**APPENDIX I** 

TECHNICAL SUPPORT DOCUMENTATION: EXEMPTION FROM OAC RULE 3745-21-07(G) FOR FOUNDRY CORE-MAKING AND MOLD-MAKING OPERATIONS THAT USE EITHER A PHENOLIC URETHANE COLD BOX RESIN BINDER SYSTEM OR A PHENOLIC URETHANE NO-BAKE RESIN BINDER SYSTEM Technical and Economic Feasibility Study for Control of VOCs from Phenolic Urethane Cold Box and No Bake Core- and Mold-Making Operations in Foundries Technical and Economic Feasibility Study for Control of VOCs from Phenolic Urethane Cold Box and No Bake Core- and Mold-Making Operations in Foundries

Prepared For: The Ohio Cast Metals Association and American Foundrymen's Society, Inc.

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#### EXECUTIVE SUMMARY

#### Background:

Over the past several years there has been an increasing awareness on the part of the foundry industry, its suppliers and environmental regulatory agencies of the potential for organic compound/volatile organic compound (OC/VOC) air emissions from a variety of foundry processes. New information about the potential for OC/VOC emissions from foundry processes has been developed through engineering calculations and stack testing to meet permitting and reporting requirements (e.g. Form R Reporting). In particular, Ohio Cast Metals Association (OCMA) members and Ohio Environmental Protection Agency (OEPA) air permitting staff became aware of the potential for OC/VOC emissions from certain chemically-bonded core- and mold-making processes. Based on this new information, the OEPA concluded that certain core- and mold-making operations are subject to Ohio Rule OAC 3745-21-07(G)(2). This rule applies to operations using liquid photochemically reactive organic materials, and requires 85% control of organic materials if the operation emits more than 8 pounds per hour or 40 pounds per day of organic materials.

As this issue was further scrutinized, it became clear that there was a distinct lack of reliable emission factors for these core- and mold-making processes. As a result, OC/VOC emissions from these processes could not be estimated accurately. Both OCMA members and OEPA agreed that a literal application of this rule to foundries has the potential to cause an excessive economic burden on Ohio foundries and adversely affect their ability to compete with foundries in other states that are not subject to similar requirements. Since this issue was of major significance to Ohio foundries, its suppliers and the state of Ohio, OCMA (representing Ohio metal casting companies and their suppliers) and the OEPA agreed to work jointly to address it, and signed a

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Memorandum of Understanding (MOU) in December 1996. The main elements of the MOU are as follows:

- OCMA supplier members would develop more reliable emission factors based on limited laboratory testing of the most common or representative binder systems affected by this rule.
- OCMA would conduct a study to determine the cost effectiveness of controlling OC/VOC emissions in accordance with the rule for "typical" core- and mold-making operations.
- While the above studies are in progress, OEPA would process permits using USEPA published emission factor data (0.0008 pounds of VOC/ton of cores) and exercise enforcement discretion with respect to the rule.
- After completion of the study, OEPA would determine if a rule change, company-bycompany relief, or variances were warranted based on the results of the study.

The laboratory testing and cost-effectiveness study addressed Phenolic Urethane Cold Box (PUCB) and Phenolic Urethane No-Bake (PUNB) binder systems because these were identified as the most commonly used systems in Ohio foundries that were potentially subject to the rule.

#### Emission Factors:

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The laboratory testing conducted by OCMA supplier members (Ashland Chemical Company, Borden Chemical, Inc., and Delta Resins and Refractories) showed the emission factors for the two binder systems to be as follows:

- PUCB (Cold Box) 0.65 pounds of VOC/ton of sand
- PUNB (No-Bake) 1.17 pounds of VOC/ton of sand

These emission factors and supporting test data were approved by OEPA and it was agreed that the cost-effectiveness study should proceed.

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#### "Typical Operations":

Based on a telephone survey of approximately 50 OCMA member foundries in Ohio, the following three scenarios (Scenario # 1, 2 and 3) were identified initially as "typical operations" for the purpose of the study:

Scenario #1: PUCB core production and storage Production rate of 7.35 tons/hour for 8 hours/day VOC emission rate of 40 pounds/day Core storage for 12 hours after production

Scenario #2: PUNB core production and storage Production rate of 4.28 tons/ hour for 8 hours/day VOC emissions rate of 40 pounds/day Core storage for 12 hours after production

Scenario #3: PUNB mold production and storage Production rate of 11.97 tons/hour for 16 hours/day Mold storage for 12 hours after production

After the above scenarios were analyzed, OCMA decided that the following two additional scenarios should be analyzed to provide a more complete representation of the foundry industry in Ohio.

Scenario #4 PUCB core production and storage

Production rate of 7.35 tons/hour for 16 hours/day Core storage for 12 hours after production

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Scenario #5 PUNB mold production and storage

Production rate of 18 tons/hour for 16 hours/day

Mold storage for 12 hours after production

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# Cost Effectiveness Study:

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To address the cost effectiveness portion of the MOU, OCMA retained RMT to assist in conducting the study.

Conceptual designs of exhaust ventilation systems aimed at capturing the VOCs emitted during core/mold production and storage were developed for each of the five scenarios.

Three types of emission control systems were selected as options for each of the exhaust streams and quotes for control equipment were obtained from selected equipment vendors.

Annualized costs for procurement, installation, operation and maintenance for each option and the associated VOC removal rate were estimated for all five scenarios. A summary of the results of the study is presented in the following table.

The cost effectiveness (\$/ton) numbers for all five scenarios are well in excess of the range generally considered to be acceptable by state regulatory agencies and the USEPA for BAT and BACT analysis related to OC/VOC. Therefore, installation of add-on OC/VOC control devices would not be warranted for any of the five scenarios which were reviewed.

	OPERATING SCENARIO	Annual OC/VOC Reduction (tons/year)	Range of Annualized Control Costs* (\$)	Range of Cost Effectiveness* (\$/ton)
#1	PUCB Core Making: 58.8 tons			
	of sand per day Core Production	2.07	76,500 - 170,500	37,000 - 82,500
	Core Storage	4.50	430,500 - 466,500	95,500 - 103,500
#2	PUNB Core Making: 34.2 tons of sand per day			
	Core Production	2.25	358,500 - 401,000	159,500 - 178,500
	Core Storage	4.32	371,500 - 459,000	86,000 - 106,500
#3	PUNB Mold Making: 191.5 tons of sand per day			
	Mold Production	12.06	675,000 - 925,500	56,000 - 76,500
	Mold Storage	22.68	1,198,000 - 1,638,000	53,000 - 72,000
#4	PUCB Core Making: 117.6 tons			
$ _{\Lambda}$	$\left( \rho^{\sqrt{2}} \right) \left( \frac{1}{100} \right)$ Core Production	4.2	103,500 - 360,000	24,500 - 85,000
	Core Storage	9.7	515,500 - 628,500	58,000 - 65,500
#5	PUNB Mold Making: 288 tons	_		
	$\frac{1}{2} \frac{1}{2} \frac{1}$	20.8	825,500 - 1,137,500	43,500 - 59,500
1	5 Mold Storage	39.5	1,410,000 - 2,012,500	39,000 - 54,000

# Summary of Cost-Effectiveness Analysis Results

\*Rounded to nearest \$500.00.

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## 1.0 INTRODUCTION

#### 1.1 Background

The Ohio Cast Metals Association (OCMA), representing Ohio metal casting companies and their suppliers, is working jointly with the Ohio Environmental Protection Agency (OEPA) to address the issue of organic compound (OC) and volatile organic compound (VOC) emissions associated with certain chemically-bonded core- and mold-making processes used in Ohio foundries. Over the past several years there has been an increasing awareness on the part of the foundry industry, its suppliers and environmental regulatory agencies of potential OC/VOC emissions from a variety of foundry processes. New information about the potential for OC/VOC emissions from foundry processes was developed through engineering calculations and stack testing to meet permitting and reporting requirements (e.g. Form R Reporting). In particular, OCMA members and OEPA air permitting staff became aware of the potential for OC/VOC emissions from certain chemically-bonded core- and mold-making processes.

As this new information was considered during the review of Permit-To-Install (PTI) applications for new or modified core- and mold-making operations, OEPA concluded that certain operations were subject to Ohio Rule OAC 3745-21-07(G)(2). This rule applies to operations using liquid photochemically reactive organic materials, and requires 85% control of organic materials if the operation emits more than 8 pounds per hour or 40 pounds per day of organic materials. As OEPA air permitting staff and foundries seeking PTIs scrutinized this issue further, it became clear that there was a distinct lack of reliable emission factors for these core- and mold-making processes. As a result, OC/VOC emissions from these processes could not be estimated accurately. Both OCMA members and OEPA agreed that the literal application of this rule to foundries had the potential to cause an excessive economic burden on Ohio foundries and

adversely affect their ability to compete effectively with foundries in other states that were not subject to similar requirements. Since this issue was of major significance to Ohio foundries, its suppliers and the state of Ohio, OCMA and OEPA agreed to work jointly to address it. Both organizations agreed that more reliable emission factors for these processes were needed in the short term. In addition, once more reliable emission data were available, if the rule was demonstrated to impose an undue economic burden on Ohio foundries, some form of rule change or exemption would be justified.

#### Memorandum of Understanding:

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After a series of meetings between representatives of OCMA and OEPA, a Memorandum of Understanding (provided in Appendix A) was signed by the two organizations on December 30, 1996. The main elements of the MOU are as follows:

- OCMA binder supplier members would provide OEPA with a listing of common binder systems supplied to Ohio foundries.
- A working group of OEPA and OCMA representatives would be formed to share information about foundry processes in general and specifically about core- and mold-making processes.
- OCMA binder supplier members would develop and submit to Ohio EPA for approval, a
  protocol for laboratory testing of the most common or representative binder systems. After
  OEPA approval, this testing protocol would be used to measure potential VOC emissions
  from those common binder systems. Based on the test results, OCMA would recommend
  VOC emission factors for these systems to OEPA.
- OCMA would conduct a study to determine the cost effectiveness of compliance with OAC 3745-21-07(G)(2) for "typical" core- and mold-making operations for the following purposes:

- 2.4 Canal Provide State 5.5
- To serve as a model BAT analysis as required by OAC 3745-31-05 which can be used by
   Ohio foundries in support of their PTI application for "typical" core- and mold-making operations, and
- To support a RACT rule (under OAC 3745-21-09) or category exemption (under OAC 3745-21-07(G)).
- While the above studies are in progress, OEPA would process permits using the emission factor of 0.0008 pounds of VOC per ton of cores produced, and OEPA would exercise enforcement discretion with respect to the application of OAC 3745-21-07(G)(2).
- After completion of the study, OEPA would consider providing relief from the requirements of OAC 3745-21-07(G) including a rule change, company-by-company relief, or variances based on the results of the study.

Based on a review of the composition of the binder systems commonly used in Ohio foundries, OCMA binder supplier members (Ashland Chemical Company, Borden Chemical, Inc., and Delta Resins and Refractories) determined that the following three types of binder systems potentially contained photochemically reactive organic materials:

- Phenolic Urethane Cold Box (PUCB)
- Phenolic Urethane No-Bake (PUNB)
- Furan

OCMA and OEPA agreed that the most commonly used PUCB and PUNB binders sold by each of the three binder suppliers in the state of Ohio would be tested using the agreed upon protocol. Also, it was agreed that the furan binder system would not be tested or included in the cost effectiveness study for the following reasons:

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- VOC emissions from furan binder systems were thought to be lower than those from PUCB and PUNB systems;
- the furan binder system was not as widely used in Ohio foundries as the other two binder systems; and
- furan binders produce water during the curing reaction and therefore, the "weight loss" test protocol would not provide valid VOC emission data.

In lieu of testing, it was agreed that OCMA binder supplier members would provide OEPA with available emission data on furan binder systems.

The testing of the PUCB and PUNB binder systems was completed by the three OCMA binder supplier members in January 1997 and OCMA provided the test results and recommended VOC emission factors for the two systems to OEPA in February 1997.

## **Typical Operation:**

An OCMA work group was formed to address the issue of "typical operation" for the purpose of the cost effectiveness study. The work group conducted a telephone survey of approximately 50 OCMA member foundries in Ohio. The purpose of the survey was to identify the full range of operating methods and parameters in use at Ohio foundries, and to determine one or more "typical operation(s)" for the study. The work group concluded that sand throughput rate and core/mold storage time were the two main variables in defining "typical operation" and the survey showed that these two parameters varied widely among the group of foundries that were surveyed. The results of the survey were used to define the following three "typical operations" or scenarios for use in the study:

• Scenario #1: PUCB core production and storage

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- Scenario #2: PUNB core production and storage
- Scenario #3: PUNB mold production and storage

After the above scenarios were analyzed, OCMA decided that the following two additional scenarios should be analyzed to provide a more complete representation of the foundry industry in Ohio.

- Scenario #4: PUCB core production and storage (alternate to Scenario #1)
- Scenario #5: PUNB mold production and storage (alternate to Scenario #3)

Copies of correspondence from OCMA to OEPA on this subject are provided in Appendix B. Additional details on each scenario are provided in Section 2 of this report.

#### Cost Effectiveness Study:

To address the cost effectiveness portion of the MOU, OCMA retained RMT, Inc. to assist in conducting the study. This report provides the results of the study and the supporting documentation.

## 1.2 Purpose

The objective of the project was to determine the cost effectiveness of compliance with OAC 3745-21-07(G) for "typical" core/mold-making operations for the following purposes:

- a) to serve as a model BAT analysis that can be used by Ohio foundries when applying for PTIs for "typical" core/mold-making operations, as required by OAC 3745-31-05; and
- b) to support a RACT rule under OAC 3745-21-09 or category exemption under OAC 3745-21-07(G) for core/mold-making operations in foundries.

#### 1.3 Scope

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The scope of this study was as follows:

- Assist OCMA in defining "typical operations" or scenarios for PUCB and PUNB core- and mold-making processes;
- Conduct a technical feasibility analysis of selected OC/VOC emission control technologies for the aforementioned scenarios;
- Conduct an economic feasibility analysis of technically feasible OC/VOC control technologies selected for each of the aforementioned scenarios based on vendor quotes for emission control equipment;
- Prepare and submit a report to OCMA providing the findings and conclusions of the study with supporting data and information.

This report provides the results of the study.

#### 2.1 Emissions Data:

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Three OCMA binder supplier members (Ashland Chemical Company, Borden Chemical, Inc. and Delta Resins and Refractories) conducted laboratory tests using the testing protocol agreed upon by OCMA and OEPA. The purpose of the testing was to develop VOC emission factors for core/mold production and storage for the most common PUCB and PUNB binder systems used by Ohio foundries. In addition, the testing was aimed at estimating the emission profile (i.e. relationship of emission rate vs. time) for each of the binder systems. Information on the binder systems selected by each supplier, the test protocol, the laboratory test results from each supplier, and a summary of the test results are provided in Appendix C.

Based on the laboratory testing, the emission factors for VOC emissions for core/mold production and a total period of 12 hours after the resin and sand are mixed were as follows:

- PUCB 0.65 pounds of VOC per ton of sand
- PUNB 1.17 pounds of VOC per ton of sand

The emission profiles for the two binder systems for 2 minutes, 30 minutes, 1 hour and every hour up to a total of 12 hours after the sand and resin were mixed are shown in Figures 2-1 (PUCB) and 2-2 (PUNB).

For the purpose of this study, for all five scenarios, VOCs emitted during the first 30 minutes were assumed to be occurring during core/mold production, including mixing, prepared sand storage, sand blowing, core/mold-finishing and interim storage in the production area. VOCs emitted during the subsequent 11 1/2 hours were assumed to be occurring during core/mold storage.





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FIGURE 2-1 PUCB (Cold Box) Emission Profile (Average)

\* Based on average of 9 test results.

\*\* Total VOC emissions equals emissions occurring during the first 12 hours after sand/resin mixing.



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FIGURE 2-2 PUNB (No Bake) Emission Profile (Average)

\* Based on average of 9 test results.

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\*\* Total VOC emissions equal emissions occurring during the first 12 hours after sand/resin mixing.

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The 30-minute time interval for production was selected for the following reasons:

- Core/mold production times (including mixing, prepared sand storage, making and interim storage) are typically well in excess of 2 minutes and well below 1 hour.
- Laboratory testing results provided VOC emissions data for 2 minutes, 30 minutes, 1 hour and every hour up to 12 hours

Since the rule (OAC 3745-21-07(G)) requires that all VOC emissions occurring during a 12 hour period following application of the organic material be considered, a period of 11 1/2 hours after core/mold production (i.e. 12 hours after sand/resin mixing) was selected for core/mold storage. It must be emphasized that while these time periods were selected for the purpose of this study, actual core/mold production and storage times in Ohio foundries, and therefore the relative VOC emissions in production and storage are likely to vary from foundry to foundry. Based on the emission profiles in Figure 2-1 and 2-2 and the above assumptions, the relative proportions of VOC emissions assumed to be occurring during production and storage for the purpose of this study are as follows:

• <u>PUCB:</u>

- 28.8% of total VOC emissions\* occur during core/mold production

71.2% of total VOC emissions\* occur during core/mold storage

• <u>PUNB:</u>

- 34.5% of total VOC emissions\* occur during core/mold production

65.5% of total VOC emissions\* occur during core/mold storage

\* Total VOC emissions equals emissions occurring during the first 12 hours after sand/resin mixing

# 2.2 Phenolic Urethane Cold Box (PUCB) Core-making (Scenario #1)

#### 2.2.1 Process Description

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The PUCB process uses an organic binder capable of producing high quality cores at a very rapid rate at room temperature. The "wet-sand" mix is prepared by mixing sand with a two-part liquid resin binder. The mixing can be done in batch mixers (e.g. blade and wheel mullers) or continuous screw (auger) mixers. While batch mixers are generally more efficient, continuous mixers provide the ability to mix sand rapidly in the quantities needed. The remainder of the core production process typically occurs in a core machine designed to facilitate the core-making cycle rapidly and automatically. The wet-sand from the mixer is deposited into the core machine hopper and then blown into the core box, which contains a pattern in the shape of the core being produced. The core box is then placed between an upper gas input manifold and a lower air exhaust manifold. The catalyst gas (typically triethylamine (TEA) or dimethylethylamine (DMEA)) mixed with an inert carrier gas enters the core box containing the wet sand through the blow ports or vents and passes through the core, causing almost instantaneous hardening of the resin-coated sand. This is followed by a purge cycle where clean air is passed through the core box to remove residual catalyst. The core is then ready for ejection from the core box. It is typically removed by the machine operator and placed on a rack after inspection. When full, the core rack is transported to a core storage area, where the cores are stored until they are needed for placement in molds.

During catalyst gassing and purging cycles, the catalyst, carrier gas and air pass through the core and leave the core box through vents into the exhaust manifold, which conveys the gasses to an acid scrubber which removes the catalyst from the exhaust stream before discharge to atmosphere. The core box is typically sealed with rubber seals and gaskets and is maintained

under a slight negative pressure by the exhaust manifold to prevent any leakage of catalyst gas to the working environment.

2.2.2 Scenario Overview and Exhaust Ventilation System Analysis

The conceptual layouts of the core production and storage areas under Scenario #1 are shown in Figure 2-3 and 2-4 respectively. It must be emphasized that this scenario was developed specifically for the purpose of this study and is based on a number of conservative assumptions. Actual foundry operations may vary significantly to allow for required operational and maintenance flexibility.

• PUCB Core Production Area (Scenario #1):

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The core production area (see Figure 2-3) contains an automatic core-making machine capable of producing PUCB cores at the rate of 7.35 tons per hour for eight hours per day. Virgin sand from a silo is transported pneumatically to a hopper above the continuous mixer. The two part PUCB binder is introduced into the mixer. The discharge from the mixer delivers prepared sand to the core machine hopper. The core machine is equipped with a sealed core box and a TEA generator supplies the catalyst gas mixture to the machine upon demand. The operator places the finished cores on a rack adjacent to the machine after they are ejected from the core box. The rack has the capacity to hold 30 minutes of production. After the rack is full, it is transported to the core storage area and replaced by an empty rack in the production area. The machine operates continuously for eight hours per day.

The original machine enclosure has been modified to add exhaust hooding and partially enclose the machine hopper and the mixer discharge head as much as practical considering the need to provide operational and maintenance access. The purpose of the modification is



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FIGURE 2-3



to capture VOCs. Exhaust ventilation is applied to the enclosure and to the exhaust plenum situated under the sealed core box. The air exhausted from the machine enclosure and the sealed core box is routed to a sand trap to remove any sand particles before entering a packed-bed acid scrubber. The purpose of the scrubber is to remove the TEA catalyst from the exhaust air, no other VOCs are removed by the scrubber as the major constituents are assumed to be non-water soluble. The outlet from the scrubber is connected to one of three alternative VOC control devices. The exhaust from the VOC control device is discharged to the outside atmosphere through an exhaust stack.

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The total exhaust air flow rate applied to the machine enclosure and sealed core box is 2000 ft<sup>3</sup>/minute which was estimated as follows:

- a) A minimum of 1000 ft<sup>3</sup>/minute of exhaust air per machine is recommended by the acid scrubber vendor<sup>1</sup> for effective capture of catalyst from the machine enclosure and sealed core box.
- b) An additional exhaust air flow rate of 500 to 1500 ft<sup>3</sup>/minute was estimated to be required assuming an air flow rate of 200 cfm/ft<sup>2</sup> of open face area<sup>2</sup>. This estimate was based on engineering judgment to provide efficient capture of VOCs from the machine hopper and sand mixer discharge head with hooding designed to allow adequate clearance for operations and maintenance access. The exact air flow rate required would depend on the dimensions and relative configurations of the hopper and mixer relative to the machine. The average of this range, 1000 ft<sup>3</sup>/minute, was assumed to be required to provide effective capture of VOCs for the purpose of this study.
- c) The total air flow rate required for the purpose of the study equals 1000 ft<sup>3</sup>/minute as specified in (a) plus 1000 ft<sup>3</sup>/minute as specified in (b), or a total of 2000 ft<sup>3</sup>/minute.

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• PUCB Core Storage Area (Scenario #1):

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The finished cores are transported to a core storage area (see Figure 2-4) from the core production area every 30 minutes on racks, each containing cores produced at the rate of 7.35 tons per hour over a 30 minute period (i.e. 3.675 tons of cores per rack). The cores on each rack are stored in this area for 11 1/2 hours, after which they are removed from the area for use in another part of the foundry. The core storage area is located in a separate part of the foundry, not necessarily adjacent to the production area. To provide total capture of the VOCs, it is constructed as a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA Method 204<sup>3</sup>.

The dimensions of the storage area were based on the following assumptions:

- After production, cores are placed in 3 1/2 foot x 3 1/2 foot x 5 foot high storage racks.
   These racks are stacked up to two high in the storage area with a forklift. A five-foot clearance between the top of the uppermost rack and the roof will be necessary. This yields a 15-foot height.
- A rack filled with cores will utilize fifty percent of the available rack space. There will be a six-inch clearance between racks placed in the storage area.
- Core density is equal to 100 pounds per cubic foot.
- Per USEPA Method 204<sup>3</sup> for a PTE, cores must be stored a minimum of 4 equivalent duct diameters from any opening.
- The PTE will be designed to minimize the floor area and a 14-foot horizontal clearance will be required for the forklift.

The storage area has an access opening measuring 10 ft wide by 10 ft high to allow forklift trucks to transport core racks in and out of the area on a frequent basis. It is not feasible to

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install a door or other obstruction in this opening as it would interfere unduly with the required movement of cores in and out of the storage area. Therefore the access opening is a natural draft opening (NDO) as specified in US EPA Method 204, and a minimum average face velocity of 200 ft/minute of air is required. Based on this, a minimum exhaust rate of 20,000 ft<sup>3</sup>/minute is required for the PTE.

The cores on each rack placed in the PTE emit VOCs for the entire 11 1/2 hour period that they spend in the storage area at a constant rate of 0.148 pounds of VOC per hour (see Appendix D for supporting calculations). As additional racks are placed in the PTE every 30 minutes, the VOC emission rate increases. The VOC emission rate in the PTE at 30 minute increments was calculated and plotted in Figure 2-5 which illustrates how the VOC emission increases in a stepwise manner up to a maximum, remains steady for a period of time when core production stops and begins to decrease in a stepwise manner when successive core racks are removed after 11 1/2 hours of storage. Using this information, the maximum 8 hour time-weighted average VOC emission rate in the storage area was calculated to be 2.109 pounds of VOC per hour.

To protect employees working in the PTE (storage area), a dilution ventilation system comprised of roof exhausts and fresh make-up air is installed. The dilution ventilation system is based on the following criteria and assumptions:

The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade
 Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the

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PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.

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- The design of the exhaust ventilation system would be based on the maximum 8-hour time-weighted concentration of airborne contaminants to which employees in the storage area are exposed not exceeding 10% of the TLV® for the indicator chemical. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.
- A maximum 8 hour time-weighted average VOC emission rate of 2.109 pounds per hour in the storage area calculated from the emission profile in Figure 2-5 was used as the steady state emission rate for the purpose of calculating the design exhaust rate.
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the storage area PTE (see Appendix D for calculations). The results are as follows:

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	37,000
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	17,000

# Scenario #1 PUCB Core Storage Area Air Flows

# 2.3 Phenolic Urethane No-Bake (PUNB) Core-making (Scenario #2)

# 2.3.1 Process Description

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The PUNB binder system is a three component system: Parts I and II comprise the resin and Part III is a liquid amine-type catalyst. Generally the ratio of Part I to Part II ranges from 50:50 to 60:40. Part III (catalyst) is typically in the range of 2-9% of Part I. The sand is typically mixed simultaneously with all three parts. Parts I and II react to form a urethane bond, and Part III (catalyst) regulates the speed of the reaction between Parts I and II. The concentration and amount of catalyst added can be adjusted to provide the required curing time. The catalyzed resin coated sand remains flowable and workable until just before the desired "strip time" when the hardened sand is ready to be stripped from the pattern. This feature of the system provides excellent versatility and flexibility for the process as it allows strip times to be varied from less than a minute to over an hour depending on the application.

The "wet-sand" mix is prepared by mixing sand with the three parts of the binder system. The mixing can be done in batch mixers (e.g. blade and wheel mullers) or continuous screw (auger) mixers. While batch mixers are generally more efficient, continuous mixers provide the ability to

mix sand rapidly in the quantities needed. The mixed sand is deposited on a wood or metal pattern in a core box. The sand in the core box is compacted by the operator either manually or with the help of mechanical vibrating compactors. After the required amount of mixed sand is added and compacted, excess sand in the box is scraped off and the core is allowed to cure for the required curing time. After the curing reaction is complete and the sand has hardened, the pattern and the box are extracted or "stripped" from the hardened core. After inspection, the finished core/mold is placed on a rack and eventually transported to a storage area where it is kept until it is needed.

While the PUNB process can be used for production of one of a kind cores and molds, it is typically used for rapid mass production of small to medium-sized cores with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and core boxes.

# 2.3.2 Typical Scenario and Exhaust Ventilation System Analysis

The conceptual layouts of the core production and storage areas under Scenario #2 are shown in Figures 2-6 and 2-7 respectively. It must be emphasized that this scenario was developed specifically for the purpose of this study and is based on a number of conservative assumptions. Actual foundry operations may vary significantly to allow for required operational and maintenance flexibility.

