental Impacts

The major waste stream is the condensed VOCs removed in regeneration. It is assumed that the condensate can be recycled back to the Grout Treatment Facility for processing. Desorption also will cause a small nitrogen emission, which would have to be shown to meet ambient air quality standards. The technology creates no solid waste. Construction risks are normal for industrial processing equipment, and the radiation risk to maintenance workers associated with this and the other technologies is well within guidelines established by Westinghouse Hanford Company for personnel exposure.

7.1.1.2 Energy Impacts

The only energy impact of this option is 6.7E5 kWh/yr of electricity required for operation.

7.1.1.3 Economic Impact

Table 7.1 summarizes the cost analysis for this technology. The cost effectiveness of the regenerative resin bed adsorber is \$228,000/ton VOCs removed.

7.1.1.4 Summary

The environmental and energy impacts of this technology are acceptable, but the economic impact is too high to recommend it as an acceptable T-BACT option.

FIGURE 7.1. Resin Bed Adsorber

TABLE 7.1. Cost Summary for Resin Bed Adsorber

CAPITAL COSTS:	Equipment Costs (EC)	\$1,226,855
	1st Installation (I)	\$80,000
	Instrumentation & Controls	\$350,000
	Water & Steam Supply (30% of EC)	\$0
	Makeup Air & Ductwork	\$100,000
	Condensate Recycle Piping	\$50,000
	<u>Engineering & Supervision (30% of EC)</u>	\$368,057
	Subtotal	\$2,174,912
	Contingency (15% of Subtotal)	\$326,237
	<u>Start Up (10% of Subtotal)</u>	\$217,491
Total (TCC)		\$2,718,639
ANNUAL OPERATING COSTS:	Replacement Media	\$0
	Solids Disposal (\$300/ft ³)	\$0
	Operating Labor (OL)	\$20,625
	Maintenance Labor (=OL)	\$20,625
	Supervisory Labor (15% of OL)	\$3,094
	Maintenance Materials	\$20,625
	Maintenance Contracts	\$10,403
	Electricity	\$26,912
	Water	\$0
	Steam	\$0
	Natural Gas	\$0
	Other	\$5,790
	<u>Relocation (=I)</u>	\$80,000
	Total (TAOC)	\$188,074
NET PRESENT VALUES:		
10 yrs Operating Costs (NPVOC)		\$1,294,654
Total (= NPVOC + TCC, i=10%)		\$4,013,294
Annualized Cost (i=10%, 10 yr)		\$653,145
COST EFFECTIVENESS:	Ton/yr VOCs Removed	2.9
	Ton/yr Particles Removed	
	Annualized \$/ton VOCs Removed	\$227,890
	Annualized \$/ton Particles Removed	

7.1.2 Thermal Oxidation

A thermal oxidizer with a VOC removal efficiency of about 98% is assumed for this impact analysis. It is assumed that both recuperative and afterburner units would require quenchers and scrubbers for removal of HCl from the offgas, and that any waste liquid will be recycled into the Grout Treatment Facility feed system. The systems are diagrammed in Figure 7.2.

FIGURE 7.2. Recuperative Thermal Oxidizer

7.1.2.1 Environmental Impacts

This technology will remove 2.8 tons/yr of VOC from the exhaust stream with the removal efficiency of 98%. The residual liquid wastes from the quencher and scrubber may be recycled to the Grout Treatment Facility if the feed acceptance criteria are met. Supplemental fuel would have to be burned to run the oxidizer, resulting in a new source of air pollutants. The emissions from the supplemental fuel combustion would have to be shown to meet ambient air quality standards.

7.1.2.2 Energy Impacts

About $1.6\text{E}7 \text{ m}^3/\text{yr}$ ($5.6\text{E}7 \text{ ft}^3/\text{yr}$) of natural gas and $3.0\text{E}5 \text{ kWh}/\text{yr}$ of electricity would have to be supplied to a recuperative thermal oxidizer. The afterburner type would require considerably more gas at $4.8\text{E}6 \text{ m}^3/\text{yr}$ ($1.7\text{E}8 \text{ ft}^3/\text{yr}$), but somewhat less electric power at $2.0\text{E}5 \text{ kWh}/\text{yr}$. Both types would require cooling water for the quenchers and HCl scrubbers.

7.1.2.3 Economic Impacts

The cost estimate for a thermal oxidizer unit is presented in Table 7.2. The cost effectiveness for the oxidizers is about \$222,000/ton and \$367,000/ton of VOCs removed for the recuperative and afterburner types, respectively.

7.1.2.4 Summary

The environmental and energy impacts of the thermal oxidizer are acceptable, but the economic impact of even the least costly type (\$222,000/ton VOC removed) precludes this technology from selection as an acceptable T-BACT option.

7.1.3 Regenerative Activated Carbon Adsorbers

Regenerative activated carbon adsorbers have a VOC removal efficiency of about 97%. A generalized diagram of the system used in our assessment is shown in Figure 7.3.

7.1.3.1 Environmental Impacts

This technology will remove about 2.8 tons/yr of VOC from the exhaust stream with the removal efficiency of 97%. The desorption process will result in collecting the removed adsorbed product as a liquid. It is assumed that the desorbate would meet acceptance criteria for Grout Treatment Facility feed and would be recycled back to the process. Desorption also may cause a small steam or other gaseous emission, which would have to be shown to meet ambient air quality standards. The process would not create solid waste. If cooling water is used for condensation, about $9.7\text{E}6 \text{ gal}/\text{yr}$ is estimated. (The use of cooling water was assumed for the cost estimate.) However, if a refrigerated condensation unit is used, the cooling-water requirement would be replaced with a greater electricity requirement.

TABLE 7.2. Cost Summary of Two Thermal Oxidizers

	Recuperative	Afterburner
CAPITAL COSTS:		
Equipment	\$400,000	\$400,000
1st Installation (I)	\$80,000	\$80,000
Instrumentation & Controls	\$350,000	\$350,000
Water & Steam Supply (30% of EC)	\$120,000	\$120,000
Makeup Air & Ductwork	\$100,000	\$100,000
Condensate Recycle Piping	\$50,000	\$50,000
<u>Engineering & Supervision (30% of EC)</u>	<u>\$120,000</u>	<u>\$120,000</u>
Subtotal	\$1,220,000	\$1,220,000
Contingency (15% of Subtotal)	\$183,000	\$183,000
<u>Start Up (10% of Subtotal)</u>	<u>\$122,000</u>	<u>\$122,000</u>
Total (TCC)	\$1,525,000	\$1,525,000
ANNUAL OPERATING COSTS:		
Replacement	\$0	\$0
Solids Disposal (\$300/ft ³)	\$0	\$0
Operating Labor (OL)	\$20,625	\$20,625
Maintenance Labor (=OL)	\$20,625	\$20,625
Supervisory Labor (15% of OL)	\$3,094	\$3,094
Maintenance Materials	\$20,625	\$20,625
Maintenance Contracts		
Electricity	\$11,906	\$8,174
Water	\$2,000	\$4,000
Steam	\$0	\$0
Natural Gas	\$183,381	\$550,143
Other	\$0	\$0
<u>Relocation (=I)</u>	<u>\$80,000</u>	<u>\$80,000</u>
Total (TAOC)	\$342,256	\$707,286
NET PRESENT VALUES:		
10 yrs Operating Costs (NPVOC)	\$2,356,004	\$4,868,777
Total (= NPVOC + TCC, i=10%)	\$3,881,004	\$6,393,777
Annualized Cost (i=10%, 10 yr)	\$631,615	\$1,040,558
COST EFFECTIVENESS:		
Ton/yr VOCs	2.8	2.8
Ton/yr Particles Removed		
Annualized \$/ton VOCs Removed	\$222,627	\$366,768
Annualized \$/ton Particles Removed

FIGURE 7.3. Regenerative Carbon Adsorber

7.1.3.2 Energy Impacts

About 3.7E5 kWh/yr of electricity will be required for the fan, and cooling-water and waste-water pumps. If steam is used for regeneration, about 2.8E6 lb/yr would be required and is assumed to be available from the 200 East Steam Plant. About 9.7E6 gal/yr of cooling water would be required to condense the regeneration product. A hot-air regeneration system with refrigerated condensation would eliminate the steam and cooling-water requirements at the expense of additional electricity.

7.1.3.3 Economic Impacts

The cost estimate for a regenerative activated carbon adsorber is presented in Table 7.3. It is based on a steam regeneration unit with cooling water used for condensing the product. EPA (1991, 1992c, 1992d) methods were used for the equipment cost estimate. A hot-air regeneration unit is expected to have similar costs. The cost effectiveness for this control option is about \$127,000/ton of VOCs removed.

TABLE 7.3. Cost Summary for Regenerative Carbon Adsorber

CAPITAL COSTS:	Equipment Costs (EC)	\$118,800
	1st Installation (I)	\$80,000
	Instrumentation & Controls	\$350,000
	Water & Steam Supply (30% of EC)	\$35,640
	Makeup Air & Ductwork	\$100,000
	Condensate Recycle Piping	\$50,000
	<u>Engineering & Supervision (30% of EC)</u>	<u>\$35,640</u>
	Subtotal	\$770,080
	Contingency (15% of Subtotal)	\$115,512
	<u>Start Up (10% of Subtotal)</u>	<u>\$77,008</u>
Total (TCC)		\$962,600
ANNUAL OPERATING COSTS:	Replacement Media	\$0
	Solids Disposal (\$300/ft ³)	\$0
	Operating Labor (OL)	\$20,625
	Maintenance Labor (=OL)	\$20,625
	Supervisory Labor (15% of OL)	\$3,094
	Maintenance Materials	\$20,625
	Maintenance Contracts	
	Electricity	\$14,638
	Water	\$1,945
	Steam	\$17,011
	Natural Gas	\$0
	Other	\$0
	<u>Relocation (=I)</u>	<u>\$80,000</u>
	Total (TAOC)	\$178,563
NET PRESENT VALUES:		
10 yrs Operating Costs (NPVOC)		\$1,229,179
Total (= NPVOC + TCC, i=10%)		\$2,191,779
Annualized Cost (i=10%, 10 yr)		\$356,702
COST EFFECTIVENESS:	Ton/yr VOCs Removed	2.8
	Ton/yr Particles Removed	
	Annualized \$/ton VOCs Removed	\$127,024
	Annualized \$/ton Particles Removed	

7.1.3.4 Summary

The environmental and energy impacts of the regenerated activated carbon adsorber system are acceptable, but the high economic impact (\$127,000/ton of VOCs removed) precludes this technology from being recommended as an acceptable T-BACT option.

7.1.4 T-BACT Determination

None of the VOC control technologies are deemed to be acceptable because of their high economic cost for a class of pollutants already well below the accepted ASILs. The "no controls" option is proposed for implementation as T-BACT for the VOC component of the GDF exhaust.

7.2 PARTICLES/AEROSOLS

In Section 6, two control technologies for particle removal were evaluated as technically feasible, and Table 6.4 lists their removal effectivenesses.

7.2.1 HEMF Filter

HEMF filters have a particle removal efficiency of 99.99999%. A diagram of such a device is shown in Figure 7.4. The HEMF filters are backed up with a dual HEPA filter unit.

7.2.1.1 Environmental Impacts

This technology will remove virtually all of the 34 kg/yr (76 lb/yr) of toxic particulates from the exhaust stream with the removal efficiency of 99.99999%. Because the filters are washed in place with either water or a mildly acidic solution, there are no solid wastes from this device. It is assumed that the washing solution carrying the contaminants would meet the acceptance criteria for the Grout Treatment Facility's feed stream and be recycled for processing. It also is assumed that no replacement HEPA filters for the back-up unit will be required. Construction and operational safety impacts are typical for an industrial process involving the preparation of chemicals.

FIGURE 7.4. HEMF Filter Unit

7.2.1.2 Energy Impacts

The only energy requirement of this device is approximately 4.9E5 kWh/yr electrical load for the fan and HEPA filter unit heaters.

7.2.1.3 Economic Impacts

The cost estimate for a two-stage HEMF filter system is presented in Table 7.4. One stage is expected to be in service while the other is being cleaned and dried. The equipment cost of the HEPA filter system also is included. The cost effectiveness for this option is about \$15,000,000/ton of toxic particulates removed--quite high due to the low toxic particle concentration in the offgas stream. (For all particles, 0.32 ton/yr, the cost effectiveness is about \$1,800,000/ton.)

7.2.1.4 Summary

The environmental and energy impacts of this option are acceptable; however, the economic impact (\$15,000,000/ton) precludes the device from further consideration as T-BACT.