PUNB Core Production Area (Scenario #2):

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The core production area (see Figure 2-6) consists of a roller conveyor loop with a continuous sand mixer and a stripping station as shown in Figure 2-6, capable of producing PUNB cores at the rate of 4.28 tons per hour for eight hours per day. Virgin sand from a silo is transported pneumatically to the hopper of the continuous mixer. The three part PUNB binder is





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FIGURE 2-7

introduced into the mixer. The discharge from the mixer delivers mixed sand upon demand into a core box , which is positioned on a table in the conveyor loop directly below the mixer discharge. The operator can manipulate the position and location of the mixer discharge head relative to the core box and also control the rate and timing of mixed sand discharge from the mixer. The operator deposits mixed sand into the core box, which contains the pattern, by manipulating the position of the mixer and controlling the sand flow. The operator also compacts the mixed sand on the pattern manually and with the assistance of a vibratory compactor at various times during this operation. When the core box is completely filled with mixed sand, the operator scrapes off excess sand and pushes the core box on to the roller conveyor towards the stripping station. The next core box and pattern assembly is then positioned on the table under the mixer, and the sand filling and compaction cycle is repeated.

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The filled core box is transported on the conveyorized loop towards the stripping station. After the required curing time has elapsed, the core is stripped from the core box and pattern. The operator places the finished cores on a rack adjacent to the stripping station. The rack has the capacity to hold 30 minutes of production. After the rack is full, it is transported to the core storage area and replaced by an empty rack in the production area. The empty core box and pattern are returned to the conveyorized loop and transported back to the sand filling station for reuse. The process operates continuously for eight hours per day.

Exhaust ventilation controls are required to protect employees working in the production area from exposure to airborne contaminants from the binder system. A local exhaust ventilation system was considered for this purpose but this was not found to be technically feasible. The general practice in the foundry industry is to provide general or dilution ventilation in this

area to control airborne contaminants in the workplace. Attempts at installing local exhaust hoods close to the core box or on the mixer head have generally failed to provide effective VOC capture for the following reasons:

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- The labor-intensive nature of the core-making operation and consequently the need for the operator to have free access and movement at and around the core box and mixer, and the access and clearances required for jib cranes or other material handing equipment precludes the possibility of installing an exhaust hood or enclosure reasonably close to the core-making station. To allow for operations and maintenance access and clearances, any "local" exhaust ventilation hood has to be located so far away from the core box and mixer that it would provide little or no close capture of the emissions; rather it simply helps provide general or dilution ventilation in the area;
- A side-draft type hood installed at the core station significantly hinders the movement of the operator to the point where productivity and quality are adversely affected;
- A local exhaust hood fitted to the mixer discharge head provides very limited capture of VOCs emitted while the mixed sand is discharged from the mixer, and generally provides little or no capture of VOCs emitted from the sand in the core box due to the relatively low exhaust rate of this type of hood and the relatively long distance from the mixer head to the core box; and
- Any local exhaust hood and associated ductwork installed at the core-making station tends to entrain resin-coated sand particles, which deposit and harden on the hood and duct surfaces. This causes significant blockages to exhaust air flow and severely affects the effectiveness of capture within a relatively short period of time.

Therefore, to protect employees working in the production area and to provide total capture of the VOCs, a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA

Method 204<sup>3</sup> has been constructed and a dilution ventilation system comprising of roof exhausts and fresh make-up air has been installed. The dimensions of the production area PTE are based on the following assumptions:

- Per USEPA Method 204<sup>3</sup> for a PTE, cores must be located a minimum of 4 equivalent duct diameters from any opening. Therefore the distance from the access opening to the mixer is equal to 4 equivalent duct diameters.
- The distance from the mixer to the first 90 degree conveyor turn is 8 feet. There is an additional 18 foot aisleway around the conveyor for clearance and storage.
- The distance from the outside of the first 90 degree conveyor turn to the outside of the second 90 degree conveyor turn is 20 feet.
- Building height in the production area is 20 feet.

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The dilution ventilation system is based on the following criteria and assumptions:

The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.
The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the production area are exposed should not exceed 10% of the TLV<sup>®</sup> for the

indicator chemical. This assumption is based on criteria generally used by industrial
hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.

- A VOC emission rate of 1.73 pounds per hour in the production area was used as the steady state emission rate for the purpose of calculating the design exhaust rate. (See Appendix D for details.)
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the production area PTE (see Appendix D for calculations). The results are as follows:

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	30,500
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	10,500

# Scenario #2 PUNB Core Production Area Air Flows

# • PUNB Core Storage Area (Scenario #2):

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The finished cores are transported to a core storage area (see Figure 2-7) from the core production area every 30 minutes on racks, each containing cores produced at the rate of 4.28

tons per hour over a 30 minute period (i.e. 2.14 tons of cores per rack). The cores on each rack are stored in this area for 11 1/2 hours, after which they are removed from the area for use in another part of the foundry. The core storage area is located in a separate part of the foundry, not necessarily adjacent to the production area and is constructed as a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA Method 204<sup>3</sup>.

The dimensions for the storage area PTE were based on the following assumptions:

- After production, cores are placed in 3 1/2 foot x 3 1/2 foot x 5 foot high storage racks.
   These racks are stacked up to two high in the storage area via a forklift. A five-foot clearance between the top of the uppermost rack and the roof will be necessary. This yields a 15-foot height.
- A rack filled with cores will utilize fifty percent of the available rack space. There will be a six-inch clearance between racks positioned in the storage area.
- Core density is equal to 100 pounds per cubic foot.

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- Per USEPA Method 204<sup>3</sup> for a PTE, cores must be stored a minimum of 4 equivalent duct diameters from any opening.
- The PTE will be designed to minimize the area and a 14-foot clearance will be needed to provide adequate clearance for the forklift.

The storage area has an access opening measuring 10 ft wide by 10 ft high to allow forklift trucks to transport core racks in and out of the area on a frequent basis. It is not feasible to install a door or other obstruction in this opening as it would interfere unduly with the required movement of cores in and out of the storage area. Therefore the access opening is a natural draft opening (NDO) as specified in US EPA Method 204, and a minimum average

face velocity of 200 ft/minute of air is required. Based on this, a minimum exhaust rate of 20,000 ft<sup>3</sup>/minute is required for the PTE.

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The cores on each rack placed in the PTE emit VOCs for the entire 11 1/2 hours period that they spend in the storage area at a constant rate of 0.142 pounds of VOC per hour (see Appendix D for supporting calculations). As additional racks are placed in the PTE every 30 minutes, the VOC emission rate into the PTE increases. The VOC emission rate in the PTE at 30 minute increments was calculated and plotted in Figure 2-8 which illustrates how the VOC emission increases in a stepwise manner up to a maximum, remains steady for a period of time when core production stops and begins to decrease in a stepwise manner when successive core racks are removed after 11 1/2 hours of storage. Using this information, the maximum 8 hour time-weighted average VOC emission rate in the storage area was calculated to be 2.024 pounds of VOC per hour.

To protect employees working in the storage area (PTE), a dilution ventilation system comprising roof exhausts and fresh make-up air is installed. The dilution ventilation system is based on the following criteria and assumptions:

The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent.

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i:\wpcol\pjt\Sheet1 Chart 2 Sheet1 Chart 23/13/98 Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.

The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the storage area are exposed should not exceed 10% of the TLV<sup>®</sup> for the indicator chemical. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.

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- A maximum 8-hour time-weighted average VOC emission rate of 2.024 pounds per hour in the storage area calculated from the emission profile in Figure 2-8 was used as the steady state emission rate for the purpose of calculating the design exhaust rate.
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the storage area PTE (see Appendix D for calculations). The results are as follows:

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	36,000
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	16,000

# Scenario #2 PUNB Core Storage Area Air Flows

### 2.4 Phenolic Urethane No Bake (PUNB) Mold-Making (Scenario #3)

#### 2.4.1 Process Description:

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 The PUNB binder system is a three component system: Parts I and II comprise the resin and Part III is a liquid amine-type catalyst. Generally the ratio of Part I to Part II ranges from 50:50 to 60:40. Part III (catalyst) is typically in the range of 2-9% of Part I. The sand is typically mixed simultaneously with all three parts. Parts I and II react to form a urethane bond, and Part III (catalyst) regulates the speed of the reaction between Parts I and II. The concentration and amount of catalyst added can be adjusted to provide the required curing time. The catalyzed resin coated sand remains flowable and workable until just before the desired "strip time" when the hardened sand is ready to be stripped from the pattern. This feature of the system provides excellent versatility and flexibility for the process as it allows strip times to be varied from less than a minute to over an hour depending on the application.

The "wet-sand" mix is prepared by mixing sand with the three parts of the binder system. The mixing can be done in batch mixers (e.g. blade and wheel mullers) or continuous screw (auger) mixers. While batch mixers are generally more efficient, continuous mixers provide the ability to mix sand rapidly in the quantities as needed. The mixed sand is deposited on a wood or metal pattern in a mold box. The sand in the mold box is compacted by the operator either manually or with the help of mechanical vibrating compactors. After the required amount of mixed sand is added and compacted, excess sand in the box is scraped off and the mold is allowed to cure for the required curing time. After the curing reaction is complete and the sand has hardened, the pattern and the box are extracted or "stripped" from the hardened mold. After inspection, the finished mold is placed on a rack and eventually transported to a storage area where it is kept until it is needed.

While the PUNB process can be used for production of one of a kind molds, it is typically used for rapid mass production of small to medium-sized molds with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and mold boxes.

### 2.4.2 Typical Scenario and Exhaust Ventilation System Analysis

The conceptual layout of the mold production and storage areas under Scenario #3 is shown in Figures 2-9 and 2-10 respectively. It must be emphasized that this scenario was developed specifically for the purpose of this study and is based on a number of conservative assumptions. Actual foundry operations may vary significantly to allow for required operational and maintenance flexibility.

• PUNB Mold Production Area (Scenario #3):

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The mold production area (see Figure 2-9) comprises of a roller conveyor loop with a continuous sand mixer and a stripping station capable of producing PUNB molds at the rate of 11.97 tons per hour for 16 hours per day. Virgin sand from a silo is transported pneumatically to the hopper of the continuous mixer. The three part PUNB binder is introduced into the mixer. The discharge from the mixer delivers mixed sand upon demand into a mold box, which is positioned on a table in the conveyor loop directly below the mixer discharge. The operator can manipulate the position and location of the mixer discharge head relative to the mold box and also controls the rate and timing of sand discharge from the mixer. The operator deposits mixed sand into the mold box, which contains the pattern, by manipulating the position of the mixer and controlling the sand flow. The operator also compacts the mixed sand on the pattern manually and with the assistance of a vibratory compactor at various times during this operation. When the mold box is completely filled



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FIGURE 2-10

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with mixed sand, the operator scrapes off excess sand and pushes the mold box on to the roller conveyor towards the stripping station. The next mold box and pattern assembly is then positioned on the table under the mixer, and the sand filling and compaction cycle is repeated. The filled mold box is transported on the conveyorized loop towards the stripping station. After the required curing time has elapsed, the mold is stripped from the mold box and pattern.

The mold enters the storage area via a conveyor and the empty mold box and pattern are returned to the conveyorized loop and transported back to the sand filling station for reuse. The process operates continuously for sixteen hours per day.

Exhaust ventilation controls are required to protect employees working in the production area from exposure to airborne contaminants from the binder system. A local exhaust ventilation system was considered for this purpose but this was not found to be technically feasible. The general practice in the foundry industry is to provide general or dilution ventilation in this area to control airborne contaminants in the workplace. Attempts at installing local exhaust hoods close to the mold box or on the mixer head have generally failed to provide effective VOC capture for the following reasons:

The labor-intensive nature of the mold-making operation and consequently the need for the operator to have free access and movement at and around the core box and mixer, and the access and clearances required for jib cranes or other material handing equipment precludes the possibility of installing an exhaust hood or enclosure reasonably close to the mold-making station. To allow for operations and maintenance access and clearances, any "local" exhaust ventilation hood has to be located so far away from the mold box and mixer that it would provide little or no close capture of the emissions; rather it simply helps provide general or dilution ventilation in the area;

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 A side-draft type hood installed at the mold station significantly hinders the movement of the operator to the point where productivity and quality are adversely affected;

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- A local exhaust hood fitted to the mixer discharge head provides very limited capture of VOCs emitted while the mixed sand was discharged from the mixer, and generally provides little or no capture of VOCs emitted from the sand in the mold box due to the relatively low exhaust rate of this type of hood and the relatively long distance from the mixer head to the mold box; and
- Any local exhaust hood and associated ductwork installed at the mold-making station tends to entrain resin-coated sand particles, which deposit and harden on the hood and duct surfaces. This causes significant blockages to exhaust air flow and severely affects the effectiveness of capture within a relatively short period of time.

To protect employees working in the production area, a permanent total enclosure (PTE) and a dilution ventilation system comprised of roof exhausts and fresh make-up air is installed.

The dimensions of the production area PTE are based on the following assumptions:

- Per USEPA Method 204<sup>3</sup> for a PTE, molds must be located a minimum of 4 equivalent duct diameters from any opening. Therefore the distance from the access opening to the mixer is equal to 4 equivalent duct diameters.
- The distance from the mixer to the first 90-degree conveyor turn is 15 feet. There is an additional 20-foot aisleway around the conveyor for clearance and storage.
- The distance from the outside of the first 90-degree conveyor turn to the outside of the second 90-degree conveyor turn is 50 feet.
- Building height in the production area is 20 feet.

The dilution ventilation system is based on the following criteria and assumptions:

The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.

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- The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the storage area are exposed should not exceed 10% of the TLV<sup>®</sup> for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.
- A VOC emission rate of 4.83 pounds per hour in the production area was used as the steady state emission rate for the purpose of calculating the design exhaust rate. (See Appendix D for details.)
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the production area PTE (see Appendix D-1 for calculations). The results are as follows:

	Airflow Rate (ft³/min.)
Total Exhaust Airflow	85,000
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	65,000

• PUNB Mold Storage Area (Scenario #3):

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The finished molds are transported to a mold storage area (see Figure 2-10) from the production area in batches every 30 minutes. Each batch contains 5.98 tons of molds (based on a production rate of 11.97 tons per hour over a 30 minute period). Each batch of molds is stored in this area for 11 1/2 hours, after which it is removed from the area for use in another part of the foundry. The mold storage area is located in a separate part of the foundry, not necessarily adjacent to the production area and is constructed as a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA Method 204<sup>3</sup>.

The dimensions for the storage area were based on calculations using the following assumptions:

- Mold size is 4 foot x 5 foot x 2 foot.
- Density of iron is 489.7 pounds per cubic foot and the density of sand is 100 pounds per cubic foot.
- Sand to metal ratio for the PUNB (chemically-bonded) molds is 1.7 to 1.
- Per USEPA Method 204<sup>3</sup> for a PTE, molds must be stored a minimum of 4 equivalent duct diameters from any openings.

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 Molds are stored one high on conveyors. Floor space utilization is forty percent. The building height is 15 feet.

The storage area has two access openings each measuring 10 ft wide by 5 ft high to allow the molds to be transported in and out of the storage area via a conveyor. To meet the criterion for a natural draft opening (NDO) as specified in US EPA Method 204, the opening requires a minimum average face velocity of 200 ft/minute of air entering the enclosure. Based on this, the minimum exhaust rate required for this area is 20,000 ft<sup>3</sup>/minute.

Each batch of molds placed in the PTE emits VOCs for the entire 11 1/2 hours period that it spends in the storage area at a constant rate of 0.400 pounds of VOC per hour (see Appendix D for supporting calculations). As additional batches are placed in the PTE every 30 minutes, the VOC emission rate into the PTE increases. The VOC emission rate in the PTE at 30 minute increments was calculated and plotted in Figure 2-11 which illustrates how the VOC emission increases in a stepwise manner up to a maximum, remains steady for a period of time when mold production stops and begins to decrease in a stepwise manner when successive batches of molds are removed after 11 1/2 hours of storage are completed. Using this information, the maximum 8 hour time-weighted average VOC emission rate in the storage area was calculated to be 8.9 pounds of VOC per hour.

To protect employees working in the storage area (PTE), a dilution ventilation system comprising roof exhausts and fresh make-up air is installed. The dilution ventilation system is based on the following criteria and assumptions:





does not exceed this number.

The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV®) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs® equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.

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- The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the storage area are exposed should not exceed 10% of the TLV<sup>®</sup> for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.
- A VOC emission rate of 8.9 pounds per hour in the storage area calculated from the emission profile in Figure 2-11 was used as the steady state emission rate for the purpose of calculating the design exhaust rate.
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>3</sup> for the storage area PTE (see Appendix D for calculations). The results are as follows:

## Scenario #3 PUNB Mold Storage Area Air Flows

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	156,000
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	136,000

### 2.5 Phenolic Urethane Cold Box (PUCB) Core-making (Scenario #4)

### 2.5.1 Process Description

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The PUCB process uses an organic binder capable of producing high quality cores at a very rapid rate at room temperature. The "wet-sand" mix is prepared by mixing sand with a two-part liquid resin binder. The mixing can be done in batch mixers (e.g. blade and wheel mullers) or continuous screw (auger) mixers. While batch mixers are generally more efficient, continuous mixers provide the ability to mix sand rapidly in the quantities needed. The remainder of the core production process typically occurs in a core machine designed to facilitate the core-making cycle rapidly and automatically. The wet-sand from the mixer is deposited into the core machine hopper and then blown into the core box, which contains a pattern in the shape of the core being produced. The core box is then placed between an upper gas input manifold and a lower air exhaust manifold. The catalyst gas (typically triethylamine (TEA) or dimethylethylamine (DMEA)) mixed with an inert carrier gas enters the core box containing the wet sand through the blow ports or vents and passes through the core, causing almost instantaneous hardening of the resin-coated sand. This is followed by a purge cycle where clean air is passed through the core box to remove residual catalyst. The core is then ready for ejection from the core box. It is typically removed by the machine operator and placed on a rack after inspection. When full, the

core rack is transported to a core storage area, where the cores are stored until they are needed for placement in molds.

During catalyst gassing and purging cycles, the catalyst, carrier gas and air pass through the core and leave the core box through vents into the exhaust manifold, which conveys the gasses to an acid scrubber which removes the catalyst from the exhaust stream before discharge to atmosphere. The core box is typically sealed with rubber seals and gaskets and is maintained under a slight negative pressure by the exhaust manifold to prevent any leakage of catalyst gas to the working environment.

2.5.2 Scenario Overview and Exhaust Ventilation System Analysis

The conceptual layouts of the core production and storage areas under Scenario #4 are shown in Figure 2-12 and 2-13 respectively. It must be emphasized that this scenario was developed specifically for the purpose of this study and is based on a number of conservative assumptions. Actual foundry operations may vary significantly to allow for required operational and maintenance flexibility.

PUCB Core Production Area (Scenario #4):

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The core production area (see Figure 2-12) contains an automatic core-making machine capable of producing PUCB cores at the rate of 7.35 tons per hour for sixteen hours per day. Virgin sand from a silo is transported pneumatically to a hopper above the continuous mixer. The two part PUCB binder is introduced into the mixer. The discharge from the mixer delivers prepared sand to the core machine hopper. The core machine is equipped with a sealed core box and a TEA generator supplies the catalyst gas mixture to the machine upon demand. The operator places the finished cores on a rack adjacent to the machine after they are ejected from the core box. The rack has the capacity to hold 30 minutes of production.



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FIGURE 2-12



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FIGURE 2-13

After the rack is full, it is transported to the core storage area and replaced by an empty rack in the production area. The machine operates continuously for sixteen hours per day.

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The original machine enclosure has been modified to add exhaust hooding and partially enclose the machine hopper and the mixer discharge head as much as practical considering the need to provide operational and maintenance access. The purpose of the modification is to capture VOCs. Exhaust ventilation is applied to the enclosure and to the exhaust plenum situated under the sealed core box. The air exhausted from the machine enclosure and the sealed core box is routed to a sand trap to remove any sand particles before entering a packed-bed acid scrubber. The purpose of the scrubber is to remove the TEA catalyst from the exhaust air, no other VOCs are removed by the scrubber as the major constituents are assumed to be non-water soluble. The outlet from the scrubber is connected to one of three alternative VOC control devices. The exhaust from the VOC control device is discharged to the outside atmosphere through an exhaust stack.

The total exhaust air flow rate applied to the machine enclosure and sealed core box is 2000 ft<sup>3</sup>/minute which was estimated as follows:

- a) A minimum of 1000 ft<sup>3</sup>/minute of exhaust air per machine is recommended by the acid scrubber vendor<sup>1</sup> for effective capture of catalyst from the machine enclosure and sealed core box.
- b) An additional exhaust air flow rate of 500 to 1500 ft<sup>3</sup>/minute was estimated to be required assuming an air flow rate of 200 cfm/ft<sup>2</sup> of open face area<sup>2</sup>. This estimate was based on engineering judgment to provide efficient capture of VOCs from the machine hopper and sand mixer discharge head with hooding designed to allow adequate clearance for operations and maintenance access. The exact air flow rate required would depend on the

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dimensions and relative configurations of the hopper and mixer relative to the machine. The average of this range, 1000 ft<sup>3</sup>/minute, was assumed to be required to provide effective capture of VOCs for the purpose of this study.

- c) The total air flow rate required for the purpose of the study equals 1000 ft<sup>3</sup>/minute as specified in (a) plus 1000 ft<sup>3</sup>/minute as specified in (b), or a total of 2000 ft<sup>3</sup>/minute.
- PUCB Core Storage Area (Scenario#4):

The finished cores are transported to a core storage area (see Figure 2-13) from the core production area every 30 minutes on racks, each containing cores produced at the rate of 7.35 tons per hour over a 30 minute period (i.e., 3.675 tons of cores per rack). The cores on each rack are stored in this area for 11 1/2 hours, after which they are removed from the area for use in another part of the foundry. The core storage area is located in a separate part of the foundry, not necessarily adjacent to the production area. To provide total capture of the VOCs, it is constructed as a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA Method 204<sup>3</sup>.

The dimensions of the storage area were based on the following assumptions:

- After production, cores are placed in 3 1/2 foot x 3 1/2 foot x 5 foot high storage racks.
   These racks are stacked up to two high in the storage area with a forklift. A five-foot clearance between the top of the uppermost rack and the roof will be necessary. This yields a 15-foot height.
- A rack filled with cores will utilize fifty percent of the available rack space. There will be a six-inch clearance between racks placed in the storage area.

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- Core density is equal to 100 pounds per cubic foot.
- Per USEPA Method 204<sup>3</sup> for a PTE, cores must be stored a minimum of 4 equivalent duct diameters from any opening.
- The PTE will be designed to minimize the floor area and a 14-foot horizontal clearance will be required for the forklift.

The storage area has an access opening measuring 10 ft wide by 10 ft high to allow forklift trucks to transport core racks in and out of the area on a frequent basis. It is not feasible to install a door or other obstruction in this opening as it would interfere unduly with the required movement of cores in and out of the storage area. Therefore the access opening is a natural draft opening (NDO) as specified in US EPA Method 204, and a minimum average face velocity of 200 ft/minute of air is required. Based on this, a minimum exhaust rate of 20,000 ft<sup>3</sup>/minute is required for the PTE.

The cores on each rack placed in the PTE emit VOCs for the entire 11 1/2 hour period that they spend in the storage area at a constant rate of 0.148 pounds of VOC per hour (see Appendix D for supporting calculations). As additional racks are placed in the PTE every 30 minutes, the VOC emission rate increases. The VOC emission rate in the PTE at 30 minute increments was calculated and plotted in Figure 2-14 which illustrates how the VOC emission increases in a stepwise manner up to a maximum, remains steady for a period of time when core production stops and begins to decrease in a stepwise manner when successive core racks are removed after 11 1/2 hours of storage. Using this information, the maximum 8 hour time-weighted average VOC emission rate in the storage area was calculated to be 3.293 pounds of VOC per hour.

# Figure 2-14

Scenario #4 PUCB (Cold Box) Core Storage Area Emissions



\*Although the emission rate at the end of the first 24 hour period is not zero, it has been verified that the maximum 8-hour TWA emission rate in subsequent 24 hour periods does not exceed this number.

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To protect employees working in the PTE (storage area), a dilution ventilation system comprised of roof exhausts and fresh make-up air is installed. The dilution ventilation system is based on the following criteria and assumptions:

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- The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.
- The design of the exhaust ventilation system would be based on the maximum 8-hour time-weighted concentration of airborne contaminants to which employees in the storage area are exposed not exceeding 10% of the TLV<sup>®</sup> for the indicator chemical. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.
- A maximum 8 hour time-weighted average VOC emission rate of 3.293 pounds per hour in the storage area calculated from the emission profile in Figure 2-14 was used as the steady state emission rate for the purpose of calculating the design exhaust rate.
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

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Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the storage area PTE (see Appendix D for calculations). The results are as follows:

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	58,000
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	38,000

# Scenario #4 PUCB Core Storage Area Air Flows

### 2.6 Phenolic Urethane No Bake (PUNB) Mold-Making (Scenario#5)

### 2.6.1 Process Description:

The PUNB binder system is a three component system: Parts I and II comprise the resin and Part III is a liquid amine-type catalyst. Generally the ratio of Part I to Part II ranges from 50:50 to 60:40. Part III (catalyst) is typically in the range of 2-9% of Part I. The sand is typically mixed simultaneously with all three parts. Parts I and II react to form a urethane bond, and Part III (catalyst) regulates the speed of the reaction between Parts I and II. The concentration and amount of catalyst added can be adjusted to provide the required curing time. The catalyzed resin coated sand remains flowable and workable until just before the desired "strip time" when the hardened sand is ready to be stripped from the pattern. This feature of the system provides excellent versatility and flexibility for the process as it allows strip times to be varied from less than a minute to over an hour depending on the application.

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The "wet-sand" mix is prepared by mixing sand with the three parts of the binder system. The mixing can be done in batch mixers (e.g. blade and wheel mullers) or continuous screw (auger) mixers. While batch mixers are generally more efficient, continuous mixers provide the ability to mix sand rapidly in the quantities as needed. The mixed sand is deposited on a wood or metal pattern in a mold box. The sand in the mold box is compacted by the operator either manually or with the help of mechanical vibrating compactors. After the required amount of mixed sand is added and compacted, excess sand in the box is scraped off and the mold is allowed to cure for the required curing time. After the curing reaction is complete and the sand has hardened, the pattern and the box are extracted or "stripped" from the hardened mold. After inspection, the finished mold is placed on a rack and eventually transported to a storage area where it is kept until it is needed.

While the PUNB process can be used for production of one of a kind molds, it is typically used for rapid mass production of small to medium-sized molds with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and mold boxes.

### 2.6.2 Typical Scenario and Exhaust Ventilation System Analysis

The conceptual layout of the mold production and storage areas under Scenario #5 is shown in Figures 2-15 and 2-16 respectively. It must be emphasized that this scenario was developed specifically for the purpose of this study and is based on a number of conservative assumptions. Actual foundry operations may vary significantly to allow for required operational and maintenance flexibility.