7.2.2 HEPA Filter

Single HEPA filters have a minimum tested particle removal efficiency of 99.97% for 0.3- μm particles. A bank of installed filters has a minimum acceptance criterion of 99.95% efficiency for 0.3- μm particles. Diagrams of an individual filter and of a multifilter system such as would be used in this application are shown in Figures 7.5 and 7.6. The housing includes two testable stages of HEPA filters in series, and a heater bank to decrease the relative humidity to keep the filters dry. The flow capacity is 250 m³/min (9,000 ft³/min) and each bank of filters consists of nine filters arranged three high by three deep.

7.2.2.1 Environmental Impacts

To estimate the production of solid waste, it is assumed that this technology will remove essentially all of the 34 kg/yr (76 lb/yr) of toxic particles from the exhaust stream. Furthermore, it is assumed, for convenience, that all the toxic and nontoxic particles 290 kg/yr (640 lb/yr) are collected in the first filtration stage, and that each filter will collect about 450 g (1 lb) of solids before the increased pressure drop prompts a change of filters. About 72.5 m³ (2,560 ft³) of solid wastes would be

TABLE 7.4. Cost Summary for HEMF Filter System

CAPITAL COSTS:	Equipment Costs (EC)	\$1,020,000
	1st Installation (I)	\$80,000
	Instrumentation & Controls	\$350,000
	Water & Steam Supply (30% of EC)	\$0
	Makeup Air & Ductwork	\$100,000
	Condensate Recycle Piping	\$50,000
	<u>Engineering & Supervision (30% of EC)</u>	<u>\$306,000</u>
	Subtotal	\$1,906,000
	Contingency (15% of Subtotal)	\$285,900
	<u>Start Up (10% of Subtotal)</u>	<u>\$190,600</u>
Total (TCC)		\$2,382,500
ANNUAL OPERATING COSTS:	Replacement Media	\$0
	Solids Disposal (\$300/ft ³)	\$0
	Operating Labor (OL)	\$20,625
	Maintenance Labor (=OL)	\$20,625
	Supervisory Labor (15% of OL)	\$3,094
	Maintenance Materials	\$20,625
	Maintenance Contracts	
	Electricity	\$19,482
	Water	\$0
	Steam	\$0
	Natural Gas	\$0
	Other	\$2,000
	<u>Relocation (=I)</u>	<u>\$80,000</u>
	Total (TAOC)	\$166,451
NET PRESENT VALUES:		
10 yrs Operating Costs (NPVOC)		\$1,145,808
Total (= NPVOC + TCC, i=10%)		\$3,528,308
Annualized Cost (i=10%, 10 yr)		\$574,216
COST EFFECTIVENESS:		
Ton/yr VOCs Removed		
Ton/yr Particles Removed		0.038
Annualized \$/ton VOCs Removed		
Annualized \$/ton Particles Removed		\$15,110,942

Filter Media

FIGURE 7.5. HEPA Filters

FIGURE 7.6. HEPA Filter System.

produced per year, as the first-stage filters would be replaced about 71.1 times a year. This device produces no liquid waste streams. Construction and maintenance impacts are acceptable, but radiation exposure to workers may occur during filter changeout; however, the radiation-monitoring procedures and familiarity with the bag-in/-out procedure for changing filters would place radiation exposure within safe limits.

7.2.2.2 Energy Impacts

The only energy impact of this option is 4.9E5 kWh/yr of electricity required for the exhauster fan and heaters.

7.2.2.3 Economic Impacts

The cost estimate for the HEPA filter system described is presented in Table 7.5. The cost effectiveness of this technology is about \$35,600,000/ton of toxic particles removed--quite high due to the low concentration of toxic particles in the offgas stream. (For all particles, 0.32 ton/yr, the cost effectiveness is about \$4,200,000/ton.)

7.2.2.4 Summary

The environmental and energy impacts of this technology are acceptable; however, the high economic impact (\$35,600,000/ton toxic particles removed) precludes a recommendation as an acceptable T-BACT option.

7.2.3 T-BACT DETERMINATION

None of the toxic-particle control technologies are deemed to be acceptable because of their high economic cost for a class of pollutants already well below the accepted ASILs. A "no controls" option is acceptable for implementation as T-BACT for the toxic-particle component of the GDF exhaust; however, to meet the requirements of other regulations and the DOE policy for "as low as reasonably achievable" (ALARA) radionuclide exposures, a HEPA filter system such as that diagrammed in Figure 7.5 will be implemented for the GDF exhauster.

7.3 CONTROL TECHNOLOGY IMPACT SUMMARY

Table 7.6 summarizes the environmental, energy and economic analysis for each of the control technologies discussed in this section.

TABLE 7.5. Cost Summary for HEPA Filter System

CAPITAL COSTS:	Equipment Costs (EC)	\$220,000
	1st Installation (I)	\$80,000
	Instrumentation & Controls	\$350,000
	Water & Steam Supply (30% of EC)	\$0
	Makeup Air & Ductwork	\$100,000
	Condensate Recycle Piping	
	<u>Engineering & Supervision (30% of EC)</u>	\$66,000
	Subtotal	\$816,000
	Contingency (15% of Subtotal)	\$122,400
	<u>Start Up (10% of Subtotal)</u>	\$81,600
Total (TCC)		\$1,020,000
ANNUAL OPERATING COSTS:	Replacement Media	\$128,000
	Solids Disposal (\$300/ft ³)	\$768,000
	Operating Labor (OL)	\$20,625
	Maintenance Labor (=OL)	\$20,625
	Supervisory Labor (15% of OL)	\$3,094
	Maintenance Materials	\$20,625
	Maintenance Contracts	
	Electricity	\$19,482
	Water	\$0
	Steam	\$0
	Natural Gas	\$0
	Other	\$0
	<u>Relocation (=I)</u>	\$80,000
	Total (TAOC)	\$1,060,451
NET PRESENT VALUES:		
	10 yrs Operating Costs (NPVOC)	\$7,299,874
	Total (= NPVOC + TCC, i=10%)	\$8,319,874
	Annualized Cost (i=10%, 10 yr)	\$1,354,021
COST EFFECTIVENESS:		
	Ton/yr VOCs Removed	
	Ton/yr Particles Removed	0.038
	Annualized \$/ton VOCs Removed	
	Annualized \$/ton Particles Removed	\$35,632,132

TABLE 7.6. Summary of Control Technology Impacts

	Resin Bed Adsorber	Recuperative Thermal Oxidizer	Afterburner Thermal Oxidizer	Regenerated Carbon Adsorber	HEMF	HEPA
Solid Waste, ft ³ /yr						2,560
Liquid Waste	desorbate	HCl scrubber liquid & cooling water	HCl scrubber liquid & cooling water	desorbate & cooling water	cleaning solution	
Electricity, 10 ⁵ kWhr/yr	6.7	3.0	2.0	3.7	4.9	4.9
Gas 10 ⁸ ft ³ /yr		0.6	1.7			
Cooling Water 10 ⁶ gal/yr		10	20	9.7		
Steam 10 ⁶ lb/yr				2.8		
Capital Cost \$M	2.7	1.5	1.5	1.0	2.4	1.0
Operation & Maintenance \$K/yr	188	342	707	179	166	1,060
Net Present Value \$M	4.0	3.9	6.4	2.2	3.5	8.3
Annualized \$K/ton toxics removed	228	223	367	127	1,500	35,600

8.0 THE IMPACT OF CONTROLLED EMISSIONS ON AIR QUALITY

This section presents the maximum short-term and long-term air quality impacts to the public that could result from individual pollutant emissions at the GDF when the facility is operated with appropriate emissions-control equipment (Section 4 presented air quality impacts without emissions controls). The assessment presented in Section 7 called for no emissions controls on toxic VOCs and the use of a HEPA filter system to meet DOE's ALARA requirements. To estimate air quality impacts, information on pollutant emission levels is obtained from Section 3, and information on local atmospheric dispersion characteristics from Section 4. The air quality impact projections presented in this section are formatted to correspond to the "no emissions control" projections presented in Section 4.

Table 8.1 presents the following information:

- maximum short-term and annual average emission rate at the GDF for each contaminant of concern using the recommended emissions-control methods (a particle-removal effectiveness of only 99.95% is assumed for the HEPA filter system).
- concentration limit prescribed for each contaminant by WAC 173-460 (i.e., in the form of ASILs)
- maximum short-term and annual average pollutant concentrations at the site boundary

Results indicate that with the required HEPA filter system to restrict emissions of radiological particles, and without any emissions controls for VOCs, the highest predicted concentrations of pollutants at the site boundary (the maximum offsite exposure location) will be far below ASIL limits. With HEPA filters, the highest particle concentration from GDF emissions is a fraction of a percent of the allowed limit. With the adoption of the "no controls" option for toxic VOCs, the air quality impacts for these pollutants are identical to those predicted in Section 4. For the public, this implies a maximum concentration for each toxic VOC of less than 0.5% of its respective 24-h ASIL.

TABLE 8.1. Abated Emission Rates and Site Boundary Concentrations

Contaminant	ASIL Class	Maximum total Emission lb/hr	Annual Average Emission lb/year	Annual Average Emission Rate $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
VAPORS:									
Methyltoluidine [Xylidine]	B	2.1e-04	8.8e-01	1.4e+01	8.8e-07	2.6e+01	3.5e-04	3.3e+01	S
C3-alkylbenzene	B	3.8e-01	1.8e+03	2.7e+04	1.8e-03	5.0e+04	6.6e-01	8.2e+02	A
Trimethylbenzene	B	5.8e-02	2.8e+02	4.1e+03	2.8e-04	7.4e+03	8.8e-02	4.2e+02	S
Diethylphthalates	B	1.4e-05	2.7e-02	3.8e-01	2.7e-08	1.8e+00	2.3e-05	1.7e+01	S
Unknown phthalates (A: Dibutyl)	B	2.4e-05	3.3e-02	4.8e-01	3.3e-08	3.1e+00	4.1e-05	1.7e+01	S
Diethylphthalate	A	2.3e-05	1.2e-02	1.7e-01	1.2e-08	2.8e+00	3.8e-05	2.0e-03	A
Ethanedioic Acid	B	3.8e-03	1.8e+00	2.6e+01	1.8e-08	5.0e+02	6.6e-03	3.3e+00	A
Tri-n-butyl phosphate	B	4.8e-05	6.6e-02	8.4e-01	6.6e-08	6.2e+00	8.2e-05	2.7e+02	A
Methylene Chloride	A	4.4e+00	2.6e+02	3.8e+03	2.6e-04	5.5e+05	7.4e+00	2.0e+00	A
Trichloroethane, 1,1,1-	B	4.0e-01	6.7e+01	8.8e+02	6.7e-05	5.1e+04	6.7e-01	6.3e+03	A
Acetone	B	8.3e+00	2.1e+03	3.1e+04	2.1e-03	1.0e+08	1.4e+01	5.8e+03	S
Methyl Isobutyl Ketone	B	3.1e-01	5.3e+02	7.6e+03	5.3e-04	3.8e+04	5.2e-01	6.8e+02	S
Butyl alcohol, n-	B	1.7e-02	4.3e+01	6.1e+02	4.3e-05	2.1e+03	2.8e-02	5.0e+02	S
Methyl Ethyl Ketone	B	8.8e-01	5.4e+02	7.7e+03	5.3e-04	1.3e+05	1.7e+00	2.0e+03	S
Dichloroethylene, 1,1-	B	4.3e-02	8.8e+00	1.3e+02	8.8e-08	5.4e+03	7.2e-02	6.7e+01	A
Nitrobenzene	B	2.5e-04	1.2e+00	1.7e+01	1.2e-08	3.2e+01	4.3e-04	1.7e+01	S
Trichloroethylene	A	1.6e-02	7.3e+00	1.0e+02	7.3e-08	2.0e+03	2.7e-02	8.0e-01	A
Toluene	B	7.0e-04	1.3e+00	1.8e+01	1.3e-08	8.8e+01	1.2e-03	1.2e+03	S
Phenol	B	3.0e-05	1.4e-01	2.1e+00	1.4e-07	3.8e+00	5.0e-05	6.3e+01	S
Cresol	B	2.3e-03	1.1e+01	1.6e+02	1.1e-05	2.8e+02	3.8e-03	7.3e+01	S
PARTICLES									
Ag metal	B	1.0e-11	3.3e-08	4.8e-08	3.3e-15	1.3e-06	1.7e-11	3.0e-01	S
Soluble Ag compounds	B	1.0e-08	3.3e-06	4.8e-05	3.3e-12	1.3e-03	1.7e-08	3.0e-02	S

TABLE 8.1. (contd)