## PUNB Mold Production Area (Scenario#5):

The mold production area (see Figure 2-15) comprises of a roller conveyor loop with a continuous sand mixer and a stripping station capable of producing PUNB molds at the rate



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FIGURE 2-15



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FIGURE 2-16

of 18.0 tons per hour for 16 hours per day. Virgin sand from a silo is transported pneumatically to the hopper of the continuous mixer. The three part PUNB binder is introduced into the mixer. The discharge from the mixer delivers mixed sand upon demand into a mold box, which is positioned on a table in the conveyor loop directly below the mixer discharge. The operator can manipulate the position and location of the mixer discharge head relative to the mold box and also controls the rate and timing of sand discharge from the mixer. The operator deposits mixed sand into the mold box, which contains the pattern, by manipulating the position of the mixer and controlling the sand flow. The operator also compacts the mixed sand on the pattern manually and with the assistance of a vibratory compactor at various times during this operation. When the mold box is completely filled with mixed sand, the operator scrapes off excess sand and pushes the mold box on to the roller conveyor towards the stripping station. The next mold box and pattern assembly is then positioned on the table under the mixer, and the sand filling and compaction cycle is repeated. The filled mold box is transported on the conveyorized loop towards the stripping station. After the required curing time has elapsed, the mold is stripped from the mold box and pattern.

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The mold enters the storage area via a conveyor and the empty mold box and pattern are returned to the conveyorized loop and transported back to the sand filling station for reuse. The process operates continuously for sixteen hours per day.

Exhaust ventilation controls are required to protect employees working in the production area from exposure to airborne contaminants from the binder system. A local exhaust ventilation system was considered for this purpose but this was not found to be technically feasible. The general practice in the foundry industry is to provide general or dilution ventilation in this area to control airborne contaminants in the workplace. Attempts at installing local exhaust

hoods close to the mold box or on the mixer head have generally failed to provide effective VOC capture for the following reasons:

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- The labor-intensive nature of the mold-making operation and consequently the need for the operator to have free access and movement at and around the core box and mixer, and the access and clearances required for jib cranes or other material handing equipment precludes the possibility of installing an exhaust hood or enclosure reasonably close to the mold-making station. To allow for operations and maintenance access and clearances, any "local" exhaust ventilation hood has to be located so far away from the mold box and mixer that it would provide little or no close capture of the emissions; rather it simply helps provide general or dilution ventilation in the area;
- A side-draft type hood installed at the mold station significantly hinders the movement of the operator to the point where productivity and quality are adversely affected;
- A local exhaust hood fitted to the mixer discharge head provides very limited capture of VOCs emitted while the mixed sand was discharged from the mixer, and generally provides little or no capture of VOCs emitted from the sand in the mold box due to the relatively low exhaust rate of this type of hood and the relatively long distance from the mixer head to the mold box; and
- Any local exhaust hood and associated ductwork installed at the mold-making station tends to entrain resin-coated sand particles, which deposit and harden on the hood and duct surfaces. This causes significant blockages to exhaust air flow and severely affects the effectiveness of capture within a relatively short period of time.

To protect employees working in the production area, a permanent total enclosure (PTE) and a dilution ventilation system comprised of roof exhausts and fresh make-up air is installed.

The dimensions of the production area PTE are based on the following assumptions:

- Per USEPA Method 204<sup>3</sup> for a PTE, molds must be located a minimum of 4 equivalent duct diameters from any opening. Therefore the distance from the access opening to the mixer is equal to 4 equivalent duct diameters.
- The distance from the mixer to the first 90-degree conveyor turn is 15 feet. There is an additional 20-foot aisleway around the conveyor for clearance and storage.
- The distance from the outside of the first 90-degree conveyor turn to the outside of the second 90-degree conveyor turn is 50 feet.
- Building height in the production area is 20 feet.

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The dilution ventilation system is based on the following criteria and assumptions:

- The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV®) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs® equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.
- The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the storage area are exposed should not exceed 10% of the TLV<sup>®</sup> for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries.

Also, the 10% criterion is recommended in the proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.

- A VOC emission rate of 7.3 pounds per hour in the production area was used as the steady state emission rate for the purpose of calculating the design exhaust rate. (See Appendix D for details.)
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>8</sup> for the production area PTE (see Appendix D-1 for calculations). The results are as follows:

	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	127,500
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	107,500

### Scenario #5 PUNB Mold Production Area Air Flows

## • PUNB Mold Storage Area (Scenario#5):

The finished molds are transported to a mold storage area (see Figure 2-16) from the production area in batches every 30 minutes. Each batch contains 9.0 tons of molds (based on a production rate of 18.0 tons per hour over a 30 minute period). Each batch of molds is stored

in this area for 11 1/2 hours, after which it is removed from the area for use in another part of the foundry. The mold storage area is located in a separate part of the foundry, not necessarily adjacent to the production area and is constructed as a Permanent Total Enclosure (PTE) according to the criteria specified in US EPA Method 204<sup>3</sup>.

The dimensions for the storage area were based on calculations using the following assumptions:

Mold size is 4 foot x 5 foot x 2 foot.

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- Density of iron is 489.7 pounds per cubic foot and the density of sand is 100 pounds per cubic foot.
- Sand to metal ratio for the PUNB (chemically-bonded) molds is 1.7 to 1.
- Per USEPA Method 204<sup>3</sup> for a PTE, molds must be stored a minimum of 4 equivalent duct diameters from any openings.
- Molds are stored one high on conveyors. Floor space utilization is forty percent. The building height is 15 feet.

The storage area has two access openings each measuring 10 ft wide by 5 ft high to allow the molds to be transported in and out of the storage area via a conveyor. To meet the criterion for a natural draft opening (NDO) as specified in US EPA Method 204, the opening requires a minimum average face velocity of 200 ft/minute of air entering the enclosure. Based on this, the minimum exhaust rate required for this area is 20,000 ft<sup>3</sup>/minute.

Each batch of molds placed in the PTE emits VOCs for the entire 11 1/2 hours period that it spends in the storage area at a constant rate of 0.60 pounds of VOC per hour (see Appendix D for supporting calculations). As additional batches are placed in the PTE every 30 minutes, the VOC emission rate into the PTE increases. The VOC emission rate in the PTE at 30 minute

increments was calculated and plotted in Figure 2-17 which illustrates how the VOC emission
increases in a stepwise manner up to a maximum, remains steady for a period of time when
mold production stops and begins to decrease in a stepwise manner when successive batches
of molds are removed after 11 1/2 hours of storage are completed. Using this information, the
maximum 8 hour time-weighted average VOC emission rate in the storage area was
calculated to be 13.350 pounds of VOC per hour.
To protect employees working in the storage area (PTE), a dilution ventilation system
comprising roof exhausts and fresh make-up air is installed. The dilution ventilation system is

based on the following criteria and assumptions:

- The chemical composition of the VOCs emitted from the production and storage areas vary depending on the type of binder and the binder supplier. Commercial grade Stoddard Solvent with a Threshold Limit Value (TLV<sup>®</sup>) of 525 ug/m<sup>3</sup> was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the PTE. Based on discussions with the three OCMA binder supplier members, the substances the suppliers would recommend for sampling, to access employee exposures in production and storage, generally had TLVs<sup>®</sup> equal to or lower than Stoddard Solvent. Therefore use of Stoddard Solvent as the indicator chemical would provide a conservative (i.e. lower air flow) estimate of the exhaust ventilation rates for the purpose of this study.
- The maximum 8-hour time weighted concentration of airborne contaminants to which employees in the storage area are exposed should not exceed 10% of the TLV<sup>®</sup> for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals<sup>4,5,6</sup> as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard<sup>7</sup> for industrial process exhaust recirculation systems.

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Figure 2-17

Scenario #5 PUNB (No Bake) Mold Storage Area Emissions



\*Although the emission rate at the end of the first 24 hour period is not zero, it has been verified that the maximum 8-hour TWA emission rate in subsequent 24 hour periods does not exceed this number.
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- A VOC emission rate of 13.350 pounds per hour in the storage area calculated from the emission profile in Figure 2-17was used as the steady state emission rate for the purpose of calculating the design exhaust rate.
- A K-Factor (mixing factor) of 3.5 was used to represent reasonably good mixing of dilution air in the PTE<sup>2</sup>.

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual<sup>2</sup> and the AIHA Engineering Field Reference Manual<sup>3</sup> for the storage area PTE (see Appendix D for calculations). The results are as follows:

Scenario	#5 PUNB	Mold Storag	e Area Air Flows
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	Airflow Rate (ft <sup>3</sup> /min.)
Total Exhaust Airflow	234,500
Air Entering Through NDO	20,000
Air Entering Through Make-Up Air Unit	214,500

#### 2.7 OC/VOC Control Technology Technical Feasibility Review:

The following technologies for controlling OC/VOC emissions were considered for all three scenarios:

- Thermal oxidation (recuperative and regenerative)
- Catalytic oxidation (recuperative and regenerative)
- Carbon adsorption

- Concentrator
- Biofiltration

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- Condensors
- Scrubbers

The first step in evaluating the technical feasibility of different control options was to review the OC/VOC concentrations in the exhaust air stream for each scenario. The exhaust air flow rates estimated in Sections 2.2 through 2.6 and the corresponding OC/VOC concentrations calculated for each scenario are presented in Table 2-1.

Each of the emission control technologies was reviewed for technical feasibility for controlling VOC emissions from the production and storage areas for all three scenarios, based on the exhaust air flow rate, the VOC concentration and other relevant factors. Based on this review, three emission control technology alternatives were selected for the production area and storage area for each scenario (see Table 2.2) for a detailed economic feasibility analysis. These selections and the rationale for the selections were discussed with selected equipment vendors, and they confirmed that the selected technologies were appropriate. The basis for selecting the technologies is summarized below.

Thermal Oxidation: Thermal oxidizers, also known as thermal incinerators are used to control a wide variety of VOC emission streams, yielding destruction efficiencies greater than 99 percent. Thermal oxidizers are typically designed with one of two types of primary heat recovery systems. Recuperative systems use a conventional system to pre-heat incoming exhaust air. Regenerative systems use ceramic beds to pre-heat the incoming exhaust air stream. Since thermal oxidizers can be effectively used for a wide range of inlet concentrations and flow rates, thermal oxidation was considered for the economic feasibility analysis for production and storage area emissions for all three scenarios.

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	PRODU	CTION A	REA	STORAGE AREA			
	Ext	naust Rate	;	E	xhaust Rat	e	
SCENARIO	:	ft³/min			ft³/min		
	Total	NDO*	Make-Up	Total	NDO*	Make-Up	
#1 PUCB Cores	2,000**	N/A	N/A	37,000	20,000	17,000	
#2 PUNB Cores	30,500	20,000	10,500	36,000	20,000	16,000	
#3 PUNB Molds	85,000	20,000	65,000	156,000	20,000	136,000	
#4 PUCB Cores	2,000**	N/A	N/A	58,000	20,000	38,000	
#5 PUNB Molds	127,500	20,000	107,500	234,500	20,000	214,500	

Table 2-1 Summary of Exhaust Rates

Note: Airflow rates are rounded to the nearest 500 CFM.

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\* NDO = Natural Draft Opening
\*\* Airflow Rate for Local Exhaust Ventilation on Core Machine

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Table 2-2
<b>Emission Control Technologies Selected</b>
for Economic Feasibility Study

SC	CENARIOS	PRODUCTION AREA	STORAGE AREA		
#1		Recuperative Thermal Oxidizer	Concentrator		
	PUCB Cores	Recuperative Catalytic Oxidizer Carbon Adsorption	Regenerative Thermal Oxidizer Biofiltration		
#2		Concentrator	Concentrator		
	PUNB Cores	Regenerative Thermal Oxidizer	Regenerative Thermal Oxidizer		
		Biofiltration	Biofiltration		
#3		Concentrator	Concentrator		
	PUNB Molds	Regenerative Thermal Oxidizer Biofiltration	Regenerative Thermal Oxidizer Biofiltration		
#4		Recuperative Thermal Oxidizer	Concentrator		
	PUCB Cores	Recuperative Catalytic Oxidizer	Regenerative Thermal Oxidizer Biofiltration		
#5		Concentrator	Concentrator		
	PUNB Molds	Regenerative Thermal Oxidizer	Regenerative Thermal Oxidizer		
		Biofiltration	Biofiltration		

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Catalytic Oxidation: This technology is similar to thermal oxidation except that a catalyst is employed to allow the oxidation to occur at a lower temperature, thereby providing significant fuel savings compared to thermal oxidation. Both regenerative and recuperative systems are used. However, this technology is not as broadly applicable as thermal oxidation because the catalyst is sensitive and prone to damage by certain pollutants or process conditions. This technology was selected for economic feasibility analysis for all the scenarios. However, after reviewing the cost estimates from equipment vendors, regenerative thermal oxidation was substituted for catalytic oxidation for all scenarios except the production area for Scenario #1 and#4 as it was found to be more favorable (i.e. lower costs).

Carbon Adsorption: An activated carbon bed is used to adsorb VOC's from the exhaust stream. When the bed is nearly saturated with VOC's it is regenerated *in situ*, sent off site for regeneration or disposed, depending on the type of system installed. Since this technology is not applicable for exhaust air inlet concentrations of less than 10 to 20 ppmv, it was selected for economic feasibility analysis for the production areas in Scenario #1 and #4, and was ruled out for all the other scenarios.

Concentrator: This emission control method combines two technologies and is aimed at treating relatively high volume dilute air streams. The exhaust air is first passed through a carbon adsorption system where the VOCs are adsorbed. When the bed is nearly saturated, the VOCs are desorbed with air and the VOC-laden air is passed through a thermal oxidation system where the VOCs are destroyed. The air flow rate of the desorbtion air is much lower than the original exhaust air rate and the VOC concentration in the desorbtion air is much higher, thereby making thermal oxidation of the VOCs a more attractive proposition. Because of its applicability to dilute high volume exhaust air streams, it was selected for economic feasibility analysis for all scenarios

except the production areas for Scenario #1 and #4 where the exhaust air flow rate is relatively low.

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Biofiltration: This is a relatively new technology where VOCs are removed by passing the exhaust air through a bio-mass which essentially captures and destroys the VOCs through biological activity. It is typically used for dilute high volume exhaust streams. It was selected for economic feasibility analysis for all scenarios except the production areas for Scenario #1 and #4 where the exhaust air flow rate is relatively low.

Condensers: These devices are used for removing VOCs from high concentration (usually greater than 5000 ppmv) exhaust streams by cooling the exhaust stream and thereby condensing the VOCs. Since the inlet concentrations for all scenarios were well below the minimum range for condensers, this technology was ruled out as technically infeasible for all scenarios.

Scrubbers (Absorbers): are widely used as a recovery technique in the separation and purification of gaseous streams containing high concentrations of VOCs. They are more widely used as an emission control method for inorganic vapors than for VOCs. The primary criterion for determining feasibility of this technique is the solubility of the VOCs in water or other suitable solvent. Since the major constituents of PUCB and PUNB binder systems are generally non-water soluble, this technology was not selected for economic feasibility analysis for any of the scenarios.

#### 3.0 Economic analysis for add-on OC/VOC emissions controls

After conducting the technical feasability analysis described in Section 2.5, a meeting to review the selected emission control alternatives was held on July 22, 1997 with OEPA staff and OCMA representatives. At this meeting OEPA staff generally concurred with the selected emission control alternatives and agreed that the economic feasability analysis of these alternatives should proceed. Detailed cost-benefit analyses were performed for each of the selected control alternatives in accordance with OEPA Engineering Guide #46.

Capital costs for emission control equipment used in the analyses are based upon actual quotes obtained from equipment vendors. The capital costs associated with constructing the enclosure and ventilation system for each control scenario were derived based upon a combination of vendor quotes and engineering analyses performed by RMT staff experienced in ventilation system design. Copies of the vendor quotes and supporting background data on RMT's cost estimates for the enclosure/duct work are provided in Appendix E.

The following key assumptions were made:

- The emissions control equipment for each control option could be located within 150 feet of the operation;
- Electric and gas rates used in the analysis were mid-range values based on experience with a variety of manufacturing facilities. Actual rates could vary significantly based on overall consumption at the facility, the specific location of the facility in Ohio and other factors;
- Due to the lack of a known precedent for use of biofiltration for controlling OC/VOC emissions from core- and mold-making operations ,and the need for guaranteed performance in terms of controlled emissions, a 15% contingency for capital costs was added to the biofiltration quotes

provided. This was based upon the guidance provided in Table 4-4 of the OEPA Engineering Guide #46;

 Installation costs were derived based upon vendor quotes or standard Ohio EPA Engineering Guide #46 recommended values. Actual costs could vary significantly depending on sitespecific requirements, especially for retrofitting controls to existing operations.

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- Production costs were assumed to not increase as a result of installing enclosures, exhaust ventilation and emissions controls. For example, additional production costs could be incurred for management of inventory and movement of stored cores or molds in and out of the enclosure. However, these costs were not considered in the feasability analysis;
- Enclosures for Scenario #1 (Storage), Scenario #2 (Production and Storage), Scenario #3 (Production and Storage), Scenario #4 (Production and Storage) and Scenario #5 (Production and Storage) would be Permanent Total Enclosures (PTEs) meeting the criteria in USEPA Method 204<sup>3</sup>.

When conducting site-specific evaluations (for example BAT reviews for PTIs, etc.) for add-on OC/VOC controls for core- and mold-making operations in the future, the above assumptions should be carefully scrutinized and adjusted as necessary in relation to actual site-specific conditions.

3.1 Scenario #1: PUCB Core-making (7.35 tons per hour, 8 hours per day)
Table 3-1A and Table 3-1B provides the results of the Cost Benefit Analysis for the production and storage areas of Scenario #1, respectively. The detailed analysis of each evaluated control technology can be found in Appendix E.

## TABLE 3-1A Scenario #1 Cost Effectiveness Results PUCB Core Production

CONTROL SYSTEM	ANNUALIZED COST (\$)*	Annual OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ ton)
Recuperative Thermal Oxidizer	79,000	2.07	38,000
Recuperative Catalytic Oxidizer	76,500	2.07	37,000
Carbon Adsorption	170,500	2.07	82,500

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\* Rounded to nearest \$500.00.

## TABLE 3-1B Scenario #1 Cost Effectiveness Results PUCB Core Storage

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CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ ton)
Concentrator	444,000	4.5	98,500
Regenerative Thermal Oxidizer	466,500	4.5	103,500
Biofilter	430,500	4.5	95,500

\* Rounded to nearest \$500.00.

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#### 3.2 Scenario #2: PUNB Core-making (4.28 tons per hour, 8 hours per day)

Table 3-2A and Table 3-2B provides the results of the Cost Benefit Analysis for the production and storage areas of Scenario #2, respectively. The detailed analysis of each evaluated control technology can be found in Appendix E.

#### 3.3 Scenario #3: PUNB Mold-making (11.97 tons per hour, 16 hours per day)

Table 3-3A and Table 3-3B provides the results of the Cost Benefit Analysis for the production and storage areas of Scenario #3, respectively. The detailed analysis of each evaluated control technology can be found in Appendix E.

## 3.4 Scenario #4: PUCB Core-making (7.35 tons per hour, 16 hours per day)

Table 3-4A and Table 3-4B provides the results of the Cost Benefit Analysis for the production and storage areas of Scenario #4, respectively. The detailed analysis of each evaluated control technology can be found in Appendix E.

# 3.5 Scenario #5: PUNB Mold-making (18.0 tons per hour, 16 hours per day) Table 3-5A and Table 3-5B provides the results of the Cost Benefit Analysis for the production and storage areas of Scenario #5, respectively. The detailed analysis of each evaluated control technology can be found in Appendix E.

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## TABLE 3-2A Scenario #2 Cost Effectiveness Results PUNB Core Production

CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	401,000	2.25	178,500
Regenerative Thermal Oxidizer	358,500	2.25	159,500
Biofilter	361,000	2.25	160,500

\*Rounded to the nearest \$500.00.

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## TABLE 3-2B Scenario #2 Cost Effectiveness Results PUNB Core Storage

CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	441,500	4.32	102,000
Regenerative Thermal Oxidizer	459,000	4.32	106,500
Biofilter	371,500	4.32	86,000

\*Rounded to the nearest \$500.00.

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## TABLE 3-3A Scenario #3 Cost Effectiveness Results PUNB Mold Production

CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	877,500	12.06	73,000
Regenerative Thermal Oxidizer	925,500	12.06	76,500
Biofilter	675,000	12.06	56,000

\*Rounded to the nearest \$500.00.

## TABLE 3-3B Scenario #3 Cost Effectiveness Results PUNB Mold Storage

CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	1,198,000	22.68	53,000
Regenerative Thermal Oxidizer	1,638,000	22.68	72,000
Biofilter	1,267,500	22.68	56,000

\*Rounded to the nearest \$500.00.

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## TABLE 3-4A Scenario #4 Cost Effectiveness Results PUCB Core Production

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CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Recuperative Thermal Oxidizer	114,000	4.2	27,000
Recuperative Catalytic Oxidizer	103,500	4.2	24,500
Carbon Adsorption	360,000	4.2	85,000

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\* Rounded to nearest \$500.00.

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## TABLE 3-4B Scenario #4 Cost Effectiveness Results PUCB Core Storage

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CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	515,500	8.9	58,000
Regenerative Thermal Oxidizer	628,500	9.7	65,000
Biofilter	586,000	8.9	65,500

\* Rounded to nearest \$500.00.

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## TABLE 3-5A Scenario #5 Cost Effectiveness Results PUNB Mold Production

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CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	825,500	19.1	43,500
Regenerative Thermal Oxidizer	1,081,500	20.8	52,000
Biofilter	1,137,500	19.1	59,500

\*Rounded to the nearest \$500.00.

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## TABLE 3-5B Scenario #5 Cost Effectiveness Results PUNB Mold Storage

CONTROL SYSTEM	ANNUALIZED COST (\$)*	OC/VOC REDUCTION (tons/year)	COST EFFECTIVENESS* (\$/ton)
Concentrator	1,410,000	36.3	39,000
Regenerative Thermal Oxidizer	2,012,500	39.5	51,000
Biofilter	1,955,500	36.3	54,000

\*Rounded to the nearest \$500.00.

#### Acknowledgments:

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Ohio Cast Metals Association, American Foundrymen's Society, Inc. and RMT would like to thank the following organizations for assistance provided during this study:

Binder Suppliers who conducted laboratory emissions testing:

Ashland Chemical Company

Borden Chemical, Inc.

Delta Resins & Refractories

Emission Control Equipment Vendors who provided control equipment costs:

Ambient Engineering Inc.

Barnebey & Sutcliffe Corporation

CSM Environmental Systems

Durr Environmental, Inc.

Met Pro Corporation

**PPC Biofilter** 

Smith Environmental Corporation

#### References

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- 1. Interel Environmental Technologies, Inc.; "Guide to Planning Your Iso-Cure Cold Box Gas Scrubber Installation", December 1992.
- 2. <u>Industrial Ventilation A Manual of Recommended Practice</u>; 21st edition, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio(1992).
- 3. <u>Criteria For and Verification of A Permanent or Temporary Total Enclosure</u>; US EPA Method 204 (June 1997), Code of Federal Regulations, 40 CFR Part 51, Appendices M.
- J. T. Radia; "Dust and Fume Control for Cleaning and Finishing Operations in Foundries", <u>Proceedings of AFS-CMI Conference on Cleaning Room Technology - An Update for the</u> <u>80s; pp 235-298 (1981).</u>
- 5. Private Communication with Gary Mosher, CIH, Vice President, Environmental Health and Safety, American Foundrymen's Society, Des Plaines, IL, July 23, 1997.
- 6. Private Communication with Patricia Schilling, CIH, Industrial Hygienist, Deere & Co., Moline, IL, July 22, 1997.
- 7. <u>Proposed American National Standard for the Recirculation of Air from Industrial Process</u> <u>Exhaust Systems</u>; ANSI/AIHA Standard Z9.7 (1997).
- 8. <u>Engineering Field Reference Manual</u>; American Industrial Hygiene Association, Akron, Ohio (1982).



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MEMORANDUM OF UNDERSTANDING BETWEEN	Million 210103010 0383181		
OHIO CAST METALS ASSOCIATION	0EC 30 - 89		
& THE OHIO ENVIRONMENTAL PROTECTION AGENCY	CHIO E.P.A.		
OCMA supplier members will provide a listing of the common binder systems (with trade names) supplied to Ohio foundries for core/mold making operations. The suppliers will define common, categories of resins/binders used in the foundry industry.			
A working group will be formed with representatives from OCMA and Ohio EPA/DAPC to share information about core/mold making processes.			
OCMA supplier members agree to test the most common or representative systems in a Round Robin Double Blind Study to be conducted using their respective laboratories. The emission data will be determined using "weight loss" analyses. The tests will be performed in accordance with the attached testing protocol and will measure potential VOC emissions from core/mold making operations. OCMA will provide recommendations for emission factors for VOC to Ohio EPA/DAPC in the form of a written report summarizing, analyzing, and interpreting the test data.			
In addition to the testing program, OCMA agrees to provide available data on furan based binder systems.			
Utilizing the data gathered under item (3), OCMA will determine the cost-effectiveness of compliance with OAC rule 3745-21-07(G) for "typical" core/mold making operations for the following purposes:			
a) to serve as a model BAT analysis that can be used by Ohio foundrie for "typical" core/mold making operations, as required by OAC rule 3	s when applying for PTI's 745-31-05; and		

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b) to support a RACT rule under OAC rule 3745-21-09 or category exemption under OAC rule 3745-21-07(G) for core/mold making operations in foundries.

The definitions of the various, "typical" operations will be agreed upon by the Ohio EPA and OCMA in advance of the cost-effectiveness studies. A preliminary industry-wide cost impact for Ohio will be estimated from available vendor data. The OCMA effort also will include a review of regulations on VOC emissions in other states with major foundry populations.

- 5. During the preparation by OCMA of the information outlined in items (1), (3), and (4), Ohio EPA will continue to process permits to install and permits to operate submitted to Ohio EPA from Ohio foundries using an emission factor of .0008 pound of OC per ton of cores produced (from the AIRS data base), unless facility-specific test data is available for use in processing the permits. OCMA and Ohio EPA/DAPC agree to the use of the attached "reopening" language in the permits during this interim period.
- 6. The attached timetable sets forth the schedule for completion of this activity. Ohio EPA will continue to exercise enforcement discretion with respect to the application of OAC rule 3745-21-07(G) for core/mold making operations until the OCMA research program is complete, the data are evaluated by OCMA and Ohio EPA/DAPC, and consensus is reached on the appropriate emission factors and air pollution control requirements. This enforcement discretion shall not extend beyond the completion date set forth in the timetable.
- 7. Ohio EPA/DAPC is prepared to consider various types of relief from OAC rule 3745-21-07(G) including a change in the rule, company-by-company relief, or variances, but this consideration will depend upon the knowledge gained in the project. Ohio EPA/DAPC agrees to work with the OCMA and the industry to resolve any compliance issues that may arise as a result of improved knowledge about actual OC/VOC emissions from the core/mold making operations.

#### SIGNATORIES FOR THE MEMORANDUM OF UNDERSTANDING BETWEEN **OHIO CAST METALS ASSOCIATION** &

#### THE OHIO ENVIRONMENTAL PROTECTION AGENCY

Each signatory represents and warrants that he has been duly authorized to sign this document and so bind the Ohio Cast Metals Association and the Ohio Environmental Protection Agency to all terms and conditions thereof.

IT IS SO ORDERED AND AGREED:

Donald R. Schregardus Director

Ohio Environmental Protection Agency

Mark E. Armstrong President Ohio Cast Metals Association

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Date

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TIMETABLE FOR DEVF JPING EMISSION FACTORS FOR TH. JASTING INDUSTRY IN OHIO

- 1. On June 27, 1996, a list of common categories and specific trade names of resins/binders used in the foundry industry in Ohio was completed.
- 2. A working group with representatives from the Ohio Cast Metals Association and Ohio EPA/DAPC has been formed to share information about core/mold making processes.
- 3. OCMA supplier members agree to test the most common or representative systems in a Round Robin Double Blind Study to be conducted using their respective laboratories. OCMA will provide recommendations for emission factors for VOC to Ohio EPA/DAPC in the form of a written report summarizing, analyzing, and interpreting the test data.
- 4. On or before February 28, 1997, OCMA/DAPC will determine the appropriate emission factors to be used in the "typical" core/mold making operations using the data gathered under item (3).
- 5. On or before September 1, 1997, the activities outlined under items (3), (4) and (6) of the Memorandum of Understanding will be completed.

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### PTI Terms and Conditions

The Ohio EPA reserves the right to: (a) update the emissions factors used to estimate Organic Compound (OC) and Volatile Organic Compounds (VOC) emissions and/or (b) redefine the actual and allowable OC/VOC emissions in this permit to install for the core and/or mold making process(es) at the facility.

Upon written notification from the Ohio EPA concerning the identification and availability of updated and more representative OC/VOC emission factors, the permittee may be required to reevaluate the estimated OC/VOC emissions from the core and/or mold making operation(s) using the updated emission factors. Should the updated emission factors indicate an increase in estimated OC and/or VOC emissions the permittee shall submit the following (one copy to the appropriate District Office or Local Air Agency and one copy to the Ohio EPA, Division of Air Pollution Control, Engineering Section):

1) Revised OC/VOC Emissions Estimates:

> Within sixty (60) days of receipt of the written notification from Ohio EPA, the permittee shall submit updated OC/VOC emissions estimates (maximum rate in Ibs/hour and tons/year) for each core and/or mold making operation covered under this permit, using the updated emission factors.

- 2) Reevaluation of BAT and Compliance with OAC Rule 3745-21-07(G):
  - Within one hundred and twenty (120) days of submittal of the revised a. emissions estimates, for each core and/or mold making operation the permittee shall submit:

(i) for each core and/or mold making operation permitted herein utilizing photochemically reactive materials, as defined in OAC rule 3745-21-01, an analysis that reevaulates the status of compliance with the requirements of OAC rule 3745-21-07(G); and

- (ii) a Best Available Technology (BAT) analysis or study, conducted in accordance with Ohio EPA Engineering Guide #46, if appropriate, that defines BAT for the operation(s).
- b. Within thirty (30) days of submittal of the rule analysis and the BAT analysis or study, facility representatives shall meet with representatives of the Ohio EPA, DAPC and the appropriate District Office of local air agency to discuss and resolve any issues related to the submittals.
- Should the rule analysis and/or BAT analysis or study indicate that at the с. revised estimated OC/VOC emission rates additional emissions reductions are warranted to meet the requirements of OAC rule 3745-21-07(G) and/or the BAT requirements (OAC rule 3745-31-05), within thirty (30) days after CHIO E.P.A. submission of the analysis or study, the permittee shall submit an

expeditious schedule for implementation of the additional emissions control DEC 30 96 for the core and/or mold making operations permitted herein. This schedule TRED DIRECTOR'S JOURNAL

### Milestone Date Submit, if required, a PTI modification application implementing the revised BAT determination by Execute the purchase order(s) for procurement of equipment or components needed to implement additional emissions control by iii. Initiate installation of equipment and/or components, or initiate implementation of operational changes, to implement additional OC/VOC emissions control by iv. Complete installation of equipment and/or components, or operational changes, to implement additional OC/VOC emissions control by Achieve and demonstrate final compliance with OAC rule 3745-21-07(G) and/or the revised BAT determination. by

#### 3. Title V Permit Application:

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#### Existing Title V facilities a.

For a facility with a Title V application previously submitted, within one hundred and eighty (180) days of the revised BAT determination or submittal of the revised emissions estimates, whichever is later, the permittee shall submit a revised Title V application incorporating the revised emissions estimates and any other information needed to update the application as a result of the revised emissions estimates.

- b. "New" Title V facilities (only applicable to facilities which become subject to Title V permitting requirements (OAC Chapter 3745-77) as a result of increased OC/VOC emissions from the use of the updated emission factors)
  - i. Within thirty (30) days of submittal of the revised estimated emissions (item #1 above), the permittee shall submit a revised "potential to emit" determination for the facility to the Ohio EPA, DAPC, Engineering Section and appropriate District Office or local air agency.
  - ii. Within one year of submittal of the revised emissions estimates (item #1), the permittee shall submit a complete Title V permit application, federally enforceable state operating permit application, or permit to install application.

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#### Emissions Fee Report (for facilities subject to the Title V regulations):

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Within ninety (90) days of submittal of the revised estimated emissions (item #1), the permittee shall submit a Fee Emission Report to the Ohio EPA, in accordance with OAC Chapter 3745-78 and Ohio EPA Engineering Guide #61, for the most recent completed calendar year in which the facility would be classified as a "major" under the Ohio Title V regulations.

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### PTO/Title V Terms and Conditions

The Ohio EPA reserves the right to: (a) update the emission factors used to estimate Organic Compound (OC) and Volatile Organic Compounds (VOC) emissions and/or (b) redefine the actual and allowable OC/VOC emissions in this permit to operate for the core and/or mold making process(es) at the facility.

Upon written notification from the Ohio EPA concerning the identification and availability of updated and more representative OC/VOC emissions factors, the permittee may be required to reevaluate the estimated OC/VOC emissions from the core and/or mold making operation(s) using the updated emission factors. Should the updated emission factors indicate an increase in estimated OC and/or VOC emissions the permittee shall submit the following (one copy to the appropriate District Office or local air agency and one copy to the Ohio EPA, Division of Air Pollution Control, Engineering Section):

#### 1) <u>Revised OC/VOC Emissions Estimates:</u>

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Within sixty (60) days of receipt of the written notification from Ohio EPA, the permittee shall submit updated OC/VOC emissions estimates (maximum rate in lbs/hour and tons/year) for each core and/or mold making operation covered under this permit, using the updated emission factors.

#### 2) <u>Reevaluation of Compliance with OAC Rule 3745-21-07(G)</u>:

a. For each core and/or mold making operation permitted herein and using photochemically reactive materials, as defined in OAC rule 3745-21-01, within one-hundred and twenty (120) days of submittal of the revised emissions estimates, the permittee shall submit an analysis that reevaluates for each operation the status of compliance with OAC rule 3745-21-07(G).

b. Within thirty (30) days of submittal of the analysis, facility representatives shall meet with representatives of the Ohio EPA, DAPC and the appropriate District Office or local air agency to discuss and resolve any issues related to the submittal.

c. Should the analysis indicate that at the revised estimated OC/VOC emissions rates additional emission reductions are necessary to meet the requirements of OAC rule 3745-21-07(G), within sixty (60) days after submission of the analysis or the meeting conducted under item (2)(b), the permittee shall submit an expeditious schedule for implementation of the additional emissions reductions for the core and/or mold making operations permitted herein. This schedule shall include the following milestone dates, as applicable:

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- i. Execute the purchase order(s) for procurement of equipment or components needed to implement additional emissions control by
- ii. Initiate installation of equipment and/or components, or initiate implementation of operational changes, to implement additional OC/VOC emissions control by
- iii. Complete installation of equipment and/or components, or operational changes, to implement additional OC/VOC emissions control by
- iv. Achieve and demonstrate final compliance with OAC rule 3745-21-07(G) by
- 3. <u>Title V Permit Application:</u>
  - a. <u>Existing Title V facilities</u>

For a facility with a Title V application previously submitted, within one hundred and eighty (180) days of the submittal of the revised emissions estimates, the permittee shall submit a revised Title V application incorporating the revised emissions estimates and any other information needed to update the application as a result of the revised emissions estimates.

- <u>"New" Title V facilities</u> (only applicable to facilities which become subject to Title V permitting requirements (OAC Chapter 3745-77), as a result of increased estimated OC/VOC emissions from use of the updated emission factors)
  - Within thirty (30) days of submittal of the revised estimated emissions (item #1 above), the permittee shall submit a revised "potential to emit" determination for the facility to the Ohio EPA, DAPC, Engineering Section and the appropriate District Office or local air agency.
  - Within one year of submittal of the revised emissions estimates (item #1), the permittee shall submit a complete Title V permit application, federally enforceable state operating permit application, or permit to install application.

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<u>Date</u>

#### 4. <u>Emissions Fee Report (for facilities subject to the Title V regulations):</u>

Within ninety (90) days of submittal of the revised estimated emissions (item #1), the permittee shall submit a Fee Emission Report to the Ohio EPA, in accordance with OAC Chapter 3745-78 and Ohio EPA Engineering Guide #61, for the most recent completed calendar year in which the facility would be classified as a "major" under the Ohio Title V regulations.

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Appendix B Correspondence on "Typical Operations"

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" Marys Foundry, Inc. Varys

Dave Yonto The Quality Castings Co.

Stephen Barry

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Joe W. Harden Buckeye Steel Castings Co. Ms. Tammy Hilkens Environmental Supervisor Ohio EPA/DAPC P.O. Box 1049 Columbus, OH 43216-1049

Dear Ms. Hilkens:

SSOCIATION

As promised at our Working Group meeting on Friday, February 7, 1997, enclosed is information pertaining to the Ohio Cast Metals Association (OCMA) efforts to define a "typical" core/mold making operation. The attached memo from Craig Schmeisser, RMT, Inc., outlines the activities of the OCMA Typical Foundry Subcommittee and summarizes the results. Also enclosed is a spread sheet that contains specific information about core/mold making operations from approximately 50 foundries in Ohio contacted by subcommittee members in a telephone survey. As we discussed, the efforts determined what we had assumed earlier, due to great variation in operations of the individual foundries, it is impossible to define a "typical" core/mold making operation.

In light of this result, under Item #4 of the MOU, we are recommending the following:

- 1. For the BAT study, assume the "typical" core/mold making operation is one that has a throughput rate that will lead to VOC emissions near or equal to eight (8) pounds per hour or forty (40) pounds per day using the emission factors that we have recommended to the Agency.
- 2. OCMA's Typical Foundry Subcommittee will provide to you in the next two weeks further descriptive information pertaining to what we believe constitutes a typical core/mold making operation. Variables we plan to include are throughput rate, storage time and size of storage area.
- 3. Once selected, OCMA's environmental consultant for the BAT analysis will be responsible for working with the OCMA BAT subcommittee and the Working Group to determine any other assumptions necessary for the BAT study.

artes Rentschler The Hamilton Foundry & Machine Co. Ms. Tammy Hilkens Page 2 February 21, 1997

Under this scenario, if it is determined that it is not cost-effective to control VOC's at selected throughput rate(s), it should follow that controls for a lesser throughput rate will also not be cost effective. If it is determined that controls at the higher rate of throughput are appropriate, the information should be extremely useful in determining at what throughput rate controls are not economically justifiable.

If you have any questions concerning our recommendation, please do not hesitate to call.

Per our discussion at the Working Group meeting, we are anticipating a response from the DAPC concerning the OCMA recommended emission factors for potential VOC emissions outlined in my letter to Robert Hodanbosi on February 7, 1997. Per the Timetable, Item #4, we are to determine these factors by February 28, 1997. We are looking forward to your response.

Sincerely, Muss Munay

Russ Murray Executive Director

Mark E. Armstrong, OCMA President
 William L. Tordoff, OCMA Secretary
 Steve Wilson, OCMA Vice President for Environmental Affairs
 Members of the OCMA Environmental Affairs Typical Foundry Subcommittee
 Al Franks, Ohio EPA
 Robert Hodanbosi, Ohio EPA
 James A. Orlemann, Ohio EPA

MEMORANDUM

DATE:	February 18, 1997	
TO:	Mr. Russ Murray	
FROM:	Craig Schmeisser	
SUBJECT:	PUCB/PUNB "Typical" Operations Subcommittee	

I thought I would try and bring the subcommittee to a close by issuing this memorandum. I have attached the latest spreadsheet of collected data as prepared by Harry.

The subcommittee completed the following tasks:

- Created a datasheet to collect information relevant to identifying the typical PUNB/PUCB operation;
- Contacted 50 foundries to discuss their coremaking operations;
- Compiled the survey information into a spreadsheet, and
- Reviewed the information to determine characteristics of the "typical" core/mold making operation.

#### Findings and Conclusions

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- 68% of the foundries contacted have at least one core or moldmaking operation utilizing a PUCB or PUNB binder systems.
- Over 30 coremaking operations were found using a PUCB binder system.
   Only 4 moldmaking operations were found using a PUCB binder system.
   Over 35 coremaking operations were found using a PUNB binder system.
   Over 50 moldmaking operations were found using a PUNB binder system.
- Most configurations were one mixer supplying sand to one machine.
- Highly variable sand throughput rates were found for both binder systems

-	PUCB Coremaking	140 to 18,000 lbs/hr
	PUNB Coremaking	30 to 12,000 lbs/hr
-	PUNB Moldmaking	47 to 40,000 Ibs/hr

• Range of time stored was variable; ranging from two to 72 hours. With the production and time stored being highly variable, it follows that the storage areas will also differ substantially.

2/18/97

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TYPICAL CORE / MOLD MAKING OPERATIONS IN OHIO

C. Box Collector's Foundry Core or or No-Average Sand Range of Thruput Configuration Name Number Mold Bake Max Sand Thruput Time Core (lbs/hr) (TPY) (lbs/hr) (TPY) Stored 3 8 9 12 13 1 2 4 6 7 CS 1 cb 18000 2089 18000 8640 8 c 18000 <2 cs 1 c cb 18000 6000 21 Stations most 7 1885 2587 have own mixer cs c cb cs 11 cb 1426 8580 <12 c CS 12 cb 3000 1000 c cs 15. съ 2000 6480 С Assumed for new cs 15 cb 2000 6480 core mach. c 15000 20000 20000 16 Multiple Stations 2 RM с cb 15000 1 Mixer / 3 <24 stations CS 5 140 220 съ С cs 14 cb с 7200 cs 14 cb 6000 С nb CS 2 1875 5800 (24-72) С (2-24) 1 Mixer / Station CS 4 С nb 4803 5764 cs 4 nb 4803 5764 (2-24) 1 Mixer / Station c CS 10 nb <1 c CS 14 c nb 1352 3776 nb RM 1 c 400 48 RM 3 nb (24-48) c <24 RM 4 С nb 1 с nb 160 528 2400 10512 (2-4) 5 core mach. JA

**Revision 2**
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TYPICAL CURE / MULD MAKING OPERA NONS

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Revision 2

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Collector's Name	System Number	Core or Mold	C. Box or No- Bake	Average Thru	e Sand put	Max Sand T	hruput	Range of Time Core	Configuration
				(lbs/hr)	(TPY)	(lbs/hr)	(TPY)	Stored	
1	2	3	4	6	7	8	9	12	13
JA	2	<u>c</u>	nb	39.71	38.9	8571	37543		7 core mach.
JA	3	с	nb	766.6/900	230/270	13500 / 900	59130 / 3942		Core lg/sm
JA	5	с	nb	192	192	733.33	6716	= 1 day</td <td>3 core mach.</td>	3 core mach.
JA	6	с	nb	30.4	31.57	2000	8760		2 core mach.
JA	9	c	nb	3000	1872	3000	13140	96 Max.	1 mixer & 1 core mach.
JA	10	c	nb	12000	1080	18000	78840		1 mbxer & 1 core mach.
JA	11	c	nb	1800	375.75	1800	1884		1 mixer and 1 core machine
JA	13	С	nb				_		
JA .	14	c	nb	6000	507.2	6000	26280		1 mixer and 1 core machine
JA	15	C	punb	13,000	3266	13500	59130		
JA	16	c	punb	1276	2249.1	6120	26805		1 mixer and 1 core machine
JA	17	C	punb	3500	9000	5000	21900		
JA	4	c/m	сь	4465	9776	4465	19553		5 Inter-changeable core and mold mach.
CS	2	c/m	nb	3656			7020	(8-10)	
CS	5	c/m	nb	468			508	c: (8-48) m:(Sameday)	
CS	9	c/m	nb	44			66	48 cores 9 molds	2 mach 1 does 90% cores; 1 does 90% molds

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## TYPICAL CORE / MOLD MAKING OPERATIONS IN OHIO

Revision 2

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			C. Box						
Collector's	System	Core or	or No-	Average	Sand			Range of	
Name	Number	Mold	Bake	Thru	put	Max Sand T	hruput	Time Core	Configuration
				(lbs/hr)	(TPY)	(lbs/hr)	(TPY)	Stored	
1	2	3	4	6	7	8	9	12	13
CS	6	m	cb	6000			21710		
CS	6	m	cb	6000			21710		
CS	6	m	cb	6000			21710		
CS	6	m	cb	6000			21710		
CS	1	m ·	nb	8625	19622	20060	69538	<2	
CS	4	m	nb	22415			26898	24	1 mixer & station
CS	12	m	nb	4337 Max			3375		
									10,000 total between 2
CS	13	m	nb				10000	(1-3)	machines
RM	1	m	nb					48	
RM	3	m	nb					(24-48)	
RM	4	m	nb					<24	
JA	1	m	nb	500	170	6000	76280		2 mold mach.
JA	2	m	nb	57.14	70.88	6000	26280		6 mold mach.
JA	3	m	nb	96.13	115.33	1750	7665		3 mold mach.
JA	5	m	nb	1054	1581	2680	11738		7 mold mach.
JA	6	m	nb	323.13	336.06	4000	17520		6 mold mach.
AL	9	m	nb	18000	24837	72000	315360		3 mixers and 3 mold mach.
JA	14	m	nb	43067	12311	45200	127976		3mullers and 3 mold machines
JA	15	m	punb	38800	25872	42000	183960		3 mullers and 3 mold mach.
JA	17	m	punb	12110	24030	13750	69225		2 mixers and 2 mold mach.

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(614) 876-5100 • FAX (614) 876-3615

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y Dine Marys Foundry, Inc. s Unite Orably Castings Co. vie *xp:re 1909* phon Barry

S, Inc

March 13, 1997

Ms. Tanımy Hilkens Environmental Supervisor Ohio EPA - DAPC P.O. Box 1049 Columbus, OH 43216-1049

Dear Ms. Hilkens:

CAST METALS ASSOCIATION

This letter is a follow-up to my letter of February 21, 1997. As promised, outlined below is additional information from the OCMA Typical Foundry Subcommittee to further describe the typical foundry phenolic urethane coldbox (PUCB) and no-bake (PUNB) mold/core making operations for purposes of the BAT development.

### Scleetion of Throughput Rates and Maximum Annual Emissions

A sand throughput rate will be selected such that total VOC emissions from the emissions unit (including storage) will equal 40 pounds per day. Binder additions will be 1% by weight of sand as was used in the Round Robin Double Blind Study conducted by OCMA supplier members. Catalyst usage will be assumed to be 10% by weight of binder.

For the acid scrubber, which is included in the "typical" PUCB operation, vendor design control efficiency information or actual stack testing data will be used to estimate the catalyst emission rate. An estimated capture efficiency of 99.5% will be used for the catalyst.

An annual maximum VOC emission of seven tons will be used based on 40 pounds of VOC per day at a production schedule of 50 weeks per year and 7 days per week.

### Storage Time

In the survey of Ohio foundries conducted by the OCMA Typical Foundry Operations Subcommittee, the actual storage times in Ohio foundries varied widely and a typical storage time could not be clearly identified. By taking the mean of storage time ranges, the average storage time was found to be approximately 16 hours, though 15 of 24 systems surveyed were less than 12 hours (or a part of the range was below 12 hours). Ms. Tammy Hilkens Page 2 March 13, 1997

Because of the requirement of OAC 3745-21-07 (G) (5) which states that "emissions of organic material to the atmosphere resulting from air or heated drying of products for the first 12 hours after their removal from any article, machine, equipment...shall be included with the emissions of organic materials..."and the fact that the Round Robin Double Blind Study measured emissions for a 12 hour period, a storage time of 12 hours has been selected for the BAT analysis of the typical operation.

#### Storage Area

For the BAT analysis, the dimensions and ventilation parameters for the storage area will be determined by reviewing member foundry mold/core making operations and corresponding storage areas. The dimensions of the storage area will then be the area necessary to store 12 hours of production at the selected throughput rate.

Should you have any questions, please contact me. We are anxious to move forward with the BAT analysis as discussed at our Working Group meeting on February 24, 1997. However, per the memorandum of agreement, we need to reach agreement on the appropriate emission factors before the BAT analysis can proceed. We are already behind schedule so we need to reach agreement as soon as possible. Looking forward to your response.

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Russ Murray C

Mark E. Armstrong, OCMA President William L. Tordoff, OCMA Secretary Steve Wilson, OCMA Vice President for Environmental Affairs Al Franks, Ohio EPA Robert Hodanbosi, Ohio EPA James A. Orlemann, Ohio EPA

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# Appendix C Binder Test Results

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Appendix C-1 Test Protocol

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### PROTOCOL FOR VOC TESTING FOR FOUNDRY BINDER SYSTEMS

### INTRODUCTION

The State of Ohio regulates VOC emissions from photochemically reactive materials under OAC 3745-21. This regulation has the greatest impact on those foundries using the phenolic urethane cold box and no-bake systems. The VOC emissions from these systems during coremaking and core storage only are limited by this regulation to 8 pounds per hour and 40 pounds per day from a given process. There are many ways to estimate the emissions, but no one generally accepted emission factor has been established. The purpose of this protocol is to establish a more accurate estimate of the VOC emissions from the mixing, coremaking, and core storage when using phenolic urethane binders.

### SCOPE

The major suppliers of foundry binders in Ohio, Ashland Chemical, Borden Industrial Resins, and Delta Resins and Refractories have agreed to perform laboratory testing to determine VOC emissions during mixing, coremaking and core storage for the phenolic urethane coldbox and no-bake systems. Each of the suppliers will supply to the other laboratories samples of their most typical systems sold in the State of Ohio. The supplier laboratories will test the resin systems using the "weight loss" method described below.

### APPARATUS

- 1. Thermometer, 0-300 F accurate to 1 degree F.
- 2. Balance, 5000 g capacity accurate to 0.1 gram.
- 3. Sand mixer, Hobart N-50 with bowl and flat mixer blade.
- . 4. Timer accurate to 1 second.

### MATERIALS

- 1. Wedron 540 washed and dried silica sand.
- 2. Resin systems to be tested.
- 3. Containers for resins and eyedroppers necessary to accurately transfer resins and catalysts.

### PROCEDURE

1. Weigh the mixing bowl and blade and record the data on the work sheet.

2. Add 3000 grams of Wedron sand at 72-77 degrees F to the mixing bowl. OHIO E.P./Record the weight of the bowl plus sand.

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Add the prescribed amounts of Part I resins, Catalysts, and Part II resins to the sand mix being careful to keep resins away from the sides of the mixing bowl. Record the weights of the components added.

	Part I	Part II	Catalyst
Phenolic Urethane No-bake	İ6.5 g	13,5 g	0.5 g
Phenolic Urethane Coldbox	16.5 g	13.5 g	NA

4. Insert the mixing blade into the bowl and record the weight of the bowl, blade, sand, and resin components.

5. Mix for 2 minutes at speed #1 then record the weight of the bowl, blade, sand and resin components. Record the difference of the weight in step 4 and step 5 as the VOC emissions during mixing.

Place the bowl, blade, sand and resin component mix in an area kept between 72 and 77 degrees F free of air flow variations. Record the weight of the undisturbed sand mix at 30 minutes, 1 hour and every hour until the mix is 12 hours old. Record the incremental VOC loss at the end of each time period and the total VOC loss (difference from the weight in step 4).

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# Appendix C-2 Supplier Laboratory Results

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COMPANY: Ashland Chemical - OCMA ADDRESS: Dublin, Ohio

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WO#: 10766 Originator: Greg Sturtz

و ربد میسه

DATE: 1/8/97

OBJECTIVE: Determine VOC emmissions using "Weight Loss Method" on typical phenolic urathane coldbox and nobake systems from ACME, DELTA and ASHLAND.

Wedron 540 SAND: BALANCE: Meller PE 16 #E29707

		Mix 1		<u><u><u>u</u>ix 2</u></u>				Mitr 3		AVERAGE		
<b>AESIN PT 1</b>		DELTA Technikure A			Borden PUCB   Coldbo	ĸ		Ashland ISDCURE A		Phenolic Urethane	Coldbox	
RESIN PT 2		DELTA Technikure B			Borden PUCB & Coldbo	x		Ashland ISOCURE B		Binder Syst	am	
	Weight	incremental VOC's	Total YOC's	Weight	Incremental VOC's	Total VOC's	Weight	Incremental YOC's	Total YOC's	incremental VOC's	Total VOC's	
Bofore Mix	4178.4	•	-	4234.7	•	•	4360.5	-	-	-	~	
After Mix	4178.4	0.0	0.0	4234.8	-0.1	-0.1	4360.5	0.0	0.0	0.0	0.0	
At 30 Min	4178.4	0.0	0.0	4234.7	0.1	0.0	4360.2	0.3	0.3	0.1	0.1	
At 1 Hour	4178.5	-0.1	-0.1	4234.6	0.1	0.1	4360.1	0.1	0.4	0.0	0.1	
At 2 Hour	4178.3	0.2	0.1	4234.5	0.1	0.2	4360.0	0.1	0.5	0.1	0.3	
At 3 Hour	4178.2	0.1	0.2	4234.5	0.0	0.2	4360.0	0.0	0.5	0.0	0.3	
At 4 Hour	4178.1	0.1	0.3	4234.3	0.2	0.4	4360.0	0.0	0.5	0.1	0.4	
At 5 Hour	4177.9	0.2	0.5	4234.2	0.1	0.5	4359.9	0.1	0.6	0.1	0.5	
At 6 Hour	4177.9	0.0	0.5	4234.4	-0.2	0.3	4359.7	0.2	0.8	0.0	0.5	
At 7 Hour	4177.9	0.0	0.5	4234.3	0.1	0.4	4359.6	0.1	0.9	0.1	0.6	
At 8 Hour	4177.8	0.1	0.6	4234.2	0.1	0.5	4359.6	0.0	0.9	0.1	0.7	
A19 Hour	4177.7	0.1	0.7	4234.2	0.0	0.5	4359.5	0.1	1.0	0.1	0.7	
At 10 Hour	4177.5	0.2	0.9	4234.1	0.1	0.6	4359.5	0.0	1.0	0.1	8.0	
At 11 Hour	4177.5	0.0	0.9	4234.0	0,1	0.7	4359.4	0.1	1.1	0.1	0.9	
AI 12 Hour	4177.5	0.0	0.9	4234.0	0.0	0.7	4359.3	D.1	1.2	0.0	0.9	

## **CAREFORNTIAL**

COMPANY: Ashland Chemical - OCMA ADDRESS: Dublin, Ohlo WO#: 10766

Originator: Greg Sturtz

DATE: 1/8/97

OBJECTIVE: Determine VOC emmissions using "Weight Loss Method" on typical phenolic urethane coldbox and nobake systems from ACME, DELTA and ASHLAND.