Contaminant	ASIL Class	Maximum total Emission lb/hr	Annual Average Emission lb/year	Annual Average Emission Rate $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
Alkyl Al	B	2.3e-07	7.7e-05	1.1e-03	7.7e-11	2.9e-02	3.8e-07	6.7e+00	S
Al metal dust	B	2.3e-08	7.7e-06	1.1e-04	7.7e-12	2.9e-03	3.8e-08	3.3e+01	S
Soluble Al salts	B	2.3e-05	7.7e-03	1.1e-01	7.7e-09	2.9e+00	3.8e-05	6.7e+00	S
As	A	8.4e-08	2.8e-05	4.1e-04	2.8e-11	1.1e-02	1.4e-07	2.3e-04	A
Soluble Ba compounds	B	8.9e-09	3.0e-06	4.3e-05	3.0e-12	1.1e-03	1.5e-08	1.7e+00	S
Be	A	9.6e-09	3.2e-06	4.6e-05	3.2e-12	1.2e-03	1.6e-08	4.2e-04	A
Ca cyanamide	B	8.1e-10	2.7e-07	3.9e-06	2.7e-13	1.0e-04	1.4e-09	1.7e+00	S
Ca hydroxide	B	4.0e-08	1.4e-05	1.9e-04	1.4e-11	5.1e-03	6.8e-08	1.7e+01	S
Cd	A	3.8e-08	1.3e-05	1.8e-04	1.3e-11	4.8e-03	6.4e-08	5.6e-04	A
Ce hydroxide	B	3.0e-08	9.9e-06	1.4e-04	9.9e-12	3.7e-03	4.9e-08	6.7e+00	S
CN (total)	B	6.4e-08	2.1e-05	3.1e-04	2.1e-11	8.1e-03	1.1e-07	1.7e+01	S
Cr VI	A	7.7e-09	2.6e-06	3.7e-05	2.6e-12	9.7e-04	1.3e-08	8.3e-05	A
Cr II	B	7.7e-08	2.6e-05	3.7e-04	2.6e-11	9.7e-03	1.3e-07	1.7e+00	S
Cr III	B	7.7e-07	2.6e-04	3.7e-03	2.6e-10	9.7e-02	1.3e-06	1.7e+00	S
Cr metal	B	7.7e-10	2.6e-07	3.7e-06	2.6e-13	9.7e-05	1.3e-09	1.7e+00	S
Cu dusts and mists	B	8.8e-11	2.9e-08	4.2e-07	2.9e-14	1.1e-05	1.5e-10	3.3e+00	S
F	B	1.0e-06	3.4e-04	4.8e-03	3.4e-10	1.3e-01	1.7e-06	8.3e+00	S
Soluble Fe salts	B	3.2e-08	1.1e-05	1.5e-04	1.1e-11	4.0e-03	5.3e-08	3.3e+00	S
Inorganic Hg compounds	B	8.6e-09	3.2e-06	4.6e-05	3.2e-12	1.2e-03	1.6e-08	3.0e-01	S
Alkyl Hg compounds	B	9.6e-11	3.2e-08	4.6e-07	3.2e-14	1.2e-05	1.6e-10	3.0e-02	S
K hydroxide	B	1.3e-05	4.5e-03	6.5e-02	4.5e-09	1.7e+00	2.2e-05	6.7e+00	S
Mn dust and compounds	B	2.1e-08	6.9e-06	9.9e-05	6.9e-12	2.6e-03	3.4e-08	1.7e+01	S
Soluble Mo compounds	B	3.5e-08	1.2e-05	1.7e-04	1.2e-11	4.4e-03	5.8e-08	1.7e+01	S
Insoluble Mo compounds	B	3.5e-09	1.2e-06	1.7e-05	1.2e-12	4.4e-04	5.8e-09	3.3e+01	S
Na fluoroacetate	B	1.4e-08	4.7e-04	6.7e-03	4.7e-10	1.8e-01	2.3e-06	2.0e-01	S

TABLE 8.1. (contd)

Contaminant	ASIL Class	Maximum total Emission lb/yr	Annual Average Emission lb/year	Annual Average Emission Rate $\mu\text{g/s}$	Maximum Annual Impact At Site Boundary $\mu\text{g/m}^3$	Maximum Short Term Emission Rate $\mu\text{g/s}$	Maximum Short Term Impact At Site Boundary $\mu\text{g/m}^3$	ASIL $\mu\text{g/m}^3$	ASIL Type: Short Term (S) Annual (A)
Na hydroxide	B	7.0e-05	2.3e-02	3.4e-01	2.3e-08	8.8e+00	1.2e-04	6.7e+00	S
Ni	A	6.8e-08	2.3e-05	3.3e-04	2.3e-11	8.6e-03	1.1e-07	3.3e+00	S
Pb acetate	A	2.2e-09	7.3e-07	1.1e-05	7.3e-13	2.8e-04	3.7e-09	8.3e-05	A
Pb phosphate	A	2.2e-09	7.3e-07	1.1e-05	7.3e-13	2.8e-04	3.7e-09	8.3e-05	A
Pb arsenate	B	2.2e-09	7.3e-07	1.1e-05	7.3e-13	2.8e-04	3.7e-09	5.0e-01	S
Pb chromate	B	2.2e-09	7.3e-07	1.1e-05	7.3e-13	2.8e-04	3.7e-09	2.0e-01	S
Sb compounds	B	9.6e-08	3.2e-05	4.6e-04	3.2e-11	1.2e-02	1.6e-07	1.7e+00	S
Se compounds	B	9.5e-08	3.2e-05	4.6e-04	3.2e-11	1.2e-02	1.6e-07	7.0e-01	S
Ta metal/oxide dusts	B	2.1e-07	7.1e-05	1.0e-03	7.1e-11	2.7e-02	3.5e-07	1.7e+01	S
U	B	6.8e-08	2.3e-05	3.3e-04	2.3e-11	8.5e-03	1.1e-07	7.0e-01	S
V 205	B	9.6e-11	3.2e-08	4.6e-07	3.2e-14	1.2e-05	1.6e-10	2.0e-01	S
Insoluble W compounds	B	8.4e-09	2.8e-06	4.1e-05	2.8e-12	1.1e-03	1.4e-08	1.7e+01	S
Soluble W compounds	B	8.4e-08	2.8e-05	4.1e-04	2.8e-11	1.1e-02	1.4e-07	3.3e+00	S
Zn chromates	B	1.9e-10	6.5e-08	9.3e-07	6.5e-14	2.4e-05	3.3e-10	3.0e-02	S
Zr	B	1.4e-07	4.6e-05	6.6e-04	4.6e-11	1.7e-02	2.3e-07	1.7e+01	S
X/Q s/m3 assumed -->					6.88e-08		1.33e-05		

9.0 CONCLUSIONS AND RECOMMENDATIONS

This report constitutes a *Best Available Control Technology for Toxics* (T-BACT) study, as required in the Washington Administrative Code (WAC 173-460) to support a Notice of Construction for the operation of the Grout Disposal Facility (GDF) exhausters at a modified rate that exceeds the previously permitted value. This T-BACT is required because, as part of operations at the GDF, small amounts of toxic volatile organic compounds (VOCs) and particles will be released to the atmosphere through the GDF's exhaust system.

Using data on the projected rate of uncontrolled GDF emissions and an assessment of atmospheric dispersion factors for the Hanford Site, air quality impacts were computed for the site boundary. These impacts, for both toxic VOCs and particles, are estimated to be well within the appropriate Acceptable Source Impact Levels (ASILs) as specified in WAC 173-460. Without emissions controls, the greatest impact of any toxic VOC compound will be less than 1% of the compound's ASIL standard at any maximum offsite exposure location, and the greatest impact of any toxic particle emission will be less than 10% of the compound's ASIL standard at any maximum offsite exposure location.

The assessment of emissions-control devices for VOCs and particles identified a considerable number of technologies that could be employed at the GDF to reduce pollutant emissions. Based on an evaluation of the environmental, energy, and economic impacts of using each control technology to reduce GDF emissions, the following recommendations are made:

- Owing to the extremely low air quality impact to the public (impacts well below permissible levels) that would result from uncontrolled emissions of VOCs from the GDF, and to the high economic costs associated with employing a VOC control technology, a control technology to limit the emissions of toxic VOCs from the GDF is not warranted. From a cost-benefit perspective, the funds that would be used to reduce already low VOC emissions from the GDF could be employed to much greater effect if used to address other aspects of Hanford's environmental restoration mission.

- Although the air quality impacts from GDF toxic particle emissions is quite low, the DOE's policy to reach "as low as reasonably achievable" levels of radiological exposure requires the use of High Efficiency Particulate Air (HEPA) filters on facility exhausts. With a HEPA filter system installed on the GDF exhausters to remove radioactive particulates, toxic particles also would be removed. With this technology in place, further particle-control technologies need not be considered.

With these recommendations implemented, the greatest impact of any toxic VOC at a maximum offsite exposure location will be less than 1% of the compound's ASIL standard. The greatest impact of any toxic particle emission at a maximum offsite exposure location will be substantially less than 1% of any compound's ASIL standard.

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APPENDIX A

SCREEN Model Output for Estimating Atmospheric Dispersion Factors

APPENDIX A

SCREEN and ISCLT2 Model Output for Estimating Atmospheric Dispersion Factors

This appendix contains output from simulations conducted using the EPA's SCREEN and ISCLT2 models. These simulations were conducted to estimate short- and long-term air quality impacts of the emission of toxic pollutants from the GDF.

SCREEN Output File for the Disposal Area:

1

02-16-93

08:13:16

*** SCREEN-1.1 MODEL RUN ***

*** VERSION DATED 88300 ***

Grout Disposal Facility -- Unit Stack Concentration

SIMPLE TERRAIN INPUTS:

SOURCE TYPE = POINT
EMISSION RATE (G/S) = 1.000
STACK HEIGHT (M) = 6.40
STK INSIDE DIAM (M) = .61
STK EXIT VELOCITY (M/S) = 11.64
STK GAS EXIT TEMP (K) = 336.00
AMBIENT AIR TEMP (K) = 293.00
RECEPTOR HEIGHT (M) = .00
IOPT (1=URB,2=RUR) = 2
BUILDING HEIGHT (M) = 3.00
MIN HORIZ BLDG DIM (M) = 3.00
MAX HORIZ BLDG DIM (M) = 5.00

BUOY. FLUX = 1.36 M**4/S**3; MOM. FLUX = 10.98 M**4/S**2.

*** FULL METEOROLOGY ***

*** SCREEN AUTOMATED DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
200.	187.0	4	4.0	4.0	1280.0	13.1	15.7	8.7	NO
300.	174.0	4	3.0	3.0	960.0	15.4	22.8	12.4	NO
400.	153.5	4	2.0	2.0	640.0	19.9	29.7	15.7	NO
500.	133.1	4	2.0	2.0	640.0	19.9	36.4	18.7	NO
600.	112.6	4	2.0	2.0	640.0	19.9	42.9	21.6	NO
700.	105.9	4	1.0	1.0	320.0	33.3	49.8	25.2	NO
800.	99.53	4	1.0	1.0	320.0	33.3	56.1	27.9	NO
900.	92.06	4	1.0	1.0	320.0	33.3	62.4	30.5	NO
1000.	84.46	4	1.0	1.0	320.0	33.3	68.6	33.0	NO
1100.	77.34	4	1.0	1.0	320.0	33.3	74.7	35.0	NO
1200.	70.98	4	1.0	1.0	320.0	33.3	80.8	36.9	NO
1300.	72.19	6	1.0	1.0	5000.0	33.7	43.7	18.2	NO
1400.	73.87	6	1.0	1.0	5000.0	33.7	46.7	18.9	NO
1500.	74.90	6	1.0	1.0	5000.0	33.7	49.6	19.6	NO
1600.	75.38	6	1.0	1.0	5000.0	33.7	52.6	20.3	NO
1700.	75.43	6	1.0	1.0	5000.0	33.7	55.5	21.0	NO
1800.	75.11	6	1.0	1.0	5000.0	33.7	58.4	21.7	NO
1900.	74.51	6	1.0	1.0	5000.0	33.7	61.3	22.3	NO
2000.	73.68	-6	1.0	1.0	5000.0	33.7	64.2	23.0	NO
2100.	72.39	6	1.0	1.0	5000.0	33.7	67.0	23.5	NO
2200.	71.03	6	1.0	1.0	5000.0	33.7	69.9	24.1	NO
2300.	69.64	6	1.0	1.0	5000.0	33.7	72.7	24.6	NO
2400.	68.22	6	1.0	1.0	5000.0	33.7	75.5	25.1	NO
2500.	66.79	6	1.0	1.0	5000.0	33.7	78.3	25.6	NO
2600.	65.36	6	1.0	1.0	5000.0	33.7	81.1	26.1	NO
2700.	63.93	6	1.0	1.0	5000.0	33.7	83.9	26.6	NO
2800.	62.53	6	1.0	1.0	5000.0	33.7	86.7	27.1	NO
2900.	61.14	6	1.0	1.0	5000.0	33.7	89.5	27.6	NO
3000.	59.78	6	1.0	1.0	5000.0	33.7	92.3	28.1	NO
3500.	53.28	6	1.0	1.0	5000.0	33.7	105.9	30.0	NO