SAND: Wedron 540 BALANCE: Mettler PE 16 #E29710

		Max 4		Mar II				Mas		AVERAGE		
RESIN PT 1		DELTA Techniset A			Borden PUNB I			Ashland PEP SET A		Phonolic Urethane	No-Bake	
RESIN PT 2		DELTA Techniset B			Borden PUHB II			Ashland PEP SET 8		Binder Syst	em .	
	Weight	Incremental VOC's	Total VOC's	Weight	Incremental VOC's	Total VOC's	Weight	Incremental YOC's	Total VOC's	Incremental VOC's	Total VOC's	
Before Mix	4298.8	•	•	4347.7		•	4348.9	-	-	-	•	
After Hix	4298.4	0.4	0.4	4347.1	0.6	0.8	4346.6	0.3 .	0.3	0.4	0.4	
At 30 Min	4298.3	0,1	0.5	4347.0	0.1	0.7	4346.3	0.3	0.6	0.2	0.6	
At 1 Hour	4298,1	0.2	0.7	4346.9	0.1	8.0	4345.3	0.0	0.8	0.1	0.7	
At 2 Hour	4298.0	0.1	0.8	4346.8	0.1	0.9	4346.1	0.2	0.8	0.1	0.8	
A1 3 Hour	4297.9	0.1	0.9	4346.5	0.2	1.1	4346.0	0.1	0.9	0.1	1.0	
A14 Hour	4297.5	0.3	1.2	4346.4	0.2	1.3	4345.B	0.2	1.1	0.2	1.2	
A15 Hour	4297.6	0.0	1.2	4346.4	0.0	1.3	4345.7	0.1	1.2	0.0	1.2	
AL6 Hour	4297.5	0.1	1.3	4346.3	0.1	1.4	4345.6	0.1	1.3	0.1	1.3	
At 7 Hour	4297.4	0.1	1.4	4346.3	0.0	1.4	4345.5	0.1	1.4	0.1	1.4	
At 8 Hour	4297.3	0.1	1.5	4346.1	0.2	1.6	4345.5	0.0	1.4	Q.t	1.5	
At 9 Hour	4297.2	0.1	1.6	4346.1	0.0	1.6	4345.5	0.0	1.4	0.0	1.5	
At 10 Hour	4297.2	0.0	1.6	4345.9	0.2	1,8	4345.3	0.2	1.6	1.0	1.7	
At 11 Hour	4297.2	0.0	1.6	4345.9	0.0	1.8	4345.2	0.1	1.7	0.0	1.7	
AL 12 Hour	4297,1	Q.1	1.7	4345.8	0.1	1.9	4345.2	0.0	1.7	0.1	1.8	

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COMPANY: BORDEN CHEM ICAL, INC.

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Concerned and

DRESS: FOREST PARK, IL

DATE: 1/27/97

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OBJECTIVE: DETERMINE VOC EMISSIONS USING THE OCMA'S SANCTIONED WEGHT LOSS METHOD ON TYPICAL PHENOLIC URETHANE COLDBOX AND NOBAKE SYSTEMS FROM ASHLAND, BORDEN, AND DELTA

## COLD BOX

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	Mixture Nur Average of	nber 1 Duplicate Ru	ns	Mi) Avi	dure Nu erage of	mber 2 Duplicate Ru	ns		Mixture Nur Average of	nber 3 Duplicate Ru	ns	AVERAGE		
F N PT 1 RESIN PT 2	DELTA TEO	CHNIKURE P CHNIKURE P		BC	RDEN S	SIGMA CURE	7100		ASHLAND	ISOCURE IA	6	Phenolic Urethane Cold Box Binder System		
		Incremental	Total			Incremental	Tolal			Incremental	Total		Incremental	Total
	Weight	VOC's	VOC's	\ \	<u>Neight</u>	VOC's	VOC's		Weight	VOC's	VOC's		VOC's	VOC's
BEFORE MIX	3944.1	-	-	3	943.0		-		3943.0	-	-		-	-
AFTER 2 MIN MIX	3944.1	0.0	0.0	3	942.8	0.0	0.3		3942.8	0.0	0.2		0.0	0.1
30 MIN	3944.0	0.1	0.1	3	942.6	0.1	0.4	-	3942.3	0.5	0.7		0.2	0.4
1 HOUR	3943.9	0.1	0.1	3	942.6	0.1	0.4		3942.3	0.0	0.7		0.0	0.4
2 HOUR	3943.7	0.2	0.3	3	942.6	0.0	0.4		3942.3	0.0	0.7		0.1	0.5
3 HOUR	3943.6	0.1	0.4	3	942.5	0.1	0.6		3942.1	0.2	0.9		0.1	0.6
4 HOUR	3943.5	0.1	0.5	3	942.5	0.0	0.6		3942.0	0.1	1.0		0.1	0.7
5 HOUR	3943.5	0.0	0.5	3	942.4	0.1	0.6		3941.9	0.1	1.1		0.0	0.7
6 HOUR	3943.5	0,1	0.6	3	942.4	0.0	0.6		3941.9	0.0	1.1		0.0	0.8
7 HOUR	3943.5	0.0	0.6	3	942.4	0.0	0.6		3941.8	0.1	1.1		0.0	0.8
8 HOUR	3943.4	0.1	0.6	3	942.4	0.0	0.6		3941.8	0.0	1.1		0.0	0.8
9 HOUR	3943.4	0.0	0.7	3	942.4	0.0	0.6		3941.8	0.1	1.2		0.0	0.8
10 HOUR	3943.3	0.1	0.7	3	942.3	0.1	0.7		3941.7	0.1	1.3		0.1	0.9
11 HOUR	3943.3	0.0	0.7	3	3942.3 0.0 0.				3941.7	0.0	1.3		0.0	0.9
12 'JR	3943.3	0.1	0.8	3	942.3	0.0	0.7		3941.7	0.0	1.3		0.0	0.9

COMPANY: BORDEN CHEM ICAL, INC.

ADDRESS: FOREST PARK, IL

DATE: 1/27/97

OBJECTIVE: DETERMINE VOC EMISSIONS USING THE OCMA'S SANCTIONED WEGHT LOSS METHOD ON TYPICAL PHENOLIC URETHANE COLDBOX AND NOBAKE SYSTEMS FROM ASHLAND, BORDEN, AND DELTA

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	Mixture Nur Average of	nber 1 Duplicate Ru	ns	A A	Mixture Nur Average of	nber 2 Duplicale Ru	ins		Mixture Nur Average of	nber 3 Duplicate Ru	ns		AVERAGE	
IN PT 1 RESIN PT 2	DELTA TEC	CHNISET PT	IA IIB	E	BORDEN S	GIGMA SET (	5100 5500		ASHLAND	PEPSET IA PEPSET IIB		Phenolic Ur E	rethane No Ba Binder Systen	ake 1
		Incremental	Total			Incremental	Total			Incremental	Total		Incremental	Total
•	Weight	VOC's	VOC's		Weight	VOC's	VOC's		Weight	VOC's	VOC's		VOC's	VOC's
BEFORE MIX	3951.3	-	• .		3951.5	-	-		3951.2	-	-		-	-
AFTER 2 MIN MIX	3951.0	0.0	0.3		3951.3	0.0	0.3		3951.0	0.0	0.2		0.0	0.3
30 MIN	3950.6	0.4	0,8		3950.9	0.4	0.6		3950.9	0.1	0.3		0.3	0.6
1 HOUR	3950.5	0.1	0.9		3950.7	0.2	0.8		3950.5	0.4	0.7		0.2	0.8
2 HOUR	3950.3	0.2	1.0		3950.5	0.2	1.0		3950.5	0.1	0.8		0.1	0.9
3 HOUR	3950.2	0.1	1.2		3950.4	0.1	1.1		3950.3	0.2	0.9		0.1	1.1
4 HOUR	3950.2	0.0	1.2		3950.4	0.0	1.1		3950.3	0.0	1.0		0.0	1.1
5 HOUR	3950.1	0.1	1.3		395D.2	0.2	1.3		3950.1	0.1	1.1		0.1	1.2
6 HOUR	3950.0	0.1	1.3		3950.2	0.1	1.4		3950.1	0.1	1.2		0.1	1.3
7 HOUR	3949.9	0.1	1.4		3950.2	0.0	1.4		3950.0	0.1	1.2		0.1	1.3
8 HOUR	3949.9	0.0	1.4		3950.1	0.0	1.4		3950.0	0.0	1.3		0.0	1.4
9 HOUR	3949.8	0.1	1.5		3950.1	0.1	1.4		3949.9	0.1	1.3	_	0.1	1.4
10 HOUR	3949.8	0.0	1.6		3950.1	0.0	1.4		3949.8	0.1	1.4		0.0	1.5
11 HOUR	3949.7	0.0	1.6		3950.0	0.1	1.5		3949.8	0.0	1.4		0.0	1.5
1' IUR	3949.7	0.1	1.7		3950.0	0.1	1.6		3949.7	0.1	1.5		0.1	1.6

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### NO BAKE

08/97 TUE 13:37 FAX 13133688452 DELTA RESINS E **DELTA RESINS & REFRACTORIES** TSR #: 1940-2 (Page 2 of 3) Report Number: 01/05/97 Date: **OCMA** Customer: **Objective** Assist in establishing a more accurate estimate of the VOC emissions from the mixing, coremaking, and storage when using phenolic urethane binders. The major suppliers of foundry binders in Ohio - Ashland Chemical, Borden Industrial Resins, & Delta Resins and Refractories have agreed to perform laboratory testing to determine VOC emissions during mixing, coremaking, and core storage of the phenolic urethane coldbox and no-bake systems. Each of the suppliers will supply to the other laboratories, samples of their most typical systems sold in the State of Ohio. The supplier laboratories will test the resin systems using the "weight loss" method described on page one. Sand Test Parameters %Rel. Humidity: 22% Room Temp: 72°F H Sand Type: Wedron 540 Sand Temp: 72\*F % Resin: 1.00 Ratio: 55 45 2 1 3 SC CB Pt I TK PUC Part I IC IA Batch T-5178 E0210.0 T-5127 Part II SC CB Pt II TK PI II D IC II B Batch T-5179 E0211.0 T-5128 1940-2 Sand Testing Results 3 1 2 Mooing Wt Loss -0.13 -0.19 -0.23 1st 30 Min Wt Loss -0.15 -0.17 -0.17 Cumulative Wt. Loss -0.28 -0.36 -0.40 2nd 30 Min Wt Loss -0.08 -0.10 -0.12 Cumulative WL Loss ·-**0.36** -0.48 -0.52 2nd Hr Wit Loss -0.08 -0.08 -0.09 Cumulative Wt. Loss -0.42 -0.54 -0.61 3rd Hr Wt Loss -0.07 -0.08 -0.10 Comulative Wt. Loss -0.49 -0.62 -0.71 4th Hr Wt Loss -0.08 -0.08 -0.08 Cumulative Wt. Loss -0.57 -0.70 -0.79 5th Hr Wt Loss -0.05 -0.08 -0.06 Cumulative Wt. Loss -0.62 -0.78 -0.85 6th Hr Wi Losa -0.04 -0.07 -0.05 Cumulative Wt. Loss -0.66 -0.85 -0.90 7th Hr Wt Loss -0.04 -0.07 -0.07 Comulative WL Lose -0.70 -0.92 -0.97 Bth Hr Wt Loss -0.03 -0,07 -0.05 Cumulative WL Loss -0.73 -0.99 -1.02 9th Hr Wt Loss -0.05 -0.05 . -0.04 Cumulative Wt. Loss -0.78 -1.04 -1.06 10th Hr Wt Loss -0.03 -0.04 -0.04 Cumulative WL Loss -0.81 -1.08 -1.10 11th Hr Wt Loss -0.02 -0.05 -0.03 Cumulative Wt. Loss -0.83 -1.13 -1.13 12th Hr Wt Loss -0.02 -0.06 -0.04 Cumulative Wt. Loss -0.85 -1.19 -1.17 12 - 18th Hr Wt Loss -0.10 -0.26 -0.16 Cumulative Wt. Loss -0.95 -1.45 -1.33 Copies to: DMT/DMH /DJH/ SSJ/RLS Originator Stone

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	Report Number.		(	Page 3 of 3	5)	TSR #:	1940-2
	Date:	01/05/97					
	Customer	OCMA					
				Objective			
	Assist in establish making, and storag The major supplie Deita Resins and R emissione during m no-beke systems. I most typical system systems using the "	hing a more aco e when using pl ars of foundry bi efractories have ixing, coremaki Each of the sup is sold in the St 'weight loss'' me	urete estima nenolic ureti nders in Oh s agreed to j ng, and core piers will su ate of Ohio, athod descri	tte of the VC vane binders o - Ashland perform labo storage of t pply to the c The supplis bed on page Sand Test	C emissions Chemical, Bo ratory testing the phenolic u other laboratories one. Parameters	from the mixing rden Industrial to determine V rethane coldbo iss, samples of will test the rea	, core- Resins, & OC x and i their tin
	%Rel. Humidity: Sand Type: % Resin:	22% Wedron 540 1.00	Ratio: 55	li 45		Room Temp: Sand Temp: % Cat (BOPt I	72°F 72°F 3.00
				, si			
	Part t	·	SDHIA	DOIA	55 MB 041		
	Batch		502080	F 5174	33 NO P(1		
	Cator		20200.0	1-0120	1-0180		
	Part II Batch	TS	5 Pt II B 20209.0	PS II B T-5126	SS NB Pt II T-5181	·	
	Cataluct		47 707				
	Catch	-	17-737	17-737	17-737		
	Dalch	. F	10548	P10648	PT064B		
	1940-2			Band Testi	ng Results		
	Mining Millions		1	2	6		
	MIXING VYT LOSS		-0.23	-0.30	-0.44		•

	4	5	6
Mixing Wt Loss	-0.23	-0.30	-0.44
1st 30 Min Wt Loss	-0.29	-0.30	-0.38
Cumulative Wt. Loss	-0.52	-0.60	-0.82
2nd 30 Min Wt Loss	-0.19	-0.13	-0.10
Cumulative Wt. Loss	-0.71	-0.73	-0.92
2nd Hr Wt Loss	-0.21	-0.21	-0.20
Cumulative WL Loss	-0.92	-0.94	-1.12
3rd Hr Wt Loss	-0.14	-0.15	-0.14
Cumulative WL Loss	-1.06	-1.09	-1.26
4th Hr Wt Loss	-0.12	-0.15	-0.13
Cumulative WL Loss	-1.18	-1.24	-1.39
5th Hr Wt Loss	-0.10	-0.11	-0.10
Cumulative Wt. Loss	-1.28	-1.35	-1.49
6th Hr Wt Loss	-0.12	-0.11	-0.06
Cumulative Wt. Loss	-1,40	-1.46	-1.55
7th Hr Wt Loss	-0.08	-0.09	-0.09
Cumulative WL Loss	-1.48	-1.55	-1.64
8th Hr Wt Loss	-0.08	-0.10	-0.03
Cumulative Wt. Loss	-1.56	-1.65	-1.67
9th Hr Wit Loss	-0.08	-0.07	-0.07
Cumulative Wt. Loss	-1.64	-1.72	-1,74
10th Hr Wt Loss	-0.05	-0.06	-0.10
Cumulative Wt. Loss	-1.70	-1.78	-1.84
11th Hr Wt Losa	-0.06	-0.03	-0.07
Cumulative Wt. Loss	-1.76	-1.81	-1.91
12th Hr Wt Loss	-0.05	-0.06	-0.06
Cumulative Wt. Loss	-1.81	-1.87	-1.97
12 - 18th Hr Wt Loss	-0.28	-0.35	-0.28
Cumulative Wt. Loss	-2_09	-2.22	-2.25
Copies to: DMT/DMH /DJH/ SSJ/RL	S	Original	tor: Stone
	Mixing Wt Loss Cumulative Wt.	4 Mixing Wt Loss-0.231st 30 Min Wt Loss-0.522rd 30 Min Wt Loss-0.522rd 30 Min Wt Loss-0.71Cumulative Wt Loss-0.712nd Hr Wt Loss-0.712nd Hr Wt Loss-0.923rd Hr Wt Loss-0.923rd Hr Wt Loss-0.14Cumulative Wt Loss-0.12Cumulative Wt Loss-1.064th Hr Wt Loss-0.12Cumulative Wt Loss-1.186th Hr Wt Loss-0.12Cumulative Wt Loss-1.286th Hr Wt Loss-1.407th Hr Wt Loss-0.08Cumulative Wt Loss-1.407th Hr Wt Loss-0.08Cumulative Wt Loss-1.640th Hr Wt Loss-1.6410th Hr Wt Loss-0.08Cumulative Wt Loss-1.6410th Hr Wt Loss-1.7011th Hr Wt Loss-0.06Cumulative Wt Loss-1.7011th Hr Wt Loss-0.05Cumulative Wt Loss-1.8112th Hr Wt Loss-1.8112th Hr Wt Loss-0.28-1.81-2.09Copies to: DMT/DMH /DJH/ SSJ/RLS	Mixing Wt Loss -0.23 -0.30   1st 30 Min Wt Loss -0.52 -0.50   Cumulative Wt Loss -0.52 -0.60   2nd 30 Min Wt Loss -0.71 -0.73   Cumulative Wt Loss -0.71 -0.73   2nd Hr Wt Loss -0.92 -0.94   3rd Hr Wt Loss -0.14 -0.15   Cumulative Wt Loss -0.12 -0.16   Cumulative Wt Loss -1.06 -1.09   4th Hr Wt Loss -0.12 -0.16   Cumulative Wt Loss -0.12 -0.16   Cumulative Wt Loss -1.08 -1.24   8th Hr Wt Loss -0.12 -0.11   Cumulative Wt Loss -1.28 -1.35   8th Hr Wt Loss -0.08 -0.09   Cumulative Wt Loss -1.48 -1.55   8th Hr Wt Loss -0.08 -0.07   Cumulative Wt Loss -1.64 -1.72   10th Hr Wt Loss -0.08 -0.07   Cumulative Wt Loss -1.64 -1.72   10th Hr Wt Loss -0.06 -0.03   Cumulative Wt Loss -1.76 <td< td=""></td<>

# Appendix C-3 Summary of Test Results

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### PUCB Test Results % Resin Loss

Time (hou	0.03	0.5	1	2	3	4	5	6	7	8	9	10	11	12
Borden Te	sta	<b>建始就能</b>	江北部國政	國影響會	在對於認識	金融建築		或記述的影響	國建立議論	的認識認識	用品的	並這個對	的新闻的	法规理论的
Borden	1.00	1.33	1.33	1.33	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.33	2.33	2.33
Delta	0.00	0.33	0.33	1.00	1.33	1.67	1.67	2.00	2.00	2.00	2.33	2.33	2.33	2.67
Ashland	0.67	2.33	2.33	2.33	3.00	3.33	3.67	3.67	3.67	3.67	4.00	4.33	4.33	4.33
Delta Test	S在均衡和历代。	1.3节众中国社	有國家的物质	自由影响的影	宗教的法国	学校上现代达到	調査の	12-345-634	的政治部分	の見ている	的一种名		品生物理学	行政部分
Borden	0.43	0.93	1.20	1.40	1.63	1.90	2.07	2.20	2.33	2.43	2.60	2.70	:2.77	2.83
Delta	0.63	1.20	1.53	1.80	2.07	2.33	2.60	2,83	3.07	3.30	3.47	3.60	3.77	3.97
Ashland	0.77	1.33	1.73	2.03	2.37	2.63	2.83	3.00	3.23	3.40	3.53	3.67	3.77	3.90
Ashland T	ests and an	和推动的	海阳静雨	到多少的复数	这时的风热	的新行信仰为	這些感到這	(其实是)	起的感觉	豊富なな	<b>这些这种这</b>	1944年1月1日	和自己的	和原则多
Borden	0.00	0.00	0.33	0.66	0.66	1.33	1.67	1.00	1.33	1.87	1.87	2.00	2.33	2.33
Delta	0.00	0.00	0.00	0.33	0.66	1.00	1.67	1.67	1.67	2.00	2.33	3.00	3.00	3.00
Ashland	0.00	1.00	1.33	1.67	1.67	1.67	2.00	2.67	3.00	3.00	3.33	3.33	3.67	4.00
Average	0.39	0.94	1.12	1.39	1.71	1.98	2.24	2.34	2.48	2.61	2.81	3.03	3.14	3.26
% of Total	11.92	28.78	34.43	42.75	52.42	60.83	68.73	71.66	75.95	79.94	86.04	92.95	96.39	100.00

VOC Emission Factor Based on 12-Hour Storage

VOC Emissions Factor =

\$

= 0.65 # VOC/ton sand

3.26% x 30 g resin x 2000 # 100 x 3000g sand x 1 ton

### PUNB (No Bake) Test Results % Resin Loss

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Time (hou	0.03	0,5	1	2	3	4	5	6	7	8	9	10	11	12
Borden Te	sis													
Borden	0.98	1.97	2,62	3.28	3.61	3.61	4.26	4.59	4.59	4.59	4.59	4.59	4.92	5.25
Delta	0.98	2.62	2,95	3.28	3.93	3.93	4.26	4.26	4.59	4.59	4.92	5.25	5.25	5.57
Ashland	0.66	0.98	2.30	2.62	2.95	3.28	3.61	3.93	3.93	4.26	4.26	4.59	4.59	4.92
Delta Test	5													
Borden	1.44	2.69	3.02	3.67	4.13	4.56	4.89	5,08	5.38	5.48	5.70	6.03	6.26	6.46
Delta	0.75	1.70	2.33	3.02	3.48	3.87	4.20	4.59	4,85	5.11	5.38	5.57	5,77	5.93
Ashland	0.98	1.97	2.39	3.08	3.57	4.07	4.43	4.79	5.08	5.41	5.64	5.84	5.93	6.13
Ashland T	ests													
Borden	1.97	2,30	2.62	2.95	3.61	4.26	4.26	4.59	4.59	5.25	5.25	5.90	5.90	6.23
Delta	1.31	1.64	2.30	2.62	2.95	3.93	3.93	4.26	4.59	4.92	5.25	5.25	5.25	5.57
Ashland	0.98	1.97	1.97	2.62	2.95	3.61	3.93	4.26	4.59	4.59	4.59	5.25	5.57	5.57
Average	1.12	1.98	2.50	3.02	3.46	3.90	4,20	4.48	4.69	4.91	5.06	5.36	5.49	5.74
% of Total	19.47	34.55	43.58	52.57	60.39	68.02	73.16	78.15	81.72	85.61	88,28	93.49	95,76	100.00

VOC Emission Factor Based on 12-Hour Storage

VOC Emissions Factor =

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> 5.74% x 30.5 g resin/catalyst x 2000 # = 1.17 # VOC/ton sand 100 x 3000g sand x 1 ton

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# Appendix D Supporting Calculations

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### PUCB Core Production/Storage (Scenario # 1):

Emission Rate (ER)

Catalyst Emission =  $\frac{1 \text{ ton resin}}{100 \text{ ton sand}} \times \frac{10 \text{ ton catalyst}}{100 \text{ ton resin}} \times \frac{(100-98.5)}{100} \times \frac{2000 \text{ \#}}{100}$ 

= 0.03 # catalyst/ton sand

Overall VOC Emission = (0.65 # / ton) + (0.03 # / ton)

= 0.68 #VOC/ton sand

Sand Throughput Rate @  $40\#VOC/day = \frac{40\#VOC}{1 day} \times \frac{1 \text{ ton sand}}{0.68 \#VOC}$ 

= 58.8 ton sand/day

= 7.35 ton sand/hour

### **Production:**

VOC Emission Rate =  $58.8 \text{ ton sand } \times 0.65 \text{ #VOC } \times 28.8 \times 1 \text{ day}$ 1 day 1 ton sand 100 8 hours

= 1.37 #VOC/hour

TEA Emission Rate =  $\frac{58.8 \text{ ton sand} \times 0.03 \text{ #TEA} \times 1 \text{ day}}{1 \text{ day}}$ 1 day 1 ton sand 8 hours

= 0.22 #TEA/hour

Total Organics = 1.37 + 0.22 = 1.59 #/hour

Local Exhaust Ventilation Rate = 2000 CFM serving the core machine enclosure and sealed core box vent.

### Storage:

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The size of each batch is assumed to be equal to 30 minutes of production.

Hourly emission rate per batch =  $\frac{58.8 \text{ ton sand } x}{1 \text{ day}} x \frac{1 \text{ day } x}{2x8 \text{ batches } 1 \text{ ton sand } 100 \text{ } 11.5 \text{ hours}$ 

= 0.148 #VOC per hour per batch

From storage area emission profile (Figure 1), maximum 8 hour TWA emission rate = 2.11 #VOC/hour

$$=$$
 2.11 = 0.035 #VOC/minute  
60

Dilution Ventilation (D)

 $CF air/# Solvent evaporated = \frac{387 \times 10^6 \times K}{C \times 24.5}$ where K = Mixing Factor (or Safety Factor) C = Target Workplace Concentration in mg/m<sup>3</sup>

For  $C = TLV^{(B)} \times 0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ ,

CF air/#solvent evaporated =  $\frac{387 \times 10^6 \times 3.5}{52.5 \times 24.5}$ = 1.053 × 10<sup>6</sup> Total airflow rate = (1.053 × 10<sup>6</sup>) × (0.035 # VOC/minute) = 36,855 CFM Airflow rate through NDO = 10 ft × 10 ft × 200 ft/minute = 20,000 CFM

Airflow through make-up air distribution system = 36,855 - 20,000 = 16,855 CFM

PUNB Core Production/Storage (Scenario # 2):

Production:

Sand Throughput Rate @  $40\#VOC/day = \frac{40\#VOC}{1 day} \times \frac{1 \text{ ton sand}}{1.17 \#VOC}$ 

= 34.2 ton sand/day

VOC Emission Rate =  $34.2 \text{ ton sand} \times 1.17\#\text{VOC} \times 34.5 \times 1 \text{ day}$ 1 day 1 ton sand 100 8 hours

= 1.73 #VOC/hour

= 0.029 #VOC/minute

Dilution Ventilation (D)

 $CF air/# Solvent evaporated = \frac{387 \times 10^6 \times K}{C \times 24.5}$ (AIHA Engineering Field Reference Manual)  $C \times 24.5$ where K = Mixing Factor (or Safety Factor) C = Target Workplace Concentration in mg/m<sup>3</sup>

For  $C = TLV^{(R)} \times 0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ ,

CF air/#solvent evaporated =  $\frac{387 \times 10^6 \times 3.5}{52.5 \times 24.5}$ = 1.053 x 10<sup>6</sup>

Total airflow rate =  $(1.053 \times 10^6) \times (0.029 \text{ VOC/minute})$ 

= 30,537 CFM

Airflow rate through NDO = 10 ft x 10 ft x 200 ft/minute

= 20,000 CFM

Airflow through make-up air distribution system = 30,537 - 20,000 = 10,537 CFM

### Storage:

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The size of each batch is equal to 30 minutes of production.

Hourly emission rate per batch = 
$$34.2 \text{ ton sand } \times 1 \text{ day } \times 1.17 \text{ #VOC } \times 65.5 \times 1$$
  
1 day 2x8 batches 1 ton sand 100 11.5 hours

= 0.142 #VOC per hour per batch

From storage area emission profile (Figure 2), maximum 8 hour TWA emission rate = 2.02 #VOC/hour

 $= (1.053 \times 10^6) \times (0.034 \# \text{VOC/minute})$ 

Dilution Ventilation (D)

 $CF air / # Solvent evaporated = \frac{387 \times 10^6 \times K}{C \times 24.5}$  (AIHA Engineering Field Reference Manual)

For  $C = TLV^{(R)} \times 0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ ,

CF air/#solvent evaporated =  $\frac{387 \times 10^6 \times 3.5}{52.5 \times 24.5}$ 

= 1.053 x 10°

Total airflow rate

= 35,802 CFM

Airflow rate through NDO =  $10 \text{ ft } \times 10 \text{ ft } \times 200 \text{ ft/minute}$ 

= 20,000 CFM

Airflow through make-up air distribution system = 35,802 - 20,000 = 15,802 CFM

#### PUNB Mold Production/Storage (Scenario # 3):

Sand Throughput Rate @ 14 #VOC/hour = <u>14#VOC</u> x <u>1 ton sand</u> 1 hour 1.17 #VOC = 11.97 tons per hour

= 11.97 x 16 hours/day

= 191.5 tons / day

Production:

VOC Emission Rate = 14 #/hour x <u>34.5%</u> = 4.83 #VOC/hour = 0.081 #VOC/min. 100

Dilution Ventilation (D)

 $CF air/# Solvent evaporated = \frac{387 \times 10^6 \times K}{C \times 24.5}$ (AIHA Engineering Field Reference Manual)  $C \times 24.5$ where K = Mixing Factor (or Safety Factor) C = Target Workplace Concentration in mg/m<sup>3</sup>

For  $C = TLV^{(R)} \times 0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ ,

CF air/#solvent evaporated =  $\frac{387 \times 10^{6} \times 3.5}{52.5 \times 24.5}$ = 1.053 × 10<sup>6</sup> Total airflow rate = (1.053 × 10<sup>6</sup>) × (0.081# VOC/minute) = 85,293 CFM Airflow rate through NDO = 10 ft × 10 ft × 200 ft/minute = 20,000 CFM

Airflow through make-up air distribution system = 85,293 - 20,000 = 65,293 CFM

#### Storage:

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The size of each batch is equal to 30 minutes of production.

Hourly emission rate per batch =  $192 \text{ ton sand } x - 1 \text{ day } x \frac{1.17 \text{ #VOC } x \frac{65.5 \text{ x}}{1.15 \text{ hours}} \frac{1}{1 \text{ day}} x \frac{1.17 \text{ #VOC } x \frac{65.5 \text{ x}}{1.15 \text{ hours}} \frac{1}{1.5 \text{ hours}}$ 

= 0.400 #VOC per hour per batch

From storage area emission profile (Figure 3), maximum 8 hour TWA emission rate = 8.9 #VOC/hour

 $= \frac{8.9}{60} = 0.148$  #VOC/minute

Dilution Ventilation (D)

CF air/# Solvent evaporated = <u>387 x 106 x K</u> (AIHA Engineering Field Reference Manual) C x 24.5 where K = Mixing Factor (or Safety Factor) C = Target Workplace Concentration in mg/m<sup>3</sup>

For  $C = TLV^{\otimes} \times 0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ ,

CF air/#solvent evaporated =  $\frac{387 \times 10^{6} \times 3.5}{52.5 \times 24.5}$ = 1.053 × 10<sup>6</sup> Total airflow rate = (1.053 × 10<sup>6</sup>) × (0.148 # VOC/minute) = 156,204 CFM Airflow rate through NDO = 10 ft × 10 ft × 200 ft/minute = 20,000 CFM

Airflow through make-up air distribution system = 156,204 - 20,000 = 136,204 CFM

#### Scenario 4 PUCB Core Production/Storage

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Emission Rate (ER)								
	_					(100 - 98.5)		
Catalyst emission	=	1	ton resin	10	ton catalyst	1.5	2000	lbs
	_	100	ton sand	100	ton resin	100	1	ton
	=	0.03	pounds cataly	/st/ton san	d			
Overall VOC Emission	=	0.65	lbs/ton					
	+	0.03	ibs/ton					
	_	0.68	Ibs VOC/ton	sand				
	=	7.35	ton sand	16	hours			
			hours	I	day			
	=	117.6	6 ton sand/day					
Production								
VOC Emission Rate	=	117.6	ton sand	0.65	lbs VOC	28.8	1	day
		1	day	1	ton sand	100	16	hrs
	=	1.38	lbs VOC/hr	-				
TEA Emission Rate	=	117.6	ton sand	0.03	lbs TEA	1	day	
	_	1	day	1	ton sand	16	hrs	_
	=	0.22	lbs TEA/hr					
Total Organics	=	1.38	lbs VOC/hr					
	+	0.22	lbs TEA/hr					
	_	1.60	lbs/hr					

Local Exhaust Ventialtion Rate = 2000 CFM serving the core machine enclosure and sealed core box vent.

#### Storage

The size of each batch is assumed to be equal to 30 minutes of production.

Hourly emission

rate per batch	=	117.6	ton sand	1	day	0.65	lbs VOC	71.2	1	
	_	1	day	32	batches	1	ton sand	100	11.5	hrs
				(2 x 16)		-		-		

= 0.15 lbs VOC/hr/batch

From storage area emission profile maximum 8-hour TWA emission rate = 3.293 lbs VOC/hr

= 0.055 lbs VOC /minute

### Dilution Ventilation (D)

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CF air/lbs solvent evaporated = 387 x 10<sup>6</sup> x K / C x 24.5 (AIHA Engineering Field Reference Manual)

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### where K = Mixing Factor (or Safety Factor) C = Target Workplace Concentration in mg/m<sup>3</sup>

For C = TLV x 0.10 =  $525 \times 0.10 = 52.5 \text{ mg/m}^3$ 

CF	air/	lbs
sol	vent	evaporated

solvent evaporated	=	387	1.E+06	3.5	
	-	52.5	24.5		
	8	1.053E+06			
Total airflow rate	=	1.053E+06	0.055	lbs VOC	
	-			minute	
	=	57796	CFM		
Airflow rate through NDO	5	10	feet	10	

through NDO	11	10	feet	10	feet	200	feet
							minute
	=	20000	CFM				

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Airflow through make-up air distribution system =		57796	CFM
	-	20000	CFM
		37796	CFM

Scenario 5 PUNB Mold Produc	ction/	Storage							
Production									
Sand Throughput	=_	<u>18</u> 1	tons sand hr	<u>16</u> 1	hrs day	_			
	=	288	tons sand/	'day					
VOC Emission Rate	•=_	18	tons sand hr	1.17	lbs VOC ton sand	+	34.5 100	_	
	=	7.2657 0.121	lbs VOC/h lbs VOC/m	r - ain					
Dilution Ventilation (	(D)								
CF air/lbs solvent ev	apo	rated = 387 :	x 10 <sup>8</sup> x K / C	X 24.5 (A	IHA Engine	erin	g Field	Reference N	lanual)
where K = Mixing F C = Target W	actor /orkp	or Safety F lace Concer	actor) ntration in m	g/m³					
For C = TLV x 0.10	= 52	5 x 0.10 = 5	2.5 mg/m <sup>3</sup>						
CF air/ lbs solvent evaporated	=	387	1.E+06 24.5	3.5	-				
	11	1.053E+06							
Total airflow rate	_	1.053E+06	0.121	Ibs VOC minute	-				
	=	127520	CFM						
Airflow rate through NDO	_	10	feet	10	feet	$\left  \right $	200	feet minute	
	=	20000	CFM						
Airflow through mak	ke-up	air dìstributi	on system -	127520 20000 107520	CFM CFM CFM				

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#### Storage

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The size of each batch is assumed to be equal to 30 minutes of production.

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Hourty emission

rate

e per batch	= _	288.0	ton sand	1	day	1.17	<u>Ibs</u> VOC	65.5	1		
	_	1	day	32	batches	1	ton sand	100	11.5	hrs	
				(2 x 16	)						
	=	0,60	lbs VOC/h	/batch							

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From storage area emission profile maximum 8-hour TWA emission rate = 13.350 lbs VOC/hr

=	13.35	lbs VOC/hr
-	60	minutes/hr
=	0.223	lbs VOC /minute

#### Dilution Ventilation (D)

CF air/lbs solvent evaporated = 387 x 10<sup>8</sup> x K / C x 24.5 (AIHA Engineering Field Reference Manual)

where K = Mixing Factor (or Safety Factor)

C = Target Workplace Concentration in mg/m<sup>3</sup>

For C = TLV x  $0.10 = 525 \times 0.10 = 52.5 \text{ mg/m}^3$ 

CF air/ lbs

solvent evaporated = \_ 387 1.E+06 3.5 24.5 52.5

= 1.053E+06

Total airflow rate 1.053E+06 0.223 lbs VOC minute

> 234306 CFM =

Airflow rate	10	feet	1 10	feet	1 200	feet
though theo		1000	10			minute
=	20000	CFM				
Airflow through make-u	p air distribu	ition system	234306	CFM		
-		-	20000	CFM		
			214306	CFM		

# Appendix D-2 Storage Air Emission Calculations

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tions - Level - - - Barriel - - - River

Time (Hours)	Emission Rate (# VOC/hour)
0.0	0.000
0.5	0.148
1.0	0.296
1.5	0.444
2.0	0.592
2.5	0.740
3.0	0.888
3.5	1.036
4.0	1.184
4.5	1.332
5.0	1.480
5.5	1.628
6.0	1.776
6.5	1.924
7.0	2.072
7.5	2.220
8.0	2.368
8.5	2.368
9.0	2.368
9.5	2.368
10.0	2.368
10.5	2.368
11.0	2.368
11.5	2.368
12.0	2.368
12.5	2.220
13.0	2.072
13.5	1.924
14.0	1.776
14.5	1.628
15.0	1.480
15.5	1.332
16.0	1.184
16.5	1.036
17.0	0.888
17.5	0.740
18.0	0.592
18.5	0.444
19.0	0.296
19.5	0.148
20.0	0.000
Maximum 8-hour TWA	2.109

# SCENARIO #1

## PUCB (Cold Box) Storage Area Emissions

Time (Hours)	Emission Rate (# VOC/hour)
0.0	0.000
0.5	0.142
1.0	0.284 -
1.5	0.426
2.0	0.568
2.5	0.710
3.0	0.852
3.5	0.994
4.0	1.136
4.5	1.278
5.0	1.420
5.5	1.562
6.0	1.704
6.5	1.846
7.0	1.988
7.5	2.130
8.0	2.272
8.5	2.272
9.0	2.272
9.5	2.272
10.0	2.272
10.5	2.272
11.0	2.272
11.5	2.272
12.0	2.272
12.5	2.130
13.0	1.988
13.5	1.846
14.0	1.704
14.5	1.562
15.0	1.420
15.5	1.278
16.0	1.136
16.5	0.994
17.0	0.852
17.5	0.710
18.0	0.568
18.5	0.426
19.0	0.284
19.5	0.142
20.0	0.000
Maximum 8-hour TWA	2.024

# SCENARIO #2

PUNB (No Bake) Core Storage Area Emissions

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### Scenario #3 PUNB (No Bake) Mold Storage Area Emissions

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Time (Hours)	Emission Rate (# VOC/hour)
0.0	0.000
0.5	0.400
1.0	0.800
1.5	1.200
2.0	1.600
2.5	2.000
3.0	2.400
3.5	2.800
4.0	3.200
4.5	3.600
5.0	4.000
5.5	4.400
6.0	4.800
6.5	5,200
7.0	5,600
7.5	6.000
8.0	6.400
8.5	6.800
9.0	7.200
9.5	. 7.600
10.0	8.000
10.5	8.400
11.0	8.800
11.5	9.200
12.0	9.200
12.5	9.200
13.0	9.200
13.5	9.200
14.0	9.200
14.5	9.200
15.0	9.200
15.5	9.200
16.0	9.200
16.5	8.800
17.0	8.400
17.5	8.000
18.0	7.600
18.5	7.200
19.0	6.800
19.5	6.400
20.0	6.000
20.5	5.600
21.0	5.200
21.5	4.800
22.0	4.400
22.5	4.000
23.0	3.600
23.5	3.200
24.0	2.800
Maximum 8-hour TWA	8,900

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### Scenario #4

PUCB	Scenario 4
Time (Hours)	Emission Rate (# VOC/hour)
0.0	0.000
0.5	0.148
1.0	0.296
1.5	0.444
2.0	0.592
2.5	0.740
3.0	0.888
3.5	1,030
4.0	1.184
4.5	1,332
5.0	1.400
5.5	1 776
6.0	1 924
7.0	2 072
7.5	2.220
8.0	2.368
8.5	2.516
9.0	2.664
9.5	2.812
10.0	2.960
10.5	3.108
11.0	3.256
11.5	3.404
12.0	3.404
12.5	3.404
13.0	3.404
13.5	3.404
14.0	3.404
14.5	3.404
15.0	3.404
15.5	3 404
16.0	3 256
17.0	3 108
17.5	2,960
18.0	2.812
18.5	2.664
19.0	2.516
19.5	2.368
20.0	2.220
20.5	2.072
21.0	1.924
21.5	1.776
22.0	1.628
22.5	1.480
23.0	1.332
23.5	1.184
24.0	1.036
Maximum 8-hour TWA	3.293



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### Scenario #5

PUNB Molds	Scenario 5
Time (Hours)	Emission Rate (# VOC/hour)
0.0	0.000
0.5	0.600
1.0	1.200
1.5	1.800
2.0	2.400
2.5	3.000
3.0	3.600
3.5	4.200
4.0	4.800
4.5	5.400
5.0	6.000
5.5	6.600
6.0	7.200
6.5	7.800
7.0	8.400
7.5	9.000
8.0	9.600
8.5	10.200
9.0	10.800
9.5	11.400
10.0	12.000
10.5	12.600
11.0	13.200
11.5	13.800
12.0	13.800
12.5	13.800
13.0	13.800
13.5	13.800
14.0	13.800
14.5	13.800
15.0	13.800
15.5	13.800
16.0	13.800
16.5	13.200
17.0	12.600
17.5	12.000
18.0	11.400
18.5	10.800
19.0	10.200
19.5	9.600
20.0	9.000
20.5	8.400
21.0	7.800
21.5	7.200
22.0	6.600
22.5	6.000
23.0	5.400
23.5	4.800
24.0	4.200
Maximum 8-hour TWA	13.350

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## **Recuperative Thermal Oxidizer with 2000 scfm**

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Scenario 1 - Production Area

Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

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Direct Costs         Direct Costs           Basic Equipment:         110000           Auxiliary Equipment/duct to oxidizer, fan controls,stack/duct         13810           Eng. Estimate (Appendix E-3)           Total Equipment Costs:         123810           Instruments/controls         0.10           Total Equipment Costs:         123810           Instruments/controls         0.10           Traces         0.05           Freight         0.05           Base Price:         136191           Installation costs, direct:         136191           Foundations/Supports         0.08           OO2         1.00           100         10895           Eng Cuide #46, Table 4-3           Electrical         0.04           0.01         1.00           10805         Eng Cuide #46, Table 4-3           Installation         0.01           0.02         1.00           10807         Eng Cuide #46, Table 4-3           Installation         0.01           100         1362           Eng Cuide #46, Table 4-3           Electrical         0.04           0.02         1.00           1224         Eng Cuide #46, Tabl	Cost Item	Average Cost Factor	Adjustment Factor	Cost (\$s)	Basis of Costs
Direct Costs:				<u></u>	
Basic Equipment:         11000         Lowest Quote - Vendor F           Auxiliary Equipment/duct to sxidizer,         13810         Eng. Estimate (Appendix E-3)           Total Equipment Costs:         123810         Eng. Estimate (Appendix E-3)           Instruments/controls         0.10         1.00         0           Instruments/controls         0.10         1.00         6191           Freight         0.05         1.00         6191           Base Price:         136101         1         1           Installation costs, direct:         136191         1         1           Foundations/Supports         0.08         1.00         10895         Eng Cuide #46, Table 4-3           Electrical         0.04         1.00         2448         Eng Cuide #46, Table 4-3           Insulation         0.01         1.00         3542         Eng Cuide #46, Table 4-3           Insulation         0.01         1.00         1352         Eng Cuide #46, Table 4-3           Insulation         0.01         1.00         3542         Eng Cuide #46, Table 4-3           Insulation         0.01         1.00         1352         Eng Cuide #46, Table 4-3           Insulation         0.01         1.00         1352         Eng Cuide	ect Costs:		· · · · · · · · · · · · · · · · · · ·		
oxidizer, fan controla,stack/duct         110000         Lowest Quote - Vendor F           axidizer         13810         Eng. Estimate (Appendix E-3)           rotal Equipment/Costs:         122300         Eng. Estimate (Appendix E-3)           Total Equipment/Costs:         122300         Eng. Estimate (Appendix E-3)           Instruments/controls         0.10         1.00         0           Traces         0.05         1.00         6191           Freight         0.05         1.00         6191           Base Price:         136191         Eng Guide #46, Table 4-3           Exerction/handling         0.14         1.00         10895           Exerction/handling         0.14         1.00         1362           Piping         0.02         1.00         2724         Eng Guide #46, Table 4-3           Exerction/handling         0.01         1.00         1362         Eng Guide #46, Table 4-3           Piping         0.02         1.00         2724         Eng Guide #46, Table 4-3           Piping         0.01         1.00         1362         Eng Guide #46, Table 4-3           Facilities/buildings         0.00         1.00         2724         Eng Guide #46, Table 4-3           Total Installation Costs:	sic Equipment:				
Auxiliary Equipment/duct to widter       13810       Eng. Estimate (Appendix E-3)         Total Equipment Costs:       123810         Instruments/controls       0.10       1.00       0         Instruments/controls       0.05       1.00       6191         Treight       0.05       1.00       6191         Base Price:       136191	dizer, fan controls,stack/duct			110000	Lowest Quote - Vendor F
Miller         123810           Total Equipment Costs:         123810           Instruments/controls         0.10         1.00         0           Taxes         0.05         1.00         6191           Freight         0.05         1.00         6191           Base Price:         136191           Installation costs, direct:         136191           Freight         0.08         1.00           Installation costs, direct:         136191           Freeting/handling         0.14         1.00           Piping         0.02         1.00           Step reports         0.08         1.00           Step reports         0.08         1.00           Step reparation         0.01         1.00           Step reparation         0.00         1.00         1362           Frac Guide #46, Table 4.3         1.00         1362         Eng Guide #46, Table 4.3           Total Installation Costs:         40857         40857           TOTAL DIRECT COSTS (Base Price + Installation)=         177048           Eng Guide #46, Table 4.3         1.00         5810           Statiup         0.02         1.00         6810           Statup         0.02	iliary Equipment/duct to			13810	Eng. Estimate (Appendix E-3)
Total Equipment Costs:         123810           Instruments/controls         0.10         1.00         0         Included in quote           Taxes         0.05         1.00         6191         Freight         0.05         1.00           Base Price:         136191	11201				
Instruments/controls         0.10         1.00         0         Included in quote           Taxes         0.05         1.00         6191         1           Freight         0.05         1.00         6191         1           Base Price:         136191         1         1         1           Installation costs, direct:         136191         1         1         1           Installation costs, direct:         1         1         1         1         1           Freetion/handing         0.14         1.00         10895         Eng Guide #46, Table 4-3         1           Electrical         0.04         1.00         10807         Eng Guide #46, Table 4-3         1           Insulation         0.01         1.00         1362         Eng Guide #46, Table 4-3         1           Insulation         0.01         1.00         1362         Eng Guide #46, Table 4-3         1           Site preparation         0.00         1.00         0         Eng Guide #46, Table 4-3         1           Total Installation Costs:         40857         1         1         1         1         1         1         1         1         1         1         1         1         1 <td>tal Equipment Costs:</td> <td></td> <td></td> <td>123810</td> <td></td>	tal Equipment Costs:			123810	
Instruments/controls         0.10         1.00         0         Included in quote           Taxes         0.05         1.00         6191		· · · · · · · · · · · · · · · · · · ·			
Instruments/controls         0.10         1.00         0         Included in quote           Taxes         0.05         1.00         6191		· · · · · · · · · · · · · · · · · · ·			
Taxes       0.05       1.00       6191         Freight       0.05       1.00       6191         Base Price:       136191         Installation costs, direct:       136191         Foundations/Supports       0.08       1.00         Installation costs, direct:       136191         Foundations/Supports       0.08       1.00         Installation costs, direct:       136097         Erection/handling       0.14       1.00         100       10895       Eng Guide #46, Table 4-3         Erectincal       0.04       1.00         1100       1362       Eng Guide #46, Table 4-3         Insulation       0.01       1.00       1362         Insulation       0.01       1.00       1362         Site preparation       0.00       1.00       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857       1077048       1077048         Installation costs, indirect:       100       6810       small system/Table 4-3         Construction/field expenses       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up	struments/controls	0.10	1.00	0	Included in guote
Freight       0.05       1.00       6191         Base Price:       136191         Installation costs, direct:       136191         Foundations/Supports       0.08       1.00       10895         Erection/handling       0.14       1.00       19067       Eng Guide #46, Table 4-3         Electrical       0.04       1.00       5448       Eng Guide #46, Table 4-3         Piping       0.02       1.00       2724       Eng Guide #46, Table 4-3         Insulation       0.01       1.00       1362       Eng Guide #46, Table 4-3         Piping       0.02       1.00       1362       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857       40857         Total Installation costs, indirect:       1277048       1277048         Installation costs, indirect:       1277048       1277048         Eng Guide #46, Table 4-3       5810       small system/Table 4-3         Construction fiee       0.10       0.50       6810       small system/Table 4-3         Construction fiee       0.10       0.02       1.00       13619       Eng Guide #46, Table 4-3         Perf	axes	0.05	1.00	6191	
Base Price:       136191         Installation costs, direct:	eight	0.05	1.00	6191	
Base Price:         136191           Installation costs, direct:					
Installation costs, direct:         Image: Construction of the second secon	se Price:			136191	
Installation costs, direct:         Image: Cost of the second					
Installation costs, direct:					
Foundations/Supports         0.08         1.00         10895         Eng Guide #46, Table 4-3           Erection/handling         0.14         1.00         19067         Eng Guide #46, Table 4-3           Electrical         0.04         1.00         5448         Eng Guide #46, Table 4-3           Piping         0.02         1.00         2724         Eng Guide #46, Table 4-3           Insulation         0.01         1.00         1362         Eng Guide #46, Table 4-3           Site preparation         0.00         1.00         0         Eng Guide #46, Table 4-3           Facilities/buildings         0.00         1.00         0         Eng Guide #46, Table 4-3           Total Installation Costs:         40857	stallation costs, direct:				
Erection/handling         0.14         1.00         19067         Eng Guide #46, Table 4-3           Electrical         0.04         1.00         5448         Eng Guide #46, Table 4-3           Piping         0.02         1.00         2724         Eng Guide #46, Table 4-3           Insulation         0.01         1.00         1362         Eng Guide #46, Table 4-3           Painting         0.01         1.00         1362         Eng Guide #46, Table 4-3           Site preparation         0.00         1.00         0         Eng Guide #46, Table 4-3           Facilities/buildings         0.00         1.00         0         Eng Guide #46, Table 4-3           Total Installation Costs:         40857	undations/Supports	0.08	1.00	10895	Eng Guide #46, Table 4-3
Electrical       0.04       1.00       5448       Eng Guide #46, Table 4-3         Piping       0.02       1.00       2724       Eng Guide #46, Table 4-3         Insulation       0.01       1.00       1362       Eng Guide #46, Table 4-3         Painting       0.01       1.00       1362       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857	ection/handling	0.14	1.00	19067	Eng Guide #46, Table 4-3
Piping       0.02       1.00       2724       Eng Guide #46, Table 4-3         Insulation       0.01       1.00       1362       Eng Guide #46, Table 4-3         Painting       0.01       1.00       0       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857	ectrical	0.04	1.00	5448	Eng Guide #46, Table 4-3
Insulation       0.01       1.00       1362       Eng Guide #46, Table 4-3         Painting       0.01       1.00       1362       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857	ping	0.02	1.00	2724	Eng Guide #46, Table 4-3
Painting       0.01       1.00       1362       Eng Guide #46, Table 4-3         Site preparation       0.00       1.00       0       Eng Guide #46, Table 4-3         Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857       100       100       100         TOTAL DIRECT COSTS (Base Price + Installation)=       177048       100       100       100         Installation costs, indirect:       100       6810       Eng Guide #46, Table 4-3       100         Engineering/supervision       0.05       1.00       6810       small system/Table 4-3         Construction/field expenses       0.10       0.50       6810       small system/Table 4-3         Construction fee       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up       0.02       1.00       2724       Eng Guide #46, Table 4-3         Performance Test       0.07       1.00       9533       Estimate for Method 25A Inlet/Outlet         Model study       0.03       1.00       4086       Eng Guide #46, Table 4-3         'OTAL INDIRECT COSTS=       43581       100       4086       Eng Guide #46, Table 4-3	sulation	0.01	1.00	1362	Eng Guide #46, Table 4-3
Site preparation         0.00         1.00         0         Eng Guide #46, Table 4-3           Facilities/buildings         0.00         1.00         0         Eng Guide #46, Table 4-3           Total Installation Costs:         40857	inting	0.01	1.00	1362	Eng Guide #46, Table 4-3
Facilities/buildings       0.00       1.00       0       Eng Guide #46, Table 4-3         Total Installation Costs:       40857         Installation Costs:       40857         Installation Costs:       177048         Installation costs, indirect:       100         Installation costs, i	e preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:       40857         IDTAL DIRECT COSTS (Base Price + Installation)=       177048         Installation costs, indirect:       177048         Installation costs, indirect:       177048         Engineering/supervision       0.05       1.00       6810       Eng Guide #46, Table 4-3         Construction/field expenses       0.10       0.50       6810       small system/Table 4-3         Construction fee       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up       0.02       1.00       2724       Eng Guide #46, Table 4-3         Performance Test       0.07       1.00       9533       Estimate for Method 25A Inlet/Outlet         Model study       0.00       1.00       4086       Eng Guide #46, Table 4-3         OTAL INDIRECT COSTS=       43581       100       4086       Eng Guide #46, Table 4-3	cilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:       40857         INOTAL DIRECT COSTS (Base Price + Installation)=       177048         Installation costs, indirect:       177048         Installation costs, indirect:       Installation         Engineering/supervision       0.05       1.00       6810       Eng Guide #46, Table 4-3         Construction/field expenses       0.10       0.50       6810       small system/Table 4-3         Construction fee       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up       0.02       1.00       2724       Eng Guide #46, Table 4-3         Performance Test       0.07       1.00       9533       Estimate for Method 25A Inlet/Outlet         Model study       0.00       1.00       0       0         Contingencies       0.03       1.00       4086       Eng Guide #46, Table 4-3         OTAL INDIRECT COSTS=       43581       Installation       Installation					
INTAL DIRECT COSTS (Base Price + Installation)=       177048         Installation costs, indirect:	tal Installation Costs:			40857	
IOTAL DIRECT COSTS (Base Price + Installation)=       17/048         Installation costs, indirect:       Installation costs, indirect:         Engineering/supervision       0.05       1.00       6810       Eng Guide #46, Table 4-3         Construction/field expenses       0.10       0.50       6810       small system/Table 4-3         Construction fee       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up       0.02       1.00       2724       Eng Guide #46, Table 4-3         Performance Test       0.07       1.00       9533       Estimate for Method 25A Inlet/Outlet         Model study       0.00       1.00       4086       Eng Guide #46, Table 4-3         OTAL INDIRECT COSTS=       43581       Installation       Installation					
installation costs, indirect:       installation costs, indirect:         Engineering/supervision       0.05       1.00       6810       Eng Guide #46, Table 4-3         Construction/field expenses       0.10       0.50       6810       small system/Table 4-3         Construction fee       0.10       1.00       13619       Eng Guide #46, Table 4-3         Start-up       0.02       1.00       2724       Eng Guide #46, Table 4-3         Performance Test       0.07       1.00       9533       Estimate for Method 25A Inlet/Outlet         Model study       0.00       1.00       0       0         Contingencies       0.03       1.00       4086       Eng Guide #46, Table 4-3         OTAL INDIRECT COSTS=       43581       0       0	TAL DIRECT COSTS (Base Price	: + Installation)≈		177048	·
installation costs, indirect: Engineering/supervision 0.05 1.00 6810 Eng Guide #46, Table 4-3 Construction/field expenses 0.10 0.50 6810 small system/Table 4-3 Construction fee 0.10 1.00 13619 Eng Guide #46, Table 4-3 Start-up 0.02 1.00 2724 Eng Guide #46, Table 4-3 Performance Test 0.07 1.00 9533 Estimate for Method 25A Inlet/Outlet Model study 0.00 1.00 0 Contingencies 0.03 1.00 4086 Eng Guide #46, Table 4-3 DTAL INDIRECT COSTS= 43581					
Installation costs, indirect:       Image: Construction of the system of t					
Engineering/supervision         0.05         1.00         6810         Eng Guide #46, Table 4-3           Construction/field expenses         0.10         0.50         6810         small system/Table 4-3           Construction fee         0.10         1.00         13619         Eng Guide #46, Table 4-3           Start-up         0.02         1.00         2724         Eng Guide #46, Table 4-3           Performance Test         0.07         1.00         9533         Estimate for Method 25A Inlet/Outlet           Model study         0.00         1.00         0         0           Contingencies         0.03         1.00         4086         Eng Guide #46, Table 4-3           OTAL INDIRECT COSTS=         43581	tallation costs, indirect:				
Engineering/supervision         0.05         1.00         6610         Eng Guide #46, Table 4-3           Construction/field expenses         0.10         0.50         6810         small system/Table 4-3           Construction fee         0.10         1.00         13619         Eng Guide #46, Table 4-3           Start-up         0.02         1.00         2724         Eng Guide #46, Table 4-3           Performance Test         0.07         1.00         9533         Estimate for Method 25A Inlet/Outlet           Model study         0.00         1.00         0         0         0           Contingencies         0.03         1.00         4086         Eng Guide #46, Table 4-3           OTAL INDIRECT COSTS=         43581		0.05	1 00	6810	Eng Cuilde #46 Table 4.2
Construction fee         0.10         1.00         13619         Eng Guide #46, Table 4-3           Construction fee         0.10         1.00         13619         Eng Guide #46, Table 4-3           Start-up         0.02         1.00         2724         Eng Guide #46, Table 4-3           Performance Test         0.07         1.00         9533         Estimate for Method 25A Inlet/Outlet           Model study         0.00         1.00         0         0         0           Contingencies         0.03         1.00         4086         Eng Guide #46, Table 4-3           OTAL INDIRECT COSTS=         43581	gineering/supervision	0.05	0.50	6810	Eng Guide #40, Table 4-3
Construction rec         0.10         1.00         1.00         1.00         1.00         2724         Eng Guide #46, Table 4-3           Start-up         0.02         1.00         2724         Eng Guide #46, Table 4-3           Performance Test         0.07         1.00         9533         Estimate for Method 25A Inlet/Outlet           Model study         0.00         1.00         0         0           Contingencies         0.03         1.00         4086         Eng Guide #46, Table 4-3           OTAL INDIRECT COSTS=         43581	nstruction foo	0.10	1.00	13610	Eng Cuide #46 Table 4.3
Start-up     0.02     1.00     2.724     Eng Guide #40, Table 4-3       Performance Test     0.07     1.00     9533     Estimate for Method 25A Inlet/Outlet       Model study     0.00     1.00     0       Contingencies     0.03     1.00     4086       DTAL INDIRECT COSTS=     43581	rtup	0.10	1.00	2724	Eng Cuide #46, Table 4-3
Model study         0.00         1.00         0           Contingencies         0.03         1.00         4086         Eng Guide #46, Table 4-3           'OTAL INDIRECT COSTS=         43581	ri-up	0.02	1.00	0533	Fetimete for Method 25A Inlet/Outlet
Contingencies     0.03     1.00     4086     Eng Guide #46, Table 4-3       OTAL INDIRECT COSTS=     43581	del etydy	0.00	1.00		Limite for metiod 25A filler Odder
OTAL INDIRECT COSTS=     43581	ntingencies	0.03	1.00	4086	Eng Guide #46 Table 4-3
OTAL INDIRECT COSTS=     43581		0.00		4500	THE OHIGE BAD, THOILE AD
	TAL INDIRFCT COSTS#			43581	
		···	-		
	h				
TTAL CAPTEAL COSTS (Direct + Indirect) = 1 200629	TAL CAPITAL COSTS (Dimented 1)	Indirect)=		220629	