4000.	47.79	6	1.0	1.0	5000.0	33.7	119.4	31.8	NO
4500.	43.15	6	1.0	1.0	5000.0	33.7	132.7	33.5	NO
5000.	39.20	6	1.0	1.0	5000.0	33.7	145.9	35.1	NO
5500.	35.82	6	1.0	1.0	5000.0	33.7	158.9	36.6	NO
6000.	32.90	6	1.0	1.0	5000.0	33.7	171.8	38.0	NO
6500.	30.36	6	1.0	1.0	5000.0	33.7	184.5	39.4	NO
7000.	28.14	6	1.0	1.0	5000.0	33.7	197.1	40.8	NO
7500.	26.22	6	1.0	1.0	5000.0	33.7	209.7	41.9	NO
8000.	24.51	6	1.0	1.0	5000.0	33.7	222.1	43.0	NO
8500.	23.00	6	1.0	1.0	5000.0	33.7	234.5	44.1	NO
9000.	21.64	6	1.0	1.0	5000.0	33.7	246.7	45.1	NO
9500.	20.42	6	1.0	1.0	5000.0	33.7	258.9	46.1	NO
10000.	19.32	6	1.0	1.0	5000.0	33.7	271.0	47.0	NO
15000.	12.29	6	1.0	1.0	5000.0	33.7	388.5	55.4	NO
20000.	8.961	6	1.0	1.0	5000.0	33.7	501.0	60.8	NO

MAXIMUM 1-HR CONCENTRATION AT OR BEYOND 200. M:
 210. 187.7 4 4.0 4.0 1280.0 13.1 16.5 9.1 NO

DWASH= MEANS NO CALC MADE (CONC = 0.0)
 DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

 *** SCREEN DISCRETE DISTANCES ***

*** TERRAIN HEIGHT OF 0. M ABOVE STACK BASE USED FOR FOLLOWING DISTANCES ***

DIST (M)	CONC (UG/M**3)	STAB	U10M (M/S)	USTK (M/S)	MIX HT (M)	PLUME HT (M)	SIGMA Y (M)	SIGMA Z (M)	DWASH
19720.	9.102	6	1.0	1.0	5000.0	33.7	494.8	60.5	NO
18240.	9.919	6	1.0	1.0	5000.0	33.7	461.9	59.0	NO
17650.	10.28	6	1.0	1.0	5000.0	33.7	448.7	58.4	NO
22380.	7.912	6	1.0	1.0	5000.0	33.7	553.2	63.0	NO
21930.	8.092	6	1.0	1.0	5000.0	33.7	543.4	62.6	NO
22440.	7.889	6	1.0	1.0	5000.0	33.7	554.5	63.1	NO
21760.	8.163	6	1.0	1.0	5000.0	33.7	539.7	62.5	NO
21920.	8.097	6	1.0	1.0	5000.0	33.7	543.2	62.6	NO
25910.	6.721	6	1.0	1.0	5000.0	33.7	629.3	66.1	NO
21830.	8.134	6	1.0	1.0	5000.0	33.7	541.2	62.5	NO
16440.	11.12	6	1.0	1.0	5000.0	33.7	421.3	57.1	NO
13990.	13.30	6	1.0	1.0	5000.0	33.7	365.2	53.9	NO
15320.	12.01	6	1.0	1.0	5000.0	33.7	395.8	55.8	NO
18770.	9.611	6	1.0	1.0	5000.0	33.7	473.7	59.6	NO
22850.	7.731	6	1.0	1.0	5000.0	33.7	563.4	63.5	NO
19520.	9.205	6	1.0	1.0	5000.0	33.7	490.4	60.3	NO
10190.	18.92	6	1.0	1.0	5000.0	33.7	275.6	47.4	NO
9400.	20.65	6	1.0	1.0	5000.0	33.7	256.5	45.9	NO
9400.	20.65	6	1.0	1.0	5000.0	33.7	256.5	45.9	NO
10210.	18.88	6	1.0	1.0	5000.0	33.7	276.1	47.4	NO
13710.	13.61	6	1.0	1.0	5000.0	33.7	358.7	53.4	NO
17440.	10.42	6	1.0	1.0	5000.0	33.7	443.9	58.2	NO
13540.	13.80	6	1.0	1.0	5000.0	33.7	354.8	53.2	NO
13620.	13.71	6	1.0	1.0	5000.0	33.7	356.7	53.3	NO
15420.	11.92	6	1.0	1.0	5000.0	33.7	398.1	55.9	NO
11890.	15.97	6	1.0	1.0	5000.0	33.7	316.1	50.4	NO
9810.	19.72	6	1.0	1.0	5000.0	33.7	266.4	46.7	NO
9790.	19.77	6	1.0	1.0	5000.0	33.7	265.9	46.6	NO
11860.	16.01	6	1.0	1.0	5000.0	33.7	315.4	50.4	NO
17810.	10.18	6	1.0	1.0	5000.0	33.7	452.2	58.6	NO
11410.	16.71	6	1.0	1.0	5000.0	33.7	304.8	49.6	NO
14410.	12.86	6	1.0	1.0	5000.0	33.7	374.9	54.5	NO

DWASH= MEANS NO CALC MADE (CONC = 0.0)

DWASH=NO MEANS NO BUILDING DOWNWASH USED
 DWASH=HS MEANS HUBER-SNYDER DOWNWASH USED
 DWASH=SS MEANS SCHULMAN-SCIRE DOWNWASH USED
 DWASH=NA MEANS DOWNWASH NOT APPLICABLE, X<3*LB

*** CAVITY CALCULATION - 1 ***	*** CAVITY CALCULATION - 2 ***
CONC (UG/M**3) = .0000	CONC (UG/M**3) = .0000
CRIT WS @10M (M/S) = 99.99	CRIT WS @10M (M/S) = 99.99
CRIT WS @ HS (M/S) = 99.99	CRIT WS @ HS (M/S) = 99.99
DILUTION WS (M/S) = 99.99	DILUTION WS (M/S) = 99.99
CAVITY HT (M) = 4.31	CAVITY HT (M) = 3.55
CAVITY LENGTH (M) = 6.75	CAVITY LENGTH (M) = 3.04
ALONGWIND DIM (M) = 3.00	ALONGWIND DIM (M) = 5.00

CAVITY CONC NOT CALCULATED FOR CRIT WS > 20.0 M/S. CONC SET = 0.0

 *** SUMMARY OF SCREEN MODEL RESULTS ***

CALCULATION PROCEDURE	MAX CONC (UG/M**3)	DIST TO MAX (M)	TERRAIN HT (M)
SIMPLE TERRAIN	187.7	210.	0.

 ** REMEMBER TO INCLUDE BACKGROUND CONCENTRATIONS **

ISCLT2 Output for the Disposal Area

Note that the output begins with a copy of the input. Note also that the GENII joint frequency file JF20010 has been used. The title line for this file is "200 AREA - 10 M - Pasquill A - F (1983 - 1987 Average)".

```
CO STARTING
  TITLEONE Grout Disposal Area
  MODELOPT DFAULT CONC RURAL
  AVERTIME annual
  POLLUTID VARIOUS
  RUNORNOT RUN
CO FINISHED

SO STARTING
  LOCATION Exhaust1 POINT 0.0 0.0 0.0
  **          g/sec   ht,m   temp°K   m/sec   diam,m
  SRCPARAM Exhaust1 1.0    6.40    336.0    11.64    0.6096
  SRCGROUP ALL
SO FINISHED

RE STARTING
  DISCPOLR Exhaust1 19720 180.0
  DISCPOLR Exhaust1 10190 180.0
  DISCPOLR Exhaust1 18240 202.5
  DISCPOLR Exhaust1 9400 202.5
  DISCPOLR Exhaust1 17650 225.0
  DISCPOLR Exhaust1 9400 225.0
  DISCPOLR Exhaust1 22380 247.5
  DISCPOLR Exhaust1 10210 247.5
  DISCPOLR Exhaust1 21930 270.0
  DISCPOLR Exhaust1 13710 270.0
  DISCPOLR Exhaust1 22440 292.5
  DISCPOLR Exhaust1 17440 292.5
  DISCPOLR Exhaust1 21760 315.0
  DISCPOLR Exhaust1 13540 315.0
  DISCPOLR Exhaust1 21920 337.5
  DISCPOLR Exhaust1 13620 337.5
```

DISCPOLR Exhaust1	25910	0.0
DISCPOLR Exhaust1	15420	0.0
DISCPOLR Exhaust1	21830	22.5
DISCPOLR Exhaust1	11890	22.5
DISCPOLR Exhaust1	16440	45.0
DISCPOLR Exhaust1	9810	45.0
DISCPOLR Exhaust1	13990	67.5
DISCPOLR Exhaust1	9790	67.5
DISCPOLR Exhaust1	15320	90.0
DISCPOLR Exhaust1	11860	90.0
DISCPOLR Exhaust1	18770	112.5
DISCPOLR Exhaust1	17810	112.5
DISCPOLR Exhaust1	22850	135.0
DISCPOLR Exhaust1	11410	135.0
DISCPOLR Exhaust1	19520	157.5
DISCPOLR Exhaust1	14410	157.5

RE FINISHED

ME STARTING

INPUTFIL	JF20010.STA	FREE
ANEMHGHT	10.0	
SURFDATA	67656	1987 HANFORD200
UAIRDATA	67656	1987 HANFORD200
STARDATA	ANNUAL	
AVESPEED	1.00	2.682 4.694 7.153 9.835 14.304
AVETEMPS	ANNUAL	6*285.3
AVEMIXHT	ANNUAL A	6*1000.0
AVEMIXHT	ANNUAL B	6*1000.0
AVEMIXHT	ANNUAL C	6*1000.0
AVEMIXHT	ANNUAL D	6*1000.0
AVEMIXHT	ANNUAL E	6*1000.0
AVEMIXHT	ANNUAL F	6*1000.0

ME FINISHED

OU STARTING

RECTABLE	SRCGRP
MAXTABLE	10 INDSRC SOCONT

OU FINISHED

*** SETUP Finishes Successfully ***

*** ISCLT2 - VERSION 92273 ***

*** Grout Disposal Area

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** MODEL SETUP OPTIONS SUMMARY ***

**Model Is Setup For Calculation of Average CONCentration Values.

**Model Uses RURAL Dispersion.

**Model Uses Regulatory DEFAULT Options:

1. Final Plume Rise.
2. Stack-tip Downwash.
3. Buoyancy-induced Dispersion.
4. Default Wind Profile Exponents.
5. Default Vertical Potential Temperature Gradients.
6. "Upper Bound" Values For Supersquat Buildings.
7. No Exponential Decay for RURAL Mode

**Model Assumes Receptors on FLAT Terrain.

**Model Assumes No FLAGPOLE Receptor Heights.

**Model Calculates 1 STAR Average(s) for the Following Months: 0 0 0 0 0 0 0 0 0 0 0 0
Seasons/Quarters: 0 0 0 0
and Annual: 1

**Data File Includes 1 STAR Summaries for the Following Months: 0 0 0 0 0 0 0 0 0 0 0 0
Seasons/Quarters: 0 0 0 0
and Annual: 1

**This Run Includes: 1 Source(s); 1 Source Group(s); and 32 Receptor(s)

**The Model Assumes A Pollutant Type of: VARIOUS

**Model Set To Continue RUNning After the Setup Testing.

**Output Options Selected:

Model Outputs Tables of Long Term Values by Receptor (RECTABLE Keyword)
Model Outputs Tables of Maximum Long Term Values (MAXTABLE Keyword)

**Misc. Inputs: Anem. Hgt. (m) = 10.00 ; Decay Coef. = .0000 ; Rot. Angle = .0
Emission Units = GRAMS/SEC ; Emission Rate Unit Factor = .10000E+07
Output Units = MICROGRAMS/M**3

**Input Runstream File: GDA-L.IN

; **Output Print File: GDA-L.LT

*** ISCLT2 - VERSION 92273 *** *** Grout Disposal Area

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** POINT SOURCE DATA ***

SOURCE ID	NUMBER PART. CATS.	EMISSION RATE (GRAMS/SEC)	X (METERS)	Y (METERS)	BASE ELEV. (METERS)	STACK HEIGHT (METERS)	STACK TEMP. (DEG.K)	STACK EXIT VEL. (M/SEC)	STACK DIAMETER (METERS)	BUILDING EXISTS	EMISSION RATE SCALAR VARY BY
EXHAUST1	0	.10000E+01	.0	.0	.0	6.40	336.00	11.64	.61	NO	

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** ISCLT2 - VERSION 92273 ***

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** DISCRETE POLAR RECEPTORS ***
· ORIGIN: (DIST, DIR, ZELEV, ZFLAG)
SRCID: (METERS, DEG, METERS, METERS)

EXHAUST1: (19720.0, 180.0, .0, .0);	EXHAUST1: (10190.0, 180.0, .0, .0);
EXHAUST1: (18240.0, 202.5, .0, .0);	EXHAUST1: (9400.0, 202.5, .0, .0);
EXHAUST1: (17650.0, 225.0, .0, .0);	EXHAUST1: (9400.0, 225.0, .0, .0);
EXHAUST1: (22380.0, 247.5, .0, .0);	EXHAUST1: (10210.0, 247.5, .0, .0);
EXHAUST1: (21930.0, 270.0, .0, .0);	EXHAUST1: (13710.0, 270.0, .0, .0);
EXHAUST1: (22440.0, 292.5, .0, .0);	EXHAUST1: (17440.0, 292.5, .0, .0);
EXHAUST1: (21760.0, 315.0, .0, .0);	EXHAUST1: (13540.0, 315.0, .0, .0);
EXHAUST1: (21920.0, 337.5, .0, .0);	EXHAUST1: (13620.0, 337.5, .0, .0);
EXHAUST1: (25910.0, 360.0, .0, .0);	EXHAUST1: (15420.0, 360.0, .0, .0);
EXHAUST1: (21830.0, 22.5, .0, .0);	EXHAUST1: (11890.0, 22.5, .0, .0);
EXHAUST1: (16440.0, 45.0, .0, .0);	EXHAUST1: (9810.0, 45.0, .0, .0);
EXHAUST1: (13990.0, 67.5, .0, .0);	EXHAUST1: (9790.0, 67.5, .0, .0);
EXHAUST1: (15320.0, 90.0, .0, .0);	EXHAUST1: (11860.0, 90.0, .0, .0);
EXHAUST1: (18770.0, 112.5, .0, .0);	EXHAUST1: (17810.0, 112.5, .0, .0);
EXHAUST1: (22850.0, 135.0, .0, .0);	EXHAUST1: (11410.0, 135.0, .0, .0);
EXHAUST1: (19520.0, 157.5, .0, .0);	EXHAUST1: (14410.0, 157.5, .0, .0);

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** AVERAGE SPEED FOR EACH WIND SPEED CATEGORY ***
(METERS/SEC)

1.00, 2.68, 4.69, 7.15, 9.84, 14.30,

*** WIND PROFILE EXPONENTS ***

STABILITY CATEGORY	WIND SPEED CATEGORY					
	1	2	3	4	5	6
A	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
B	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01	.70000E-01
C	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00	.10000E+00
D	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00	.15000E+00
E	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00	.35000E+00
F	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00	.55000E+00

*** VERTICAL POTENTIAL TEMPERATURE GRADIENTS ***
(DEGREES KELVIN PER METER)

STABILITY CATEGORY	WIND SPEED CATEGORY					
	1	2	3	4	5	6
A	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
B	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
C	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
D	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00	.00000E+00
E	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01	.20000E-01
F	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01	.35000E-01

*** AVERAGE AMBIENT AIR TEMPERATURE (KELVIN) ***

	STABILITY CATEGORY A	STABILITY CATEGORY B	STABILITY CATEGORY C	STABILITY CATEGORY D	STABILITY CATEGORY E	STABILITY CATEGORY F
ANNUAL	285.3000	285.3000	285.3000	285.3000	285.3000	285.3000

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

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*** AVERAGE MIXING LAYER HEIGHT (METERS) ***

	WIND SPEED	WIND SPEED	ANNUAL WIND SPEED	WIND SPEED	WIND SPEED	WIND SPEED
	CATEGORY 1	CATEGORY 2	CATEGORY 3	CATEGORY 4	CATEGORY 5	CATEGORY 6
STABILITY CATEGORY A	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000
STABILITY CATEGORY B	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000
STABILITY CATEGORY C	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000
STABILITY CATEGORY D	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000
STABILITY CATEGORY E	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000
STABILITY CATEGORY F	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000	1000.0000

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: JF20010.STA

FORMAT: FREE

SURFACE STATION NO.: 67656

UPPER AIR STATION NO.: 67656

NAME: HANFORD200

NAME: HANFORD200

YEAR: 1987

YEAR: 1987

ANNUAL: STABILITY CATEGORY A

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
.000	.00330300	.01031000	.00320300	.00030000	.00010000	.00000000
22.500	.00290300	.00500500	.00250300	.00060100	.00010000	.00000000
45.000	.00310300	.00390400	.00140100	.00050100	.00010000	.00000000
67.500	.00210200	.00410400	.00060100	.00020000	.00010000	.00000000
90.000	.00280300	.00580600	.00060100	.00010000	.00000000	.00000000
112.500	.00220200	.00510500	.00050100	.00000000	.00000000	.00000000
135.000	.00120100	.00470500	.00060100	.00010000	.00000000	.00000000
157.500	.00100100	.00400400	.00070100	.00020000	.00000000	.00000000
180.000	.00120100	.00380400	.00120100	.00030000	.00000000	.00000000
202.500	.00080100	.00270300	.00180200	.00070100	.00030000	.00000000
225.000	.00060100	.00340300	.00430400	.00240200	.00090100	.00000000
247.500	.00070100	.00300300	.00470500	.00340300	.00150200	.00030000
270.000	.00100100	.00340300	.00340300	.00220200	.00040000	.00010000
292.500	.00090100	.00370400	.00330300	.00250300	.00050100	.00000000
315.000	.00160200	.00680700	.00720700	.00480500	.00170200	.00010000
337.500	.00140100	.00850900	.00320300	.00080100	.00010000	.00000000

ANNUAL: STABILITY CATEGORY B

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
.000	.00160200	.00300300	.00060100	.00010000	.00000000	.00000000
22.500	.00110100	.00160200	.00040000	.00010000	.00000000	.00000000
45.000	.00100100	.00110100	.00030000	.00010000	.00000000	.00000000
67.500	.00090100	.00120100	.00010000	.00000000	.00000000	.00000000
90.000	.00110100	.00130100	.00010000	.00000000	.00000000	.00000000
112.500	.00060100	.00130100	.00010000	.00000000	.00000000	.00000000
135.000	.00050100	.00090100	.00030000	.00000000	.00000000	.00000000
157.500	.00030000	.00080100	.00030000	.00010000	.00000000	.00000000

ANNUAL: STABILITY CATEGORY B

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
180.000	.00050100	.00100100	.00020000	.00010000	.00000000	.00000000
202.500	.00030000	.00060100	.00060100	.00040000	.00000000	.00000000
225.000	.00020000	.00090100	.00060100	.00070100	.00040000	.00010000
247.500	.00020000	.00060100	.00120100	.00080100	.00010000	.00010000
270.000	.00060100	.00080100	.00090100	.00040000	.00000000	.00000000
292.500	.00050100	.00190200	.00110100	.00060100	.00010000	.00000000
315.000	.00040000	.00280300	.00170200	.00110100	.00030000	.00000000
337.500	.00080100	.00260300	.00050100	.00020000	.00000000	.00000000

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: JF20010.STA FORMAT: FREE
SURFACE STATION NO.: 67656 UPPER AIR STATION NO.: 67656
NAME: HANFORD200 NAME: HANFORD200
YEAR: 1987 YEAR: 1987

ANNUAL: STABILITY CATEGORY C

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
.000	.00170200	.00220200	.00040000	.00010000	.00000000	.00000000
22.500	.00130100	.00090100	.00030000	.00000000	.00000000	.00000000
45.000	.00100100	.00070100	.00010000	.00010000	.00000000	.00000000
67.500	.00070100	.00070100	.00010000	.00000000	.00000000	.00000000
90.000	.00100100	.00100100	.00000000	.00000000	.00000000	.00000000
112.500	.00070100	.00060100	.00000000	.00000000	.00000000	.00000000
135.000	.00080100	.00100100	.00020000	.00000000	.00000000	.00000000
157.500	.00040000	.00050100	.00020000	.00000000	.00000000	.00000000
180.000	.00020000	.00070100	.00020000	.00010000	.00000000	.00000000
202.500	.00020000	.00050100	.00040000	.00020000	.00010000	.00000000
225.000	.00020000	.00060100	.00040000	.00050100	.00010000	.00000000
247.500	.00030000	.00050100	.00070100	.00060100	.00000000	.00000000
270.000	.00050100	.00060100	.00110100	.00040000	.00000000	.00000000
292.500	.00040000	.00110100	.00090100	.00040000	.00010000	.00000000
315.000	.00070100	.00210200	.00190200	.00070100	.00040000	.00000000
337.500	.00100100	.00220200	.00070100	.00020000	.00000000	.00000000

ANNUAL: STABILITY CATEGORY D

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
.000	.00951000	.00690700	.00170200	.00050100	.00020000	.00000000
22.500	.00620600	.00370400	.00140100	.00050100	.00030000	.00000000
45.000	.00520500	.00240200	.00050100	.00020000	.00000000	.00000000
67.500	.00410400	.00300300	.00020000	.00020000	.00010000	.00000000
90.000	.00680700	.00370400	.00030000	.00010000	.00000000	.00000000
112.500	.00690700	.00330300	.00060100	.00000000	.00000000	.00000000
135.000	.00560600	.00460500	.00110100	.00020000	.00000000	.00000000
157.500	.00390400	.00300300	.00140100	.00040000	.00000000	.00000000

A.14

ANNUAL: STABILITY CATEGORY D

DIRECTION (DEGREES)	WIND SPEED CATEGORY 1 (1.000 M/S)	WIND SPEED CATEGORY 2 (2.682 M/S)	WIND SPEED CATEGORY 3 (4.694 M/S)	WIND SPEED CATEGORY 4 (7.153 M/S)	WIND SPEED CATEGORY 5 (9.835 M/S)	WIND SPEED CATEGORY 6 (14.304 M/S)
180.000	.00440400	.00390400	.00150200	.00110100	.00020000	.00010000
202.500	.00260300	.00270300	.00240200	.00210200	.00080100	.00020000
225.000	.00260300	.00300300	.00350400	.00370400	.00130100	.00020000
247.500	.00380400	.00360400	.00550600	.00290300	.00080100	.00000000
270.000	.00580600	.00951000	.00951000	.00330300	.00040000	.00010000
292.500	.00610600	.01481500	.01661700	.00951000	.00170200	.00010000
315.000	.00670700	.01681700	.01211200	.00800800	.00280300	.00020000
337.500	.00720700	.00870900	.00270300	.00080100	.00020000	.00000000

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** FREQUENCY OF OCCURRENCE OF WIND SPEED, DIRECTION AND STABILITY ***

FILE: JF20010.STA FORMAT: FREE
 SURFACE STATION NO.: 67656 UPPER AIR STATION NO.: 67656
 NAME: HANFORD200 NAME: HANFORD200
 YEAR: 1987 YEAR: 1987

DIRECTION (DEGREES)	ANNUAL: STABILITY CATEGORY E					
	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
	(1.000 M/S)	(2.682 M/S)	(4.694 M/S)	(7.153 M/S)	(9.835 M/S)	(14.304 M/S)
.000	.00410400	.00330300	.00090100	.00030000	.00010000	.00000000
22.500	.00190200	.00110100	.00020000	.00040000	.00020000	.00010000
45.000	.00180200	.00080100	.00030000	.00010000	.00000000	.00000000
67.500	.00190200	.00080100	.00020000	.00000000	.00000000	.00000000
90.000	.00330300	.00210200	.00020000	.00000000	.00000000	.00000000
112.500	.00330300	.00300300	.00050100	.00000000	.00000000	.00000000
135.000	.00340300	.00350400	.00100100	.00000000	.00000000	.00000000
157.500	.00310300	.00390400	.00100100	.00030000	.00000000	.00000000
180.000	.00390400	.00470500	.00160200	.00080100	.00020000	.00000000
202.500	.00270300	.00300300	.00140100	.00110100	.00030000	.00010000
225.000	.00350400	.00440400	.00320300	.00190200	.00040000	.00010000
247.500	.00380400	.00991000	.00520500	.00170200	.00010000	.00000000
270.000	.00570600	.02242200	.01321300	.00140100	.00000000	.00000000
292.500	.00560600	.01952000	.01982000	.00450500	.00070100	.00000000
315.000	.00480500	.01281300	.01071100	.00480500	.00110100	.00010000
337.500	.00430400	.00560600	.00180200	.00030000	.00000000	.00000000