#### Annualized Cost Analysis Scenario 1 - Production Area

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Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

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	Cost Item	Cost(\$)/unit	Units/year	Cost	Basis of Costs
	Disert Orecetie - Contra				
	Direct Operating Costs:				
	Operating Labor				
	Operator (\$/HR X HRS/YR)	25	182.5	4563	Eng Cuide #46 Table 5-2 (5 hrs/sht x 1 sht/day x 365 days/va)
	Supervision(15% of Jabor)	2.5	102.0	681	[Lig. Outde #40, 1401e 0-2 (.5 143) 311 × 1 311/ (day × 500 days/ yr)
ļ					
	Operating Materials			0	
,					
	Maintenance (general):				
	Labor	27.5	182.5	5019	Eng. Guide #46. Table 5-2 (.5 hrs/sht x 1 sht/day x 365 days/yr)
1	Materials (100% of labor)			5019	
	Replacement parts (as required)			0	
	Labor (100% of parts cost)			0	
j.					
	Utilities:				
5q	Electricity (\$/KWHxKWH/yr)	\$0.06	20440	1226	Vendor F Quote (7.0 KWH x 2920 hrs/yr)
	Fuel oil (\$/gal x gal/yr)			0	
	Gas (\$/10 <sup>3</sup> ít <sup>3</sup> x 10 <sup>3</sup> ít <sup>3</sup> /yr)	\$4.00	2920	11680	Vendor F Quote (1Mft3/hr x2920hrs/yr)
	Water			0	
3	Steam			0	
	Other			0	
1.1				0	
	Waste Disposal				· · · · · · · · · · · · · · · · · · ·
1	Al-otoriates Treates - t				
	vastewater freatment				
*2¥ !	TOTAL DIRECT OPERATING CO			28191	1
	TOTAL DIRECT OF ERATING CC			20171	
	direct operating (fixed) costs:				· · · · · · · · · · · · · · · · · · ·
	)verhead	80% of O & M(labor)		7665	Eng. Guide #46. Table 5-1
	Property Tax	1% of capital costs		2206	Eng. Guide #46, Table 5-1
- 22	Insurance	1% of capital costs		2206	Eng. Guide #46, Table 5-1
13	dministration	2% of capital costs		4413	Eng. Guide #46, Table 5-1
2	apital Recovery CRF=	0.156	220629.42	34418	Eng. Guide #46, Table 5-1
		(9.0% for 10 years)			Eng. guide #46, Table 5-3
E.	TOTAL FIXED COSTS (B)=			50908	
20	<u>i idits</u>				
	Product recovery			0	
	Heat recovery			0	
2.5					ACC12 A
1	TAL CREDITS (C)=			0	
1	TAL ANNUALIZED COSTS (A	+B minus C)=		79099	
Ś	antrolled Finite Date (	(		22	
1	Unitolied Emissions Kate (tons	year)		£2	· · · · · · · · · · · · · · · · · · ·
;	Overall (Capture & device eff.)Con	itrol			
E.	S tem Efficiency (%)=			90	
ŝ				•	
	Controlled Emissions (tons/year)=			2.07	
	:c (\$/ton)≖			38212	

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### Recuperative Catalytic Oxidizer with 2000 scfm

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Scenario 1 - Production Area

Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			120000	Lowest Quote - Vendor F
Auxiliary Equipment/duct to oxidizer			13810	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			133810	
		ļ		
Instruments/controls	0.10	1.00	0	Included in guote
Taxes	0.05	1.00	6691	
Freight	0.05	1.00	6691	
Base Price:			147191	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	11775	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	20607	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	5888	Eng Guide #46, Table 4-3
Piping	0.02 *	1.00	2944	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	1472	Eng Guide #46, Table 4-3
Painting	0.01	1.00	1472	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:			44157	
TOTAL DIRECT COSTS (Base I	Price + Installation)=		191348	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	7360	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	0.50	7360	small capacity system/Table 4-3
Construction fee	0.10	1.00	14719	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	2944	Eng Guide #46, Table 4-3
Performance Test	0.06	1.00	8831	Estimate of inlet/outlet using Method 25A
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	4416	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			45629	
TOTAL CAPITAL COSTS (Dire	et + Indirect)=		236978	· · · · · · · · · · · · · · · · · · ·
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Scenario 1 - Production Area

Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

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Cost Item	Cost (\$)/unit	Units/year	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	182.5	4563	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 1 sht/day x 365 days/yr)
Supervision(15% of labor)			684	
Operating Materials				
/Catalyst/amoritized (CCR=0.26) at 9% for 5 years			2028	Vendor F Quote - 5 year catalyst life
	·			
Maintenance (general):				
Labor	27.5	182.5	5019	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 1 sht/day x 365 days/yr)
Materials (100% of labor)			5019	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
T T1 114 4				
	<u>¢0.06</u>	20140	100/	Vender F. Overs (7.0 VIIII v 2020 b fresh
Electricity (\$/ KWHXKWH/yt)	\$0.06	20440		Vendor F Quote (7.0 KWH X2920 hrs/yr)
Fuel oii (5/ gai x gai/ yr)		0(4	0	
Gas (\$/10 <sup>°</sup> ft <sup>*</sup> x 10 <sup>°</sup> ft <sup>*</sup> /yr)	\$4.00	964	3856	Vendor F Quote (0.33Mft3/hr x 2920hrs/yr)
Water			0	
Steam			0	
			0	
Waste Disposal				
111				
Wastewater Treatment			0	
TOTAL DIRECT ORERATING			22305	
Indirect operating (	20313 (A)-		22.375	
Indirect operating (nxed) costs:	POW of O & M/labor		7665	Eng Cuido #46 Table E 1
Breast Tax	19 of conital costs		2270	Eng. Galde #46, Table 5-1
	1% of capital costs		2370	Eng. Cuide #46, Table 5-1
Administration	1% of capital costs		4740	Eng. Guide #46, Table 5-1
Capital Pacavary CPE=	0 156	236977 51	36068	Lig. Guide #46, 12018 5-1
Capital Actively CAT-	(9.0% for 10 years)	20077201		Eng guide #46 Table 5-3
TOTAL FIXED COSTS (B)=	().070 101 10 years		54113	Lite. guide #40, 140/000
Credits				
Product recovery				
TOTAL CREDITS (C)=			0	
			<b>B</b> (200	
IUTAL ANNUALIZED COSTS	(A +B minus C)=		76507	
Uncontrolled Emissions Rate (to	ns/vear)=		2.3	
Overall (Capture & device eff.)C	Control			· · · · · · · · · · · · · · · · · · ·
System Efficiency (%)=			90	
Controlled Emissions (tons/year	)=		2.07	
			0/0/0	
Cost (\$/ton)=			36960	

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Scenario 1 - Production Area

Control System: Carbon adsorption (disposable/rechargeable) w/2000 scfm ventilation from core machine

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment	· ·			
unit, fan controls,stack/duct			14320	Vendor G Quote at \$4000/unit X 2 units; engr est of \$5000 fan and \$1320 ductwork
Auxiliary Equipment/duct to oxidizer			13810	(Appendix E-3)
Total Equipment Costs:			28130	
Instruments/controls	0.10	1.00	0	
Taxes	0.05	1.00	1407	
Freight	0.05	1.00	1407	
Base Price:			30943	
Installation costs, direct:		•		
Foundations/Supports	0.08	1.00	2475	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	4332	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	1238	Eng Guide #46, Table 4-3
Piping	0.02	1.00	619	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	309	Eng Guide #46, Table 4-3
Painting	0.01	1.00	309	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:			9283	· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT COSTS (Base Pr	 rice + Installation)= 		40226	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	1547	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	0.50	1547	small system/Table 4-3
Construction fee	0.10	1.00	3094	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	619	Eng Guide #46, Table 4-3
Performance Test	0.05	1.00	1547	
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	928	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=		· · · · ·	9283	
TOTAL CAPITAL COSTS (Direct	+ Indirect)=		49509	

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Scenario 1 - Production Area

Control System: Carbon adsorption (disposable/rechargeable) w/2000 scfm ventilation from core machine

Cost Item	\$/unit	units/year	COST	
Direct Operating Costs:				
Operating Labor:	;			
Operator (\$/HR X HRS/YR)	25	182.5	4563	Eng. Guide #46, Table 5-2 (.5 hrs/shft x 1 shft/day x 365 days/yr)
Supervision(15% of labor)			684	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	182.5	5019	Eng. Guide #46, Table 5-2 (.5 hrs/shft x 1 shft/day x 365 days/yr)
Materials (100% of labor)			5019	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	16555	993	KWH calculated base on Horsepower
Fuel oil (\$/gal x gal/yr)			0	
$G_{25} (\$/10^3 H^3 \times 10^3 / ym)$	\$4.00		0	
Water			0	
Steam			0	
Other			0	
Waste Disposal	_		136682	No. of carbon changes calculated by using Control Technologies of HAPs handbook
Wastewater Treatment			0	
TOTAL DIRECT OPERATING C	COSTS (A)=		152959	
Indirect operating (fixed) contra				
mairect operating (nxed) costs:	POP of O to Marbor		7665	Ener Cuide #46 Table E 1
Bronorte Tou	1% of capital costs		405	Eng. Guide #46, Table 5-1
	1% of capital costs		4,75	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		990	Eng Guide #46, Table 5-1
Capital Recovery CREE	0156	49508.8	7773	Eng Guide #46 Table 5-1
	(9.0% for 10 years)	47000.0		Eng. guide #46. Table 5-3
TOTAL FIXED COSTS (B)=			17369	
Cudita				
Product recovery	+			
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	A +B minus C)=		170328	
Uncontrolled Emissions Rate (tor		2.3		
Overall (Capture & device eff.)Co	ontrol			
System Efficiency (%)=			90	
Controlled Emissions (tons/year)			2.07	
Cost (\$/ton)≓			82284	
	<u></u>	L	02.003	<u> </u>

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### Concentrator/Oxidizer with 37,000 scfm

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Scenario 1 - Storage Area

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Estimates in

Control System: Concentrator/oxidizer w/37,000 scfm ventilation from enclosure around PUCB storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
	[ ·			· · · · · · · · · · · · · · · · · · ·
Direct Costs:				
Basic Equipment:				
adsorber/oxidizer, fan		~	650000	Lowest Quote - Vendor C
controls, stack/duct				
Auguiliant Francisment (anglement	<u> </u>		1.1.5	
Auxiliary Equipment/ enclosure,			147196	Eng. Estimate (Appendix E-3)
make-up air and ductwork				
Total Equipment Costs:			797196	
Instruments/controls	0.10	1.00	0	Included in guote
Taxes	0.05	1.00	39860	
Freight	0.05	1.00	39860	
				· · · · · · · · · · · · · · · · · · ·
Base Price:	1		876916	
				· · ·
Installation costs, direct:	_			· · · · · · · · · · · · · · · · · · ·
Foundations/Supports	0.08	1.00	70153	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	122768	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	35077	Eng Guide #46, Table 4-3
Piping	0.02	1.00	17538	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	8769	Eng Guide #46, Table 4-3
Painting	0.01	1.00	8769	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:			263075	
TOTAL DIRECT COSTS (Base Price	ce + Installation)=		1139990	
				·
Installation costs, indirect				
Engineering/supervision	0.05	1.00	43846	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	87692	Table 4-3
Construction fee	0.10	1.00	87692	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	17538	Eng Guide #46, Table 4-3
2	1 0.01	1.00	8769	Estimate for 25a inlet/outlet
Performance Test	0.01	4 00		
Performance Test Model study	0.00	1.00	0	
Performance Test Model study Contingencies	0.00	1.00 1.00	0 26307	Eng Guide #46, Table 4-3
Performance Test Model study Contingencies	0.00 0.03	1.00 1.00	0 26307	Eng Guide #46, Table 4-3
Performance Test Model study Contingencies TOTAL INDIRECT COSTS=		1.00 1.00	0 26307 271844	Eng Guide #46, Table 4-3
Performance Test Model study Contingencies TOTAL INDIRECT COSTS=		1.00 1.00	0 26307 271844	Eng Guide #46, Table 4-3
Performance Test Model study Contingencies TOTAL INDIRECT COSTS=		1.00	0 26307 271844	Eng Guide #46, Table 4-3
Performance Test Model study Contingencies TOTAL INDIRECT COSTS=		1.00	0 26307 271844	Eng Guide #46, Table 4-3

#### Scenario 1 - Storage Area

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Control System: Concentrator/oxidizer w/37,000 scfm ventilation from enclosure around PUCB storage

Cost Item (\$/unit x units/yea	r) COST			
Direct Operating Costs:				· · · · · · · · · · · · · · · · · · ·
Direct Operating Costs.				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	443	11075	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 2.43 shts/day x 365 days/yr
Supervision(15% of labor)			1661	
Operating Materials			0	
Maintenance (general):	J			
Labor	27.5	443	12183	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 2.43 shts/day x 365 days/yr
Materials (100% of labor)			12183	
Replacement parts (as required)			18000	
Labor (100% of parts cost)			18000	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	1024848	61491	Vendor C Quote (144 KWH x 7117 hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>3</sup> ft <sup>3</sup> /yr)	\$4.00	3559	14236	Vendor C Quote (.5 Mft <sup>9</sup> /hr x 7117 hrs/yr)
Water			0	
Steam			0	
Other	-		0	•
Waste Disposal			0	
Wastewater Treebrant			0	
TOTAL DIRECT OPERATING CO	STS (A)≕		148828	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		18606	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		14118	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		14118	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		28237	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1411834.12	220246	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)		005005	Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			295325	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A	+B minus C)=		444154	
Uncontrolled Emissions Rate (tons/	year)=		5	
Overall (Capture & device eff.)Cont	ro]			
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.50	
Cost (\$/ton)=			98701	

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### Regenerative Thermal Oxidizer with 37,000 scfm

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Scenario 1 - Storage Area

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Control System: Regenerative Thermal oxidizer w/37,000 scfm ventilation from enclosure for PUCB storage

	Average	Adjustment		
Cost Hem	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:		;		
oxidizer, fan controls,stack/duct			591782	Lowest Quote - Vendor B
			_ ب	
Auxiliary Equipment/enclosure, make-up air and ductwork			147196	Eng. Estimate (Appendix E-3)
<b>T</b> . 17			70.0070	· · · · · · · · · · · · · · · · · · ·
Total Equipment Costs:			/309/8	
Te cherry on the family and the	010	1.00		
Instruments/ controls	0.10	1.00	26040	
Freight	0.05	1.00	34040	
гненди	0.05	1.00	30949	· · · · · · · · · · · · · · · · · · ·
Press Prince			910976	
Dase Frice:			0120/6	
Installation costs direct		· · · ·		
Foundations (Suprants	0.08	1.00	65020	Ener Cuildo #46 Table 4.3
Foundations/Supports	0.08	1.00	113803	Eng Guide #46, Table 4-5
Election/handling	0.14	1.00	22515	Eng Guide #46, Table 4-3
Pietro -	0.04	1.00	14250	Eng Guide #40, Table 4-3
riping	0.02	1.00	10236	
	0.01	1.00	8129	Eng Guide #40, Table 4-3
Cite	0.01	1.00	0129	Eng Guide #40, Table 4-5
	0.00	1.00	0	Eng Guide #40, Table 4-3
Facumes/ buildings	0.00	1.00	0	
Total Installation Costs:			243863	
TOTAL DIRECT COSTS (Base Price	ce + Installation)=		1056739	
Installation costs, indirect:				
Engineering (supervision	0.05	1.00	40644	Eng Guide #46 Table 4-3
Construction / field expenses	0.00	1.00	\$1099	Table 4.3
Construction foo	0.10	1.00	81799	Fng Cuide #46 Table 4.3
Chart up	0.10	1.00	16759	Eng Cuide #46 Table 4.3
Parformance Test	0.02	1.00	0755	Estimate for 25a inlat /outlat
Model study		1.00		
Contingencies	0.03	1.00	24386	Eng Guide #46. Table 4-3
Soundigenetes		2.00	21000	Lang organic if AV/ AMPAC A V
TOTAL INDIRECT COSTS=			253617	
	Ladimet)=		1310354	
101AL CAPITAL CUS 15 (Direct +	- manecy=		1010000	

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Scenario 1 - Storage Area

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Control System: Regenerative Thermal oxidizer w/37,000 scfm ventilation from enclosure for PUCB storage

Cost Item (\$/unit x units/y	ear) COST			
Direct Operating Costs:				
Operating Labor:		110		
Operator (\$/HR X HRS/YR)	25	443	110/5	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2.43 shifts/day x 365 days/yr)
Supervision(15% of labor)			1661	
			0	
Maintenance (general):		112	10100	
	27.5	44.5	12183	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2.43 shifts/day x 365 days/yr)
Materials (100% of labor)			12183	4
Paplacement parts (as required)			0	
Labor (100% of parts cost)	-		0	
Eabor (100 % of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	861157	51669	vendor(121.0 KWH x7117 hrs/vr)
Fuel oil (\$/gal x gal/yr)			0	
$Gas($/10^3 ft^3 x 10^3 / y_T)$	\$4.00	25621	102484	vendor(3.6Mft3/Hrx7117hrs/vr)
Water			0	
Steam	-		0	
Other			0	
			0	
Waste Disposal				· · · · · · · · · · · · · · · · · · ·
			-	
Wastewater Treatment			0	
				· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT OPERATING C	OSTS (A)=		191255	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		18606	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		13104	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		13104	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		26207	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1310355.79	204416	Eng. Guide #46, Table 5-1
	( 9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			275436	
Credits				
Product recovery			· .	
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (	A +B minus C)=		466690	
	Ļ			
Uncontrolled Emissions Rate (ton	s/year)=		5	
Querell (Cartan A. L. L. 1997)				
Sustan Efficience and the	ontrol			
System Efficiency (%)=			90	
Controlled Ferringians (house to a lo	<u> </u>		4 50	
Controlled Emissions (tons/year)*	• 		4.30	
Cost (\$/top)#			102700	
			102/03	

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# Biofilter with 37,000 scfm

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Scenario 1 - Storage Area

Control System: Biofilter w/37000 scfm for PUCB Core Storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
Biofilter			1496000	Lowest Quote - Vendor E
Auxiliary				
Equipment/enclosure/make-up			147196	Eng. Estimate (Appendix E-3)
air units/ductwork		• •		
Total Equipment Costs:			1643196	
			_	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	82160	
Freight	0.05	1.00	82160	
Base Price:	·		1807516	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	0	Included in vendor quote
Erection/handling	0.14	1.00	0	Included in vendor quote
Electrical	0.04	1.00	0	Included in vendor quote
Piping	0.02	1.00	0	Included in vendor quote
Insulation	0.01	1.00	0	Included in vendor quote
Painting	0.01	1.00	0	Included in vendor quote
Site preparation	0.00	1.00	0	Included in vendor quote
Facilities/buildings	0.00	1.00	0	Included in vendor quote
Total Installation Costs:			0	
TOTAL DIRECT COSTS (Base Pr	ice + Installation)=		1807516	
Installation costs, Indirect:			·	
	0.07	1.00		
Engineering/supervision	0.05	1.00	0	included in vendor quote
Construction/field expenses	0.10	1.00	0	Included in vendor quote
Construction fee	0.10	1.00	0	Included in vendor quote
Start-up	0.02	1.00	0	Included in vendor quote
Performance Test	0.005	1.00	9038	Est. for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	5.00	271127	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
WOTAL INDIDION COOM			2001/5	
TUTAL INDIRECT COSTS=			280165	
			000710-	
IUIAL CAPITAL COSTS (Direct	+ Indirect)≖		2087681	

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Scenario 1 - Storage Area

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 $\frac{1}{2}$  :

Control System: Biofilter w/37000 scfm for PUCB Core Storage

Cost Item (\$/unit x units/ye	ar) COST			
Direct Operating Costs:				
	· ·			
Operating Labor:				
Operator (\$/HR X HRS/YR)	25			Vendor E Estimate
Supervision(15% of labor)			<u> </u>	
Operating Materials				
			╉────	
Maintenance (general).	27.5	100	2750	Vandar E Estimate
Materials (100% of labor)	27.0		2750	
Replacement parts (as required)			47500	Vendor E Estimate
Labor (100% of parts cost)			47500	
,,, <u>/</u> ,, /				
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	244113	14647	vendor (34.3 KWHx7117hrs/yr))
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>3</sup> /yr)			0	
Water			0	
Steam			0	
Other	·		0	
			0	
Waste Disposal				
Address and a market of the second				
Wastewater Treatment				· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT OPERATING CO	) STS (A)=		115147	
TOTAL DIRECT OF ERATING CC			11514/	
Indirect operating (fixed) costs:	<u> </u>			
Overhead	80% of O & M(a + b)		2200	
Property Tax	1% of capital costs		20877	
Insurance	1% of capital costs		20877	
Administration	2% of capital costs		41754	
Capital Recovery CRF=	0.11	\$2,087,681	229645	
	(9.0% for 20 years)			Vendor E estimate of equipment life
TOTAL FIXED COSTS (B)=			315352	
	_			
Credits		L		
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=				· · · · · · · · · · · · · · · · · · ·
TOTAL ANNULALIZED COETS (A	+R minus Or		130,100	
TOTAL ANNOALIZED COSTS (A	T T T T T T		4.0477	
Uncontrolled Emissions Rate (tons	(vear)=		5	
Chiestinonea Endostolis Nate (tona			†	
Overall (Capture & device eff.)Cor	ntrol			
System Efficiency (%)=			90	
			1	
Controlled Emissions (tons/vear)=			4.50	
Cost (\$/ton)=			95666	•

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### Concentrator/Oxidizer with 30,500 scfm

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Scenario 2 - Production

Control System: Concentrator/oxidizer w/30,500 scfm ventilation from enclosure around PUNB core prod.