DIRECTION (DEGREES)	ANNUAL: STABILITY CATEGORY F					
	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
	(1.000 M/S)	(2.682 M/S)	(4.694 M/S)	(7.153 M/S)	(9.835 M/S)	(14.304 M/S)
.000	.00370400	.00210200	.00030000	.00000000	.00000000	.00000000
22.500	.00190200	.00110100	.00000000	.00000000	.00000000	.00000000
45.000	.00170200	.00060100	.00020000	.00000000	.00000000	.00000000
67.500	.00170200	.00060100	.00000000	.00000000	.00000000	.00000000
90.000	.00240200	.00190200	.00010000	.00000000	.00000000	.00000000
112.500	.00300300	.00200200	.00020000	.00000000	.00000000	.00000000
135.000	.00250300	.00510500	.00110100	.00000000	.00000000	.00000000
157.500	.00240200	.00410400	.00190200	.00010000	.00000000	.00000000
180.000	.00380400	.00590600	.00070100	.00010000	.00000000	.00000000
202.500	.00310300	.00570600	.00070100	.00000000	.00000000	.00000000

DIRECTION (DEGREES)	ANNUAL: STABILITY CATEGORY F					
	WIND SPEED CATEGORY 1	WIND SPEED CATEGORY 2	WIND SPEED CATEGORY 3	WIND SPEED CATEGORY 4	WIND SPEED CATEGORY 5	WIND SPEED CATEGORY 6
	(1.000 M/S)	(2.682 M/S)	(4.694 M/S)	(7.153 M/S)	(9.835 M/S)	(14.304 M/S)
	-----	-----	-----	-----	-----	-----
225.000	.00360400	.00810800	.00110100	.00010000	.00000000	.00000000
247.500	.00370400	.01631600	.00420400	.00030000	.00000000	.00000000
270.000	.00600600	.02953000	.00540500	.00020000	.00000000	.00000000
292.500	.00500500	.02512500	.00840800	.00010000	.00000000	.00000000
315.000	.00400400	.01641600	.00760800	.00020000	.00000000	.00000000
337.500	.00370400	.00650700	.00130100	.00010000	.00000000	.00000000
	SUM OF FREQUENCIES, FTOTAL = 1.00001					

*** ISCLT2 - VERSION 92273 *** *** Grout Disposal Area

*** 03/22/93
 *** 10:19:22
 *** PAGE 10

*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE GROUP: ALL
 INCLUDING SOURCE(S): EXHAUST1, ***

*** DISCRETE POLAR RECEPTOR POINTS ***

** CONC OF VARIOUS IN MICROGRAMS/M**3 **

ORIGIN SRCID	DIST (M)	DIR (DEG)	CONC	ORIGIN SRCID	DIST (M)	DIR (DEG)	CONC
EXHAUST1:	19720.00	180.00	.019765	EXHAUST1:	10190.00	180.00	.048763
EXHAUST1:	18240.00	202.50	.011995	EXHAUST1:	9400.00	202.50	.029908
EXHAUST1:	17650.00	225.00	.010448	EXHAUST1:	9400.00	225.00	.024752
EXHAUST1:	22380.00	247.50	.007008	EXHAUST1:	10210.00	247.50	.020328
EXHAUST1:	21930.00	270.00	.011734	EXHAUST1:	13710.00	270.00	.022214
EXHAUST1:	22440.00	292.50	.012291	EXHAUST1:	17440.00	292.50	.017261
EXHAUST1:	21760.00	315.00	.013912	EXHAUST1:	13540.00	315.00	.026419
EXHAUST1:	21920.00	337.50	.012218	EXHAUST1:	13620.00	337.50	.023124
EXHAUST1:	25910.00	360.00	.012875	EXHAUST1:	15420.00	360.00	.025583
EXHAUST1:	21830.00	22.50	.012801	EXHAUST1:	11890.00	22.50	.028657
EXHAUST1:	16440.00	45.00	.024158	EXHAUST1:	9810.00	45.00	.048052
EXHAUST1:	13990.00	67.50	.044704	EXHAUST1:	9790.00	67.50	.072061
EXHAUST1:	15320.00	90.00	.069634	EXHAUST1:	11860.00	90.00	.098388
EXHAUST1:	18770.00	112.50	.053462	EXHAUST1:	17810.00	112.50	.057394
EXHAUST1:	22850.00	135.00	.032323	EXHAUST1:	11410.00	135.00	.083130
EXHAUST1:	19520.00	157.50	.022876	EXHAUST1:	14410.00	157.50	.034503

*** ISCLT2 - VERSION 92273 ***

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR SOURCE: EXHAUST1 ***

** CONC OF VARIOUS IN MICROGRAMS/M³

**

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	.098388	AT (	11860.00, .00) DP	6.	.053462	AT (	17341.22, -7182.97) DP
2.	.083130	AT (	8068.09, -8068.09) DP	7.	.048763	AT (	.00, -10190.00) DP
3.	.072061	AT (	9044.78, 3746.47) DP	8.	.048052	AT (	6936.72, 6936.72) DP
4.	.069634	AT (	15320.00, .00) DP	9.	.044704	AT (	12925.07, 5353.74) DP
5.	.057394	AT (	16454.29, -6815.59) DP	10.	.034503	AT (	5514.47, -13313.10) DP

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

A.19

*** ISCLT2 - VERSION 92273 ***

*** Grout Disposal Area

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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** SOURCE EXHAUST1 CONTRIBUTIONS TO THE MAXIMUM 10 ANNUAL AVERAGE CONCENTRATION VALUES FOR GROUP: ALL ***

** CONC OF VARIOUS IN MICROGRAMS/M³

**

RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE	RANK	CONC	AT	RECEPTOR (XR,YR) OF TYPE
1.	.098388	AT (	11860.00, .00) DP	6.	.053462	AT (	17341.22, -7182.97) DP
2.	.083130	AT (	8068.09, -8068.09) DP	7.	.048763	AT (	.00, -10190.00) DP
3.	.072061	AT (	9044.78, 3746.47) DP	8.	.048052	AT (	6936.72, 6936.72) DP
4.	.069634	AT (	15320.00, .00) DP	9.	.044704	AT (	12925.07, 5353.74) DP

5. .057394 AT (16454.29, -6815.59) DP 10. .034503 AT (5514.47, -13313.10) DP

*** RECEPTOR TYPES: GC = GRIDCART
GP = GRIDPOLR
DC = DISCCART
DP = DISCPOLR
BD = BOUNDARY

*** ISCLT2 - VERSION 92273 *** *** Grout Disposal Area

*** 03/22/93
*** 10:19:22
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*** MODELING OPTIONS USED: CONC RURAL FLAT DFAULT

*** Message Summary For ISC2 Model Execution ***

----- Summary of Total Messages -----

A Total of 0 Fatal Error Message(s)
A Total of 0 Warning Message(s)
A Total of 0 Informational Message(s)

***** FATAL ERROR MESSAGES *****
*** NONE ***

***** WARNING MESSAGES *****
*** NONE ***

*** ISCLT2 Finishes Successfully ***

APPENDIX B

Methodology For Calculating Control Technology Impacts

APPENDIX B

Methodology For Calculating Control Technology Impacts

This appendix contains a description of the methodology used to calculate the environmental, energy, and economic impacts of the technically feasible control technologies. The first exhibit is the hand calculations used in the analysis of control technologies. Tables B.1 to B.3 are the analysis results as printed from the spreadsheet COST.WR1. Table B.1 lists the key assumptions used. Table B.2 shows the intermediate calculations of items such as power, water and waste disposal requirements. Table B.3 shows the summary cost analysis for all of the control technologies and serves as the basis for Tables 7.1 through 7.6. Tables B.4 and B.5 show the spreadsheet formulas used for the intermediate and summary cost calculations respectively.

Tables B.6 and B.7 show the output of the EPA's HAP-PRO software for the recuperative thermal oxidizer and the regenerative activated carbon adsorber. The tabulated requirements for natural gas, steam, pressure drop and cooling water were used in the hand calculations. The HAP-PRO cost information was judged to be inappropriate for the Hanford site and was not used in the analysis.

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project: <u>Growth T-BACT</u>
Title/Subject: <u>Budget Estimates For Capital Costs</u>		

Other Capital Costs

Cooling Water & Steam	Pumps Piping Cooling Tower	30% EC	where needed (1)
Waste Water:	Pipe to vault or GTF	50k guess	where needed (2)
Ductwork & Makeup Air Systems		\$100k	increase the bond per Gretzinger 4/15/93 (3)
Engineering & Supervision		30% EC	all systems (4)
1st Installation = 1X Relocation			all systems (5)
Instrumentation, Control, Control Room		\$350,000	all systems (6) per Gretzinger 4/15/93

Equipment Costs

Thermal Recuperative Oxidizer

Oxidizer =	\$250,000	per Epcor (Ang. lides) 4/12/93
Quench HX + Scrubber =	\$150,000	guess
700°F → 150°F		
	<u>\$400,000</u>	

Afterburner

Unit =	\$100,000	per Epcor (Ang. lides) 4/12/93
Quench HX + Scrubber =	\$300,000	guess, 2 x price of cooler unit for recuperative oxidizer
1400°F → 150°F		
	<u>\$400,000</u>	

ENGINEERING WORKSHEET

Prepared By: <u>John R. Lissmeyer</u>	Date: <u>4/15/93</u>	Project: _____
Title/Subject: <u>Budget Estimates For Capital Costs</u>		

Equipment Costs cont'd.

<u>Resin Bed Adsorber</u>	\$ 1,223,855	Purus (Facino)
Fan for 20 in H ₂ O ΔP	3,000	guess
	<u>\$1,226,855</u>	

Regenerated Activated Carbon

Steam regenerated type 118,800 per EPA (1992)
probably low

HEMF

Unit	\$ 750,000	per Fiburamzement (Rick Bunting 4/15/93. Rep. for Fall)
Cleaning Tank & Pumps	50,000	guess
Redundant HEPI with Heater	<u>\$ 220,000</u>	per Gretsinger for existing unit 4/2/93
	<u>\$1,020,000</u>	

Subtotal Capital Costs = Equipment Costs + Other Capital Costs (7)

Indirect Costs

Contingency = 15% of Subtotal (8)
Start-Up = 10% of Subtotal (9)

Prepared By: <u>John G. Lissmeyer</u>	Date: <u>4/15/93</u>	Project:
Title/Subject: <u>Budget Estimates For Capital Costs</u>		

$$\text{TOTAL CAPITAL COSTS} = \text{Subtotal} + \text{Indirect} \quad (10)$$

OPERATING & MAINTENANCE COSTS

Filter Replacement (Applied only to HEPA system)

Assume: HEPA can retain 1 lb pollutants / filter

Virtually all particulates captured in 1st bank

9 filters in a bank

$$\text{Disposal Volume per bank} = 2' \times 2' \times 1' \times 9 \text{ filters} = 36 \text{ ft}^3 \quad (11)$$

Filter \$200 ea.

Filter bank changes per year

$$\text{changes/yr} = \text{emission rate lb/yr} / (1 \text{ lb/filter} \times 9 \text{ filter/bank}) \quad (12)$$

Emission Rate given as 76 lb/yr per Gretsinger (WHC)

$$\begin{aligned} \text{changes/yr} &= 640 \frac{\text{lb}}{\text{yr}} \times \frac{1}{(1 \text{ lb/filter})(9 \text{ filter/bank})} \\ &= 71.11 \frac{\text{banks}}{\text{yr}} \end{aligned}$$

$$\begin{aligned} \text{Volume Waste/yr} &= 71.11 \text{ banks/yr} \times 36 \text{ ft}^3/\text{bank} \\ &= 2560 \text{ ft}^3 \end{aligned} \quad (13)$$

$$\text{Disposal Cost} = \$300/\text{ft}^3 \times 2560 \text{ ft}^3 = \$768,000 \quad (14)$$

$$\begin{aligned} \text{Replacement Cost} &= 71.11 \text{ banks/yr} \times 9 \text{ filter/bank} \times \$200/\text{filter} \\ &= \$1,279,980 \end{aligned} \quad (15)$$

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project:
Title/Subject: <u>Budget Estimates For Operating Costs</u>		

FILTER Replacement Costs HEMF

Assume all particulates removed at HEMF, not at redundant HEPA's. Assume filter life, with cleaning, equals 10+ yrs. Thus, no replacement cost.

Natural Gas Usage

Recuperative Thermal Oxidizer $5.557 \times 10^7 \text{ Lb}^3/\text{yr}$
per EPA (1992) estimate using
HAP-PRO 4/17/93

Afterburner Thermal Oxidizer

3 times that of recuperative per EPCON (Angelides, 4/12/93)

Steam Usage

Regenerative Carbon Adsorber

$2.84 \times 10^6 \text{ lb/yr}$ per HAP-PRO run 4/17/93

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project:
Title/Subject: <u>Budget Estimates For Operating Cost</u>		

Cooling Water Usage

Regenerated Carbon Adsorber

Used for desorbed product condensation. Could also be done with refrigeration.

$9724 \times 1000 \text{ gal/yr}$ per HAP-PRO run 4/7/93

After burner

Cool off gas before HCL scrubber. Cool from 1400°F to, say, 150°F .

$20,000 \times 1000 \text{ gal/yr}$ Guess

Regenerative Thermal Oxidizer

For same purpose as in afterburner but less cooling required, from about 700°F to 150°F .

$1/2$ that of after burner per. Guess

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project:
Title/Subject: <u>Budget Estimate; For Operating Bst</u>		

System Pressure Drops

Thermal Oxidizer -- 15 in because of recuperative heat exchanger

(per EPA-1992)

Add another 10 in WC for quench heat exchanger and HCl absorber, for a total of 25 in WC.

After burner -- 5 in WC plus 10 in WC for quench Heat exchanger and HCl absorber, for a total of 15 in WC

Regenerated Carbon -- 32 in WC per HAP-PRO run 4/7/93

Resin Bed Adsorber -- 20 in. WC per Purus (Enrino 4/5/93)

HEMF -- 4-in. WC for HE MF per Buntin (4/13/93)

Add 4-in WC more for HEPA filters running clean.

HEPA -- 8-in WC for 2 banks HEPA's running dirty

All -- Add 5-in WC to all of above for the negative to be applied to vault.

ENGINEERING WORKSHEET

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project:
Title/Subject: <u>Budget Estimates For Operating Cost</u>		

Fan Electricity Usage

$$\text{kWhr/yr} = (1.81 \times 10^{-4}) (9000 \text{ cfm}) (\Delta P \text{ in H}_2\text{O}) (\text{hr/yr})$$

assumes 60% motor efficiency per EPA (1992)

Example -- HEMF system

$$\begin{aligned} \text{kWhr/yr} &= (1.81 \times 10^{-4}) (9,000 \text{ cfm}) (13 \text{ in H}_2\text{O}) (6000 \text{ hr/yr}) \\ &= 1.27 \times 10^5 \end{aligned}$$

Other Electricity

HEMF/EPA Units

Heating section is 60 kW

In one year

$$\text{kWhr} = 60 \text{ kW} \times 6000 \text{ hr/yr} = 3.6 \times 10^5 \text{ kWhr/yr}$$

Cooling Water Horsepower

$$\text{hp}_{\text{cw}} = 2.5 \times 10^{-4} q H S / n \quad (\text{EPA 1992})$$

q = cooling water flowrate, gal/min

H = required head (usually 100 ft H₂O)

S = fluid specific gravity (1 for H₂O)

n = pump & motor efficiency

ENGINEERING WORKSHEET

Prepared By: <u>John Glissmeyer</u>	Date: <u>4/15/93</u>	Project: _____
Title/Subject: <u>Budget Estimate For Operating Cost</u>		

Cooling Water Horsepower cont'd.

Example - - Recuperative Thermal Oxidizer requires 1×10^7 gal/yr

$$hp_{cw} = \frac{2.5 \times 10^{-4}}{1 \text{ yr}} \times \frac{10^7 \text{ gal}}{6,000 \text{ hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{100 \text{ ft H}_2\text{O}}{0.7}$$

$$= 9.92 \times 10^{-1} \text{ hp}$$

Call it 1 hp

Cooling Water Electricity

$$\text{kWhr/yr} = 0.746 (hp) (hrs/yr) \quad (\text{EPA, 1990})$$

Example

$$\begin{aligned} \text{kWhr/yr} &= (0.746) (1) (6000 \text{ hr/yr}) \\ &= 4.48 \times 10^3 \end{aligned}$$

Resin Bed Electricity

Uses 74 kWhr/16 VOC removed (per Purus Inc. Gerald Facino, 4/7/93)

$$\text{Electricity} = \frac{74 \text{ kWhr}}{16 \text{ VOC}} \times \frac{5790 \text{ 16 VOC}}{1 \text{ yr}} = 428,460 \text{ kWhr/yr}$$

Other Operating & Maintenance Costs
Resin Bed

Uses Liquid nitrogen at a rate of $71 \text{ liq N}_2 / 16 \text{ VOC removed}$
(per Purus Inc., Gerald Facino, 4/7/93)

$$\text{Liq N}_2 \text{ cost} = \frac{\$1}{16 \text{ VOC}} \times \frac{5790 \text{ 16 VOC}}{1 \text{ yr}} = \$5,790/\text{yr}$$

ENGINEERING WORKSHEET

Prepared By: <u>John Glissmeyer</u>	Date: <u>9/9/93</u>	Project: <u>Great T-RACT</u>
Title/Subject: <u>Budget Estimate For Operating Cost</u>		

Annual Operating Costs

All annual operating costs are summed. This value was used as the 1st years operating costs. Succeeding years costs are based on inflating the previous years cost by multiplying by $1 + \text{inflation rate}$.

Net Present Value of Annual Operating Costs

This was calculated using the spreadsheet's (Lotus Symphony) formula for net present value of a series of evenly spaced expenditures, discounted for the assumed interest rate. The formula is

$$NPV = \sum_{n=1}^{10} \frac{V_n}{(1+i)^n} \quad \text{where } V_1, \dots, V_n = \text{series of cash flows}$$

$n = \text{number of cash flows}$
 $i = \text{interest rate}$

Net Present Worth

This is the sum of the Net Present Value of the 10 yr operating costs plus the initial total capital cost.

Annualized Cost

The annualized cost uses the spreadsheet's payment function using the net present worth as the principal, the assumed operating period of 13 years as the term, and the assumed interest rate. The formula is

$$\text{annualized cost} = \text{net present worth} \times \frac{i(1+i)^n}{(1+i)^n - 1}$$

where $n = \text{no. of periods}$, $i = \text{periodic interest rate}$

TABLE B.1. Cost Analysis Assumptions

GROUT T-BACT COST ANALYSIS - JOHN GLISSMEYER

09/09/93 02:34 PM

ASSUMPTIONS:	name	name
relocations/yr	1 rel	steam \$/lb \$0.006 stm\$
relocation \$	\$80,000 rel\$	Nat gas \$/1000 ft3 \$3.30 gas\$
solid disposal/ft3	\$300 sol\$	Ducts, make-up \$100,000 duc\$
labor rate \$/hr	\$55 lab\$	Damper \$ \$10,000 dam\$
operate hr shift	0.5 ophr	interest rate 1 0.04 intl
maint hr/shift	0.5 mahr	interest rate 2 0.1 int2
hours/year	6000 hours	control bldg \$ \$350,000 bld\$
electric \$/kWh	\$0.04 el\$	cool H2O \$/1000 gal \$0.20 cool\$
Max. VOC lb/hr	14.9 hrvoc	Max particle lb/hr 0.00483 hrsol
annual inflation	0.03 inf	Vent Flow scfm 9000 scfm
VOC lb/yr	5790 yrvoc	Particle lb/yr 640 yrsol
		Salvage value \$0.00

TABLE B.2. Cost Analysis Intermediate Calculations

INTERMEDIATE CALCULATIONS	Thermal		Regenerated Adsorption		HEMF	HEPA
	Oxidizer	Afterburner	Carbon	Resin		
VOC Efficiency	0.98	0.98	0.97	0.99	0	0
Unit Capacity VOC lb						
VOC Unit Disposal Vol. ft3						
VOC Unit Replacement Cost						
VOC Replacement Units/yr	ERR	ERR	ERR	ERR	0	0
Particle efficiency	0	0	0	0	1	1
Unit Capacity Solids lb						9
Particle Unit Disposal Vol. ft3						36
Particle Unit Replacement Cost						\$1,800
Particle Replacement Units/yr	ERR	ERR	ERR	ERR	0	71.11
Nat Gas Usage 1000s ft3/yr	55570	166710	0	0	0	0
Steam, lb/yr			2835130			
Cooling Water 1000s gal/yr	10000	20000	9724			
Cooling Water hp.	1	2	1	0	0	0
System pressure drop in. H2O	30	20	37	25	13	13
Fan Electricity, kwhr/yr	293220	195480	361638	244350	127062	127062
Other Electricity kwhr/yr	4440	8881	4318	428460	360000	360000
Total electricity kwhr/yr	297660	204361	365956	672810	487062	487062
Solid Waste ft3/yr	ERR	ERR	ERR	ERR	0	2560.00

TABLE B.3. Cost Analysis Summary

COST SUMMARY TABLES:		Thermal		Regenerated		09/09/93	
		Oxidizer	Afterburner	Activated Carbon	Adsorption Resin	HEMF	HEPA
Capital Costs:							
Equipment Costs (EC)	\$400,000	\$400,000	\$118,800	\$1,226,855	\$1,020,000	\$220,000	
1st Install (=Relocation \$)	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	
Instrumentation & Controls	\$350,000	\$350,000	\$350,000	\$350,000	\$350,000	\$350,000	
Water & Steam Supply (30% of EC)	\$120,000	\$120,000	\$35,640	\$0	\$0	\$0	
Makeup Air & Ductwork	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	\$100,000	
Regen. Product Recycle Piping	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000		
Engineering & Supervision (30% of EC)	\$120,000	\$120,000	\$35,640	\$368,057	\$306,000	\$66,000	
Subtotal	\$1,220,000	\$1,220,000	\$770,080	\$2,174,912	\$1,906,000	\$816,000	
Contingency (15% of subtotal)	\$183,000	\$183,000	\$115,512	\$326,237	\$285,900	\$122,400	
Start Up (10% of Subtotal)	\$122,000	\$122,000	\$77,008	\$217,491	\$190,600	\$81,600	
Total Capital Cost	\$1,525,000	\$1,525,000	\$962,600	\$2,718,639	\$2,382,500	\$1,020,000	
OPS & MAINT: Replacement Media	\$0	\$0	\$0	\$0	\$0	\$128,000	
Solids Disposal (\$300/ft3)	\$0	\$0	\$0	\$0	\$0	\$768,000	
Operating Labor	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	
Maintenance Labor	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	
Supervisory Labor (15% of Operating)	\$3,094	\$3,094	\$3,094	\$3,094	\$3,094	\$3,094	
Maintenance Materials	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	\$20,625	
Maintenance Contract				\$10,403			
Electricity	\$11,906	\$8,174	\$14,638	\$26,912	\$19,482	\$19,482	
Water	\$2,000	\$4,000	\$1,945	\$0	\$0	\$0	
Steam	\$0	\$0	\$17,011	\$0	\$0	\$0	
Natural Gas	\$183,381	\$550,143	\$0	\$0	\$0	\$0	
Other	\$0	\$0	\$0	\$5,790	\$2,000	\$0	
Relocation	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	\$80,000	
Annual Total Operating and Maintenance	\$342,256	\$707,286	\$178,563	\$188,074	\$166,451	\$1,060,451	
Annual Ops & Maint Inflated 1	\$342,256	\$707,286	\$178,563	\$188,074	\$166,451	\$1,060,451	
2	\$352,524	\$728,505	\$183,919	\$193,716	\$171,445	\$1,092,265	
3	\$363,100	\$750,360	\$189,437	\$199,528	\$176,588	\$1,125,033	
4	\$373,993	\$772,871	\$195,120	\$205,514	\$181,886	\$1,158,784	
5	\$385,212	\$796,057	\$200,974	\$211,679	\$187,342	\$1,193,547	
6	\$396,769	\$819,939	\$207,003	\$218,029	\$192,963	\$1,229,354	
7	\$408,672	\$844,537	\$213,213	\$224,570	\$198,751	\$1,266,234	
8	\$420,932	\$869,873	\$219,609	\$231,307	\$204,714	\$1,304,221	
9	\$433,560	\$895,969	\$226,198	\$238,247	\$210,855	\$1,343,348	
10	\$446,567	\$922,848	\$232,984	\$245,394	\$217,181	\$1,383,648	
NPV of Annual Ops & Maint	\$2,356,004	\$4,868,777	\$1,229,179	\$1,294,654	\$1,145,808	\$7,299,874	
Net Present Worth (i=10%)	\$3,881,004	\$6,393,777	\$2,191,779	\$4,013,294	\$3,528,308	\$8,319,874	
Annualized Cost (10%, 10 yrs)	\$631,615	\$1,040,558	\$356,702	\$653,145	\$574,216	\$1,354,021	
Ton/yr VOC Removed	2.8	2.8	2.8	2.9			
Ton/yr Particulate Removed					0.320	0.320	
Annualized \$/ton Removed, VOC	\$222,627	\$366,768	\$127,024	\$227,890			
Annualized \$/ton Removed, Particles					\$1,794,424	\$4,231,316	