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
			• • •	
Direct Costs:				
Basic Equipment:		5		
oxidizer, fan controls,stack/duct			650000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure,			246340	Eng. Estimate (Appendix E-3)
make-up air units and ductwork to				
Total Faultment Costs:			896340	
Total Equipment Costs.			070040	· · · · · · · · · · · · · · · · · · ·
Instruments/controls	0.10	1.00	0	Included in quote
Тахея	0.05	1.00	44817	
Freight	0.05	1.00	44817	
Base Price:			985974	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	78878	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	138036	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	39439	Eng Guide #46, Table 4-3
Piping	0.02	1.00	19719	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	9860	Eng Guide #46, Table 4-3
Painting	0.01	1.00	9860	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	Ō	Eng Guide #46, Table 4-3
Total Installation Costs:			295792	
TOTAL DIRECT COSTS (Base Pri	ice + Installati	on)=	1281766	
		•		
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	49299	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	98597	Table 4-3
Construction fee	0.10	1.00	98597	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	19719	Eng Guide #46, Table 4-3
Performance Test	0.01	1.00	9860	Estimate for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	29579	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			305652	
TOTAL CAPITAL COSTS (Direct -	+ Indirect)=		1587418	

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Scenario 2 - Production

Control System: Concentrator/oxidizer w/30,500 scfm ventilation from enclosure around PUNB core prod.

Cost Item	\$/unit	units/yr	\$∕yr	
Direct Operating Costs:				
Operating Labor:		100 -		
Operator (\$/HR X HRS/YR)	25	182.5	4563	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 1 shifts/day x 365 days/yr)
Supervision(15% of labor)			684	
Operating Materials			<u> </u>	
Maintenance (general):	27.5	1925	E010	E-+ Cutto #46 Table 5 2 (5 b-+ (-146 1 - 146 - (-1
Labor	27.5	162.5	5019	Eng. Guide #46, Table 5-2 (.5 hts/shift x 1 shifts/day x 365 days/yr)
Materials (100% of labor)				
Poplamment nests (as required)			18000	
Labor (100% of parts (as required)			18000	
			10000	
[Itilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	420480	25229	Vendor C quote (144.0 KWH x 2920 hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
$Gas($/10^3 ft^2 x 10^3 ft^2 / yr)$	\$4.00	1460	5840	Vendor C quote (.5 Mft3/Hr x 2920 hrs/yr)
Water			0	
Steam			. 0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING CO	STS (A)≖		82353	
Indirect operating (fixed) costs:		3		
Overhead	80% of O & M(labor)		7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital	costs	15874	Eng. Guide #46, Table 5-1
Insurance	1% of capital	costs	15874	Eng. Guide #46, Table 5-1
Administration	2% of capital	costs	31748	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1587418.14	247637	Eng. Guide #46, Table 5-1
(9	.0% for 10 yea	rs)	010500	Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			318799	· · · · · · · · · · · · · · · · · · ·
Credite				
Product receiver				
Hast receivery				· · · · · · · · · · · · · · · · · · ·
TOTAL CREDITS (C)-	 			
IOTAL CREDITS (C)=				
TOTAL ANNULAU IZED COSTS (A	+B minue ()		401152	
TOTAL ANNOALIZED COSTS (A	· D IIIIIUS C)		401102	
Uncontrolled Emissions Rate (tons)	(verr)=		2.5	
Chechitotted Englasions Mate (1013	ycat/-			
Overall (Capture & device off) Con	tml			
System Efficiency (%)#			90	······································
Controlled Emissions (tons/year)=			2.25	
Cost (\$/ton)≓			178290	

### Regenerative Thermal Oxidizer with 30,500 scfm

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Scenario 2 - Production

Control System: Regen. Thermal oxidizer w/30,500 scfm ventilation from enclosure for PUNB core prod.

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment		- · ·		
oxidizer, fan, controls,stack/duct			571782	Vendor B Quote
Auxiliary Equipment/enclosure, make-up air units and ductwork		:	246340	Eng. Estimate (Appendix E-3)
Tatal Fauirment Casta			P1 91 22	
Total Equipment Costs:			010122	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	40906	
Freight	0.05	1.00	40906	
	0.00	1.00		· · · · · · · · · · · · · · · · · · ·
Base Price			899934	
Dase Trice.			0///04	
Installation costs directs				
Equadations / Supports	0.08	1.00	71005	Ena Cuida #46 Table 4.3
Foundations/Supports	0.08	1.00	125001	Eng Cuide #46, Table 4-3
Election/ nanoling	0.14	1.00	25007	Eng Guide #46, Table 4-3
Dising	0.04	1.00	17000	Eng Guide #46, Table 4-3
Insulation	0.02	1.00	8000	Eng Guide #46, Table 4-3
Painting	0.01	1.00	8000	Eng Guide #46, Table 4-3
Site proposation	0.01	1.00	0	Eng Guide #46, Table 4-3
Encilities / buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Pacifices/ buildings	0.00	1.00		
Total Installation Costs:			269980	
Total Installation Costs.			209900	
TOTAL DIRECT COSTS (Reas B	ico de Trastallat	ion)=	1160014	
TOTAL DIRECT COSTS (Base F	ice + Installat	1011)-	1107914	
Installation costs in directs				
Installation costs, indirect:				· · · · · · · · · · · · · · · · · · ·
E	0.05	1.00	44007	En a Cuida #46 Table 4.2
Engineering/supervision	0.05	1.00	4499/	Eng Guide #46, Table 4-5
Construction/ Held expenses	0.10	1.00	89993	Table 4-3
Construction fee	0.10	1.00	89993	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	1/999	Eng Guide #40, Table 4-3
renormance lest	0.012	1.00	10/33	Estimate for 25a inter/outlet
Contin and study	0.00	1.00	0	En Cuita 446 Table 4.2
Contingencies	0.03	1.00	20998	Eng Guide #40, lable 4-0
TOTAL DIDIDIO			000000	· · · · · · · · · · · · · · · · · · ·
TOTAL INDIRECT COSTS=			280779	· · · · · · · · · · · · · · · · · · ·
TOTAL CAPITAL COSTS (Direct	+ Indirect)=		1450694	

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Scenario 2 - Production

Control System: Regen. Thermal oxidizer w/30,500 scfm ventilation from enclosure for PUNB core prod.

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Cost Item	\$/unit	unite/vr	cost	
Direct Operating Costs:	+			
	+			
Operating Labor:	+			
Operator (\$/HR X HRS/YR)	25	182.5	4563	(a) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 1 shift/day x 365 days/yr
Supervision(15% of labor)	1		684	(.5 hrs/5 ftx2.43 shifts/dayx 365 days/yr)
			0	
Maintenance (general):				
Labor	27.5	182.5	5019	(b) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 1 shift/day x 365 days/yr
Materials (100% of labor)			5019	
Replacement parts (as required)	<u> </u>		0	
Labor (100% of parts cost)	<u> </u>		0	
	<u> </u>			
	<b>6</b> 0.04	280080	17245	Vender B (99.0 KW/H v2920 hrs (vr)
Electricity (\$/ KWHXKWH/yf)		207000	1/345	Vendor B (99.0 KW A 22920 Ars/ yr)
Fuel ou (5/ gai x gai/yr)		9469	22077	Vander P (2.0) (42 (11-2020 har (22)
Gas (\$/10H*x10/yr)	\$4.00	0400	33872	Vendor B (2.9Mills/ Firx2920 hrs/ yr)
Water	<u> </u>		0	
Steam	+			
Other			0	
Waste Disposal	+			
	<u>+</u>		<u> </u>	
Wastewater Treatment	<del> </del>		0	
	+		· · · ·	
TOTAL DIRECT OPERATING C	OSTS (A)=		66501	
				· · · · · · · · · · · · · · · · · · ·
Indirect operating (fixed) costs:	+			
Overhead	1 & O to %08	M(labor)	7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital	costs	14507	Eng. Guide #46, Table 5-1
Insurance	1% of capital	costs	14507	Eng. Guide #46, Table 5-1
Administration	2% of capital	costs	29014	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	\$1,450,694	226308	
()	9.0% for 10 yea	ars)		Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			292001	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (	A +B minus C	:)=	358502	
Uncontrolled Emissions Rate (ton	s/year)≖		2.5	
		<u> </u>		
Overall (Capture & device eff.)Co	ntrol			
System Efficiency (%)=		1	90	······
	+	<u> </u>	<u>+</u>	
Controlled Emissions (tonshiese)	 a	+	2 25	
	T			
Cost (\$/top)=	+	<u> </u>	159334	
	<u> </u>		107004	

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### Biofilter with 30,500 scfm

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Scenario 2 - Production

Control System: Biofilter w/30500 scfm for PUNB Core Production

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
Biofilter			1190000	Lowest Quote - Vendor D
Auxiliary				
Equipment/enclosure/make-up			246340	Eng. Estimate (Appendix E-3)
air units/ductwork	1	• •	-	
	-			
Total Equipment Costs:			1436340	
Instruments/controls	0.10	1.00	0	Include in quote
Taxes	0.05	1.00	71817	
Freight	0.05	1.00	71817	
Base Price:			1579974	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	0	Included in vendor guote
Erection/handling	0.14	1.00	0	Included in vendor guote
Electrical	0.04	1.00	0	Included in vendor quote
Piping	0.02	1.00	0	Included in vendor quote
Insulation	0.01	1.00	0	Included in vendor guote
Painting	0.01	1.00	0	Included in vendor quote
Site preparation	0.00	1.00	0	Included in vendor quote
Facilities/buildings	0.00	1.00	0	Included in vendor quote
, <u></u>				
Total Installation Costs:			0	
TOTAL DIRECT COSTS (Base Pri	ce + Installati	on)≖	1579974	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	0	Included in vendor quote
Construction/field expenses	0.10	1.00	0	Included in vendor quote
Construction fee	0.10	1.00	0	Included in vendor quote
Start-up	0.02	1.00	0	Included in vendor quote
Performance Test	0.005	1.00	7900	Estimate for Method 25A inlet/outlet
Model study	0.00	1.00	0	
	0.00	F 00	00(00)	Eng Guide #46, Table 4-4, new application of control technology and
Contingencies	0.03	5.00	236996	guaranteed performance
				·····
TOTAL INDIRECT COSTS=			244896	· · · · · · · · · · · · · · · · · · ·
······		_		
TOTAL CAPITAL COSTS (Direct	+ Indirect)=		1824870	

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Control System: Biofilter w/30500 scfm for PUNB Core Production

Cost Iters	Chan th	1	Cast	
Cost Item	Syunit	unitsyyr	Cost	
	ļ		ļ	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	0 1	0	
Supervision(15% of labor)			0	
			1	
Operating Materials			0	
operating materials				
N(-1-+				
Maintenance (general):		50	1075	
Labor	27.5	50	1373	Vendor D Quote
Materials (100% of labor)			13/5	· · · · · · · · · · · · · · · · · · ·
Replacement parts (as required)			39150	Vendor E Estimate of Media Costs
Labor (100% of parts cost)			39150	
	_			
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	82636	4958	Vendor E Quote (28.3 KWH x 2920 hrs/yr)
Fuel oil (\$/gal x gal/vr)			0	
$G_{as}(\$/10^{3}f^{3}x 10^{3}/yr)$		·	0	
Water			0	
Steam			0	
Other			0	· · · · · · · · · · · · · · · · · · ·
Ouler				· · · · · · · · · · · · · · · · · · ·
14/			<u> </u>	
waste Disposal				
Wastewater Treatment			0	· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT OPERATING CC	STS(A) =		86008	
Indirect operating (fixed) costs:				
Overhead	80% of O & N	((labor)	1100	
Property Tax	1% of capital	costs	18249	
Insurance	1% of capital	cosis	18249	
Administration	2% of capital	costs	36497	
Capital Recovery CRF=	0.11	1824869.97	200736	
(9	.0% for 20 yea	rs)		vendor eq. life estimate
TOTAL FIXED COSTS (B)=		1	274830	
Credits		-		
Product recovery				
Heat recovery				
		·····		
IOTAL CREDITS (C)=			0	
			0.00000	
IOTAL ANNUALIZED COSTS (A	+B minus C)	-	360839	
Uncontrolled Emissions Rate (tons	/year)=		2.5	
Overall (Capture & device eff.)Con	trol			
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.25	
Cost (\$/ton)=			160373	

### Concentration/Oxidizer with 36,000 scfm

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#### Scenario 2 - Storage

Control System: Concentrator/oxidizer w/36,000 scfm ventilation from enclosure for PUNB core storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
			(50000	
oxidizer, fan controls,stack/duct			650000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure,			139201	Eng. Estimate
make-up an drus and ductwork to				
Total Equipment Costs:			789201	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	39460	
Freight	0.05	1.00	39460	
Base Price:			868121	
Installation costs, direct:	1			
Foundations/Supports	0.08	1.00	69450	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	121537	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	34725	Eng Guide #46, Table 4-3
Piping	0.02	1.00	17362	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	8681	Eng Guide #46, Table 4-3
Painting	0.01	1.00	8681	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:			260436	
TOTAL DIRECT COSTS (Base Pr	ice + Installat	ion)≖	1128557	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	43406	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	86812	Eng Guide #46, Table 4-3
Construction lee	0.10	1.00	170(0	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	1/362	Eng Guide #46, Table 4-3
Performance lest	0.01	1.00		Estimate for Method 25a inlet/ outlet
Model study	0.00	1.00	0	
Conangencies	0.03	1.00	20044	Eng Guide #40, 1 2018 4-5
TOTAL INDURET COCTO			260110	· · · · · · · · · · · · · · · · · · ·
TOTAL INDIRECT COSTS=			207110	· · · ·
TOTAL CARTAL COSTS (D)	t. Tur aller - 143-		1207475	
LOTAL CAPITAL COSTS (Direct	- incurect)=		132/0/3	

Scenario 2 - Storage

Control System: Concentrator/oxidizer w/36,000 scfm ventilation from enclosure for PUNB core storage

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Cost Item	\$/unit	units/yr	Cost	
	1			
Direct Operating Costs:	Ļ			
Operating Labor:	<u> </u>			
Operator (\$/HR X HRS/YR)	25	443	11075	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2.43 shifts/day x 365 days/yr
Supervision(15% of labor)	ļ		1661	
	<u> </u>			
Operating Materials	ļ	ļ	0	
Maintenance (general):	1			
Labor	27.5	443	12183	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2.43 shifts/day x 365 days/yr
Materials (100% of labor)	<b></b>		12183	
	·			
Replacement parts (as required)			18000	Vendor C quote - annual absorbent cost
Labor (100% of parts cost)			18000	
Thilling a				
	£0.04	1024949	61.401	Vender Cauche (144 0 KW/H + 7117 har /ma)
Electricity (5/ KwHXKwH/yr)		1024040	01491	Vendor C quote (144.0 KWP1 x7117 hts/yr)
Fuel ou (5/ gai x gai/yr)		0550	14000	
Gas (\$/10°ff*x 10°/yr)	\$4.00	3008	14232	Vendor C quote (0.5Mrt3/Hr X/11/hrs/yr)
Water			0	
Steam	<u> </u>	ļ	0	
Other	 		0	
	<u> </u>		0	
Waste Disposal				
Wastewater Treatment	<u> </u>		<u> </u>	
TOTAL DIRECT OPERATING CO	<u> JSTS (A)</u> =		148824	
Indirect operating (fixed) costs:			10/0/	
Overhead	80% 010 & N	A(labor)	18606	Eng. Guide #46, Table 5-1
Property Tax	1% of capital	costs	139/7	Eng. Guide #46, Table 5-1
Insurance	1% of capital	costs	139/7	Eng. Guide #46, Table 5-1
Administration	2% of capital	COSts	2/953	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	210,196,16	218037	
()	7.0% for 10 yea	ars)		Eng. guide #46, 1able 5-3
TOTAL FIXED COSTS (B)=			292550	
	<u> </u>			
Credits	1			
Product recovery				
Heat recovery	<u> </u>			
TOTAL CREDITS (C)=	<u> </u>		0	· · · · · · · · · · · · · · · · · · ·
	<u> </u>			
TOTAL ANNUALIZED COSTS (A	A +B minus C	:)=	441374	
Uncontrolled Emissions Rate (ton	s/year)≖		4.8	
				· ·
Overall (Capture & device eff.)Co	ntrol			
System Efficiency (%)=			90	
		<u> </u>		
Controlled Emissions (tonstrong)	<u>L</u>	ł • • • •	4 3 2	
Contoned Emissions (tonsyyear)	1		7.54	
Cast (\$/tap)=	+		103170	
	<u> </u>	L	1021/0	

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### Regenerative Thermal Oxidizer with 36,000 scfm

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Scenario 2 - Storage

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Control System: Regen. Thermal oxidizer w/36,000 scfm ventilation from enclosure for PUNB core storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:		· · ·		
oxidizer, fan, controls,stack/duct			581482	Vendor Quote (Vendor B)
Auxiliary Equipment/enclosure, make-up air units and ductwork			139201	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			720683	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	36034	
Freight	0.05	1.00	36034	
Base Price:			792751	
			<u> </u>	
Installation costs, direct:		1.00		
Foundations/Supports	0.08	1.00	63420	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	110985	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	31710	Eng Guide #46, Table 4-3
Piping	0.02	1.00	15855	Eng Guide #46, Table 4-3
Printing	0.01	1.00	7928	Eng Guide #46, Table 4-3
Site propagation	0.01	1.00	/920	Eng Guide #46, Table 4-5
Facilities / buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
ractifices/ buildings	0.00	1.00		Eng Guide #46, 12012 4-5
Total Installation Costs			227825	
Total Instantion Costs.				
TOTAL DIRFCT COSTS (Base I	Price + Install	ation)=	1030577	
			1000077	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	39638	Eng Guide #46. Table 4-3
Construction/field expenses	0.10	1.00	79275	Table 4-3
Construction fee	0.10	1.00	79275	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	15855	Eng Guide #46, Table 4-3
Performance Test	0.012	1.00	9513	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	23783	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			247338	
			•	
TOTAL CAPITAL COSTS (Dired	ct + Indirect)=		1277915	

#### Scenario 2 - Storage

Control System: Regen. Thermal oxidizer w/36,000 scfm ventilation from enclosure for PUNB core storage

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	443	11075	(a) Eng. Guide #46, Table 5-2 (.5 hrs/5 ft x 2.43 shifts/day x 365 days/yr)
Supervision(15% of labor)			1661	
Operating Materials:			0	
			ļ	
Maintenance (general):				
Labor	27.5	443	12183	(b) Eng. Guide #46, Table 5-2 (.5 hrs/5 ft x 243 shifts/day x 365 days/yr)
Materials (100% of labor)			12183	
<b>D</b>		ļ		
Replacement parts (as required)			0	
Labor (100% of parts cost)				
I Itilities				
Flectricity (\$/KWH~KWH/)	\$0.06	839806	50388	Vendor B (1180 KWH x7117 hrs/vr)
Fuel oil (\$/gal x gal/yr)	\$0.00	037000	0	
$C_{ac} (f_{a} (10^3 (3.10^3 ())))$	\$1.00	25621	102484	Vendor B (3 6Mft3 / Hor 7117brs / yr)
Gas (\$/10 ft x 10 / yr)		23021	102404	
Steam			0	
Other	┟────────┤		0	
	<b> </b>		0	
Waste Disposal				
				· · · · · · · · · · · · · · · · · · ·
Wastewater Treatment			0	
Trasicitated Treatment				
TOTAL DIRECT OPERATING	COSTS(A) =		189974	
Indirect operating (fixed) costs:				
Overhead	80% of Q & N	(labor)	18606	Eng. Guide #46. Table 5-1
Property Tax	1% of capital	costs	12779	Eng. Guide #46, Table 5-1
Insurance	1% of capital	costs	12779	Eng. Guide #46, Table 5-1
Administration	2% of capital	costs	25558	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	\$1,277,915	199355	
(9	.0% for 10 yea	urs)		Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=	[		269077	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	(A +B minus	C)≖	459051	
Uncontrolled Emissions Rate (to)	ns/vear)=		4.8	· · · · · · · · · · · · · · · · · · ·
		· · · · · · · · · · · · · · · · · · ·		
Overall (Capture & device off)	ontrol			···
Svistam Effecta (0/)	Unitor			
System Efficiency (%)=				
	L			
Controlled Emissions (tons/year)			4.32	
			+ • •	
Cost (\$/ton)=	L		106262	

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### Biofilter for 36,000 scfm

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#### Annualized Cost Analysis Scenario 2 - Storage

Control System: Biofilter for 36,000 scfnyPUNB Core Storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (Ss)	Basis of Costs
Cost Acta	000112001		0001 (40)	
Direct Costs:		•		
Basic Equipment:		N. 1		
biofilter			1455000	Lowest Ouote - Vendor E
Auxiliary Equipment/enclosure,			139201	Eng. Estimate (Appendix E-3)
make up air units & ductwork		·		
Total Equipment Costs:			1594201	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	79710	
Freight	0.05	1.00	79710	
Base Price:			1753621	······································
Installation costs, direct:	0.09	1.00		ta du da dua avata
Foundations/Supports	0.08	1.00	0	Included in quote
Electrical	0.14	1.00	0	included in quote
Pipipg	0.04	1.00	0	included in quote
Ingulation	0.02	1.00	0	included in quote
Painting	0.01	1.00	0	included in quote
Site preparation	0.00	1.00	0	included in quote
Facilities/buildings	0.00	1.00	0	included in quote
Total Installation Costs:			0	
TOTAL DIRECT COSTS (Base Pri	ice + Installati	on)=	1753621	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	0	included in guote
Construction/field expenses	0.10	1.00	0	included in quote
Construction fee	0.10	1.00	0	included in quote
Start-up	0.02	1.00	0	included in quote
Performance Test	0.005	1.00	8768	Estimate for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	5.00	263043	Eng Guide #46, Table 4-4, new application of control technology and
				guaranteed performance
			0.00	· · · · · · · · · · · · · · · · · · ·
TOTAL INDIRECT COSTS=			271811	
	[]			
TOTAL CADITAL CONTRACT			2025422	
IUTAL CAPITAL COSTS (Direct	+ indirect)=		2025432	

Scenario 2 - Storage

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Control System: Biofilter for 36,000 scfm/PUNB Core Storage

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Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operation Laboration				
Operating Labor:	25	0		
Operator (5/ HK X HRS/ 1K)	25	<u> </u>	0	Vendor E estimate
Supervision(15% of labor)			<u> </u>	
Operating Metarials			46200	Vender Fredinster en vel media enste
			40200	
Maintenance (concerd):				
Maintenance (general):	27.5	100	2750	Verder Egypte
Labor	27.5		2750	Vendor E quote
Materials (100% of labor)			2/30	
Replacement marte (as required)			<u> </u>	······································
Labor (100% of parts (as required)			0	
Labor (100 % of parts cost)				
Itilitieet		<u> </u>		
Flactricity (\$/KWH-KWH/)	\$0.04	233454	14007	Vandor F. mucha (32.8 buth x 7117)
Fuel oil (\$/ gal x gal/um)		2.04.04	0	VEIGOT E QUOIE (SEO KWILX/11/)
Can (\$ / 103(12x 103 (12x))	···-			
Water				
Steam				
Other				
Otter			0	
Waste Diseasel				
Waste Disposal				
Washowston Treeston and		· · · · · · · · · · · · · · · · · · ·		
Wastewater Treatment				
TOTAL DIRECT OPER ATING CO			65707	
TOTAL DIRECT OPERATING CC	1515 (A)#		65/0/	
Indirect operating (fixed) costs:	<b></b>			
Overhead	80% of 0 % N	((labor)	2200	·····
Property Tay	1% of canital		2200	
Insurance	1% of capital	coste	20254	
Administration	2% of capital	costs	40509	
Capital Recovery CRE	0.11	\$2 025 432	222798	
Capital Recovery Citat	0% for 20 yea	v2,020,302		equipment vendor estimate
TOTAL FIXED COSTS (B)=	1		306015	
				· · · · · · · · · · · · · · · · · · ·
Cradite				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
IOTAL CREDITS (C)-				
TOTAL ANNUALIZED COSTS (A	+B minue ():		371722	
TOTAL ANNOALIZED COSTS (A			5/1/22	
Uncontrolled Emissions Rate (tone	/vear)=		4.8	
Citer Citer Citer Citer Citer Citer	<u></u>		1.0	
Overall (Capture & device off) Con	utrol			
System Efficiency (%)=			90	
wy ovent turnetency (70)-			70	
Controlled Emissions (tonshipper)			4 32	
contonea Engasiona (tonay year)4			7.04	
Cost (\$/ton)#			86047	
	l			

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# Concentrator/Oxidizer with 85,000 scfm

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Scenario 3 - Production

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Control System: Concentrator/oxidizer w/85,000 scfm ventilation from enclosure for PUNB mold production

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			1300000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure, make-up air units and ductwork to		1 J. 72.	468818	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			1768818	
	0.10			
Instruments/controls	0.10	1.00	0	Included in guote
Taxes	0.05	1.00	88441	
Freight	0.05	1.00	88441	
				·
Base Price:			1945700	
				÷ .
Installation costs, direct:	0.00			
Foundations/Supports	0.08	1.00	155656	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	272398	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	77828	Eng Guide #46, Table 4-3
Piping	0.02	1.00	38914	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	19457	Eng Guide #46, Table 4-3
Painting	0.01	1.00	19457	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Total Installation Costs:			583710	
TOTAL DIRECT COSTS (Base Pri	ce + Installation)=	ļ	2529410	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	97285	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	194570	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	194570	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	38914	Eng Guide #46, Table 4-3
Performance Test	0.006	1.00	11674	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	58371	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			595384	
TOTAL CAPITAL COSTS (Direct +	Indirect)=		3124794	

Scenario 3 - Production

Control System: Concentrator/oxidizer w/85,000 scfm ventilation from enclosure for PUNB mold production

.

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	350	8750	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Supervision(15% of labor)			1313	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	350	9625	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Materials (100% of labor)	· · ·		9625	
Replacement parts (as required)	1		40000	Vendar C Ouote
Labor (100% of parts cost)			40000	Eng. guide #46
Utilities:			<u> </u>	
Electricity (\$/KWHxKWH/yr)	\$0.06	1904000	114240	Vendor C Ouote (340 KWH x 5600 hrs/yr
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>3</sup> ft <sup>3</sup> /yr)	\$4.00	6720	26880	Vendor C Quote (1.2 Mft3/Hr x 5600hrs/
Water			0	
Steam			0	
Other			0	
Waste Disposal				
Wastewater Treatment				
			050(00	
IOTAL DIRECT OPERATING C	JSTS (A)=		250433	
ndirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		14700	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		31248	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		31248	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		62496	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	\$3,124,794	487468	
	( 9.0% for 10 years)			Eng. guide #46, Table 5-3
OTAL FIXED COSTS (B)=		<u> </u>	627160	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A	A +B minus C)=		877592	
Uncontrolled Emissions Rate (ton	¦ s/year)≖		13.4	
Jverall (Capture & device eff.)Co	ntrol			
System Efficiency (%)=	· · · · · · · · · · · · · · · · · · ·			
Controlled Emissions (tons/year)=			12.06	
Cast (\$/tan)=	<u> </u>		77740	
Lusi (ayton)=	<u> </u>		12/09	

# Regenerative Thermal Oxidizer with 85,000 scfm

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Scenario