TABLE B.4 . Spreadsheet Formulas for Intermediate Calculations, Thermal Oxidizer Example

Column C		Row
<u>Item</u>	<u>Formula or Input Value</u>	<u>Number</u>
VOC Efficiency	0.98	53
Unit Capacity VOC lb		54
VOC Unit Disposal Vol. ft3		55
VOC Unit Replacement Cost		56
VOC Replacement Units/yr $+\$YRVOC/C54$		57
		58
Particle efficiency	0	59
Unit Capacity Solids lb		60
Particle Unit Disposal Vol. ft3		61
Particle Unit Replacement Cost		62
Particle Replacement Units/yr $+\$YRSOL/C60$		63
		64
Nat Gas Usage 1000s ft3/yr	55570	65
Steam, lb/yr		66
Cooling Water 1000s gal/yr	10000	67
Cooling Water hp. $+C67*1000*0.00025*100/0.7/6000/60$		68
System pressure drop in. H2O	30	69
Fan Electricity, kwhr/yr $+\$SCFM*C69*\$HOURS*0.000181$		70
Other Electricity kwhr/yr $0.746*C68*\$HOURS$		71
Total electricity kwhr/yr $+C70+C71$		72
		73
Solid Waste ft3/yr $(C55*C57+C61*C63)$		74

TABLE B.5. Spreadsheet Formulas For Cost Summary Table, Thermal Oxidizer Example

<u>Item</u>	<u>Column C Formula or Input Value</u>	<u>Row Number</u>
Capital Costs:		
Equipment Costs (EC)	400000	112
1st Install (=Relocation \$)	+\$REL\$	113
Instrumentation & Controls	+\$BLD\$	114
Water & Steam Supply (30% of EC)	0.3*C112	115
Makeup Air & Ductwork	100000	116
Regen. Product Recycle Piping	50000	117
Engineering & Supervision (30% of EC)	0.3*C112	118
Subtotal	@SUM(C112..C118)	119
Contingency (15% of subtotal)	0.15*C119	120
Start Up (10% of Subtotal)	0.1*C119	121
Total Capital Cost	@SUM(C119..C121)	122
OPS & MAINT: Replacement Media	0	123
Solids Disposal (\$300/ft3)	0	124
Operating Labor	+\$LAB\$*\$OPHR*(\$HOURS/8)	125
Maintenance Labor	+\$LAB\$*\$MAHR*(\$HOURS/8)	126
Supervisory Labor (15% of Operating)	0.15*C125	127
Maintenance Materials	+C126	128
Maintenance Contract		129
Electricity	+\$EL\$*C72	130
Water	+\$COOL\$*C67	131
Steam	+\$STM\$*C66	132
Natural Gas	+\$GAS\$*C65	133
Other	0	134
Relocation	+\$REL*\$REL\$	135
Annual Total Operating and Maintenance	@SUM(C123..C135)	136
Annual Ops & Maint Inflated 1	+C136	137
2	+C138*(1+\$INF)	138
3	+C139*(1+\$INF)	139
4	+C140*(1+\$INF)	140
5	+C141*(1+\$INF)	141
6	+C142*(1+\$INF)	142
7	+C143*(1+\$INF)	143
8	+C144*(1+\$INF)	144
9	+C145*(1+\$INF)	145
10	+C146*(1+\$INF)	146
NPV of Annual Ops & Maint	@NPV(\$INT2,C138..C147)	147
Net Present Worth (i=10%)	+C149+C122	148
Annualized Cost (10%, 10 yrs)	@PMT(C150,\$INT2,10)	149
Ton/yr VOC Removed	+C53*\$YRVOC/2000	150
Ton/yr Particulate Removed		151
Annualized \$/ton Removed, VOC	+C151/C152	152
Annualized \$/ton Removed, Particles		153

TABLE B.6. HAP-PRO Printout For Recuperative Thermal Oxidizer

HAP-PRO Version 1.0

Date of Print: 09/10/93

Note: Parameters marked with a * are not used in calculations; all other other parameters must be input to perform calculations accurately.

PLANT DATA

Plant ID: 00001	Plant Contact:
Company: DOE	Telephone:
Description: Grout Vault Exhauster	Agency Contact:
Street: 200E	Permit Date: / /
City: Hanford	Reviewer: Glissmeyer
State: WA Zip: 99352-	Streams: 016

STREAM TYPE -- ORGANIC VAPOR

STREAM RELATED PARAMETERS

	Applicant	Default	Verified
Emission Stream No.:	01		
Maximum Flow Rate (scfm):	9000		N
Heat Content (Btu/scf):	0.0		N
Stream Temperature (F):	135	77	N
Oxygen Content (%):	20.6		N
* Moisture Content (%):	13.0		N
Stream Pressure (mmHg):	751.0		N
* Are Halogens Present? (Y/N):	Y	N	N
* Are Metals Present? (Y/N):	Y	N	N

DEVICE TYPE -- THERMAL INCINERATOR

DESIGN RELATED PARAMETERS

	Applicant	Default	Verified
Destruction Efficiency (%):	98.0	98	N
Combustion Temp (°F):	2000.000		N
Residence Time (sec):	1.000000		N
Heat Exchanger Efficiency (%):	70.0	70	N
Reference Temp (°F):	77.00000	77	N
Heat Cap. of Air at Comb. Temp (Btu/scf°F):	.2650000	0.265	N

COST RELATED PARAMETERS

Duct Cost (\$/linear ft):	100.00		N
Length of Duct (ft):	50.0		N
Total Pressure Drop (in H2O):	15.0		N
Average Equipment Life (yr):	10.0	10	N
Operator Labor Requirements (hrs/shift):	0.5	0.5	N
Maintenance Labor Requirements (hrs/shift):	0.5	0.5	N
Operator Labor Wage (\$/hr):	55.00	12.96	N
Maintenance Labor Wage (\$/hr):	55.00	14.26	N
Operating Hours (hrs/yr):	6000	6000	N
Site Preparation Cost (\$):	10000		N
Building Cost (\$):	25000		N
Interest Rate (%):	10.00	10	N
Price of Natural Gas (\$/1000 cu ft):	3.30	3.30	N
Damper Cost (\$):	10000.00		N

TABLE B.6. (contd)

HAP-PRO Version 1.0

Date of Print: 09/10/93

INTERMEDIATE RESULTS

Dilution Air Requirements (scfm):	0
Temp of Stream after Heat Exchange ($\frac{1}{2}$ F):	1440.500
Natural Gas Flow Rate (scfm):	154.3621
Combustion Chamber Volume (ft ³):	733.8832
Flue Gas Flow Rate (scfm):	9154.362
Electricity Requirement (kWh/yr):	683140.4
Fuel Usage (ft ³ /yr):	55570358

CAPITAL COSTS

Site Preparation:	10,000
Building:	25,000
Purchased Equipment:	241,700
Direct Installation:	72,500
<hr/>	
Total Direct Costs:	349,200
Total Indirect Costs:	74,900
<hr/>	
Total Capital Costs: \$	424,100

OPERATING COSTS

Fuel:	183,400
Electricity:	40,300
Labor:	20,600
Supervisory:	3,100
Maintenance Labor:	20,600
Maintenance Materials:	20,600
<hr/>	
Direct Annual Costs: \$	288,600
<hr/>	
Overhead:	38,900
Administrative:	8,500
Property Taxes:	4,200
Insurance:	4,200
Capital Recovery:	69,000
<hr/>	
Indirect Annual Costs: \$	124,800
<hr/>	
Total Annual Costs: \$	413,400

NOTES:

TABLE B.7. HAP-PRO Printout For Regenerative Carbon Adsorber

HAP-PRO Version 1.0

Date of Print: 09/10/93

Note: Parameters marked with a * are not used in calculations; all other parameters must be input to perform calculations accurately.

PLANT DATA

Plant ID: 000001	Plant Contact:
Company: DOE	Telephone:
Description: Grout Vault Exhauster	Agency Contact:
Street: 200E	Permit Date: / /
City: Hanford	Reviewer: Glissmeyer
State: WA Zip: 99352-	Streams: 016

STREAM TYPE -- ORGANIC VAPOR
STREAM RELATED PARAMETERS

	Applicant	Default	Verified
Emission Stream No.:	02		
Maximum Flow Rate (scfm):	9000		N
* Heat Content (Btu/scf):	0.0		N
Stream Temperature (F):	104	77	N
Oxygen Content (%):	21.0		N
Moisture Content (%):	5.0		N
Stream Pressure (mmHg):	751.0		N
* Are Halogens Present? (Y/N):	Y	N	N
* Are Metals Present? (Y/N):	Y	N	N

DEVICE TYPE -- CARBON ADSORBER
DESIGN RELATED PARAMETERS

	Applicant	Default	Verified
Removal Efficiency (%):	97.00000	90	N
Adsorptive Capacity (lb HAP/100 lb carbon):	2.000000	10	N
Number of Beds:	2	2	N
Number of Adsorbing Beds:	1	1	N
Number of Deadsorbing Beds:	1	1	N
Stream Velocity Through Bed (ft/min):	85.00000	85	N
Cycle Time for Adsorption (hr):	2.000000	2	N
Cycle Time for Regeneration (hr):	2.000000	2	N
Cycle Time for Drying and Cooling (hr):	.2500000	0.25	N
Steam Ratio (lb steam/lb carbon):	.3000000	0.30	N

COST RELATED PARAMETERS

Duct Cost (\$/linear ft):	100.00		N
Length of Duct (ft):	50.0		N
Stack Cost (1988 \$):	2250		N
Average Equipment Life (yr):	10.0	10	N
Operator Labor Requirements (hrs/shift):	0.5	0.5	N
Maintenance Labor Requirements (hrs/shift):	0.5	0.5	N
Operator Labor Wage (\$/hr):	55.00	12.96	N
Maintenance Labor Wage (\$/hr):	55.00	14.26	N
Operating Hours (hrs/yr):	6000	6000	N
Site Preparation Cost (\$):	10000		N

TABLE B.7. (contd)

HAP-PRO Version 1.0

Date of Print: 09/10/93

Building Cost (\$):	25000		N
Interest Rate (%):	10.00	10	N
Equipment Factor:	1	1	N
Carbon Cost (\$/lb):	2.00	2.00	N
Steam Cost (\$/lb):	0.006	0.006	N
Cooling Water Cost (\$/1000 gals):	0.20	0.20	N
Value of Recovered Product (\$/lb):	0.00		N
Damper Cost (\$):	10000		N

INTERMEDIATE RESULTS

Weighted Density of HAPs (lb/ft3):	0.16360
Inlet HAP Loading (lb/hr):	27.56377
Carbon Requirement (lbs):	5512.754
Vessel Diameter (ft):	3.147849
Vessel Length (ft):	35.30961
Vessel Surface Area (ft2):	364.7517
Steam Requirement (lbs/min):	<u>7.875362</u>
Cooling Water Flow Rate (gal/min):	<u>27.01249</u>
Bed Fluidization (lbs steam/min-ft2):	.0708178
Pressure Drop (in of water):	<u>32.13365</u>
System Fan Power (hp):	78.29906
Operating Time for dry/cool fan (hr/yr):	2400.000
Bed Gas Flow Rate (scfm):	36751.69
Elec Req for Dry/Cool Fan (kWh/yr):	543589.1
HP Required for Cooling Water Pump (hp):	1.047254

CAPITAL COSTS

Site Preparation:	10,000
Building:	25,000
Purchased Equipment:	138,400
Direct Installation:	41,500

Total Direct Costs:	214,900
Total Indirect Costs:	42,900

Total Capital Costs: \$	257,800

OPERATING COSTS

Electricity:	53,000
Cooling Water:	1,900
Labor:	20,600
Supervisory:	3,100
Maintenance Labor:	20,600
Maintenance Materials:	20,600
Steam:	17,000

Direct Annual Costs \$	136,800

TABLE B.7. (contd)

HAP-PRO Version 1.0

Date of Print: 09/10/93

Overhead:	38,900
Administrative:	5,200
Property Taxes:	2,600
Insurance:	2,600
Capital Recovery:	29,800

Indirect Annual Costs: \$	79,100
Value of Recovered Product:	
Total Annual Costs: \$	215,900

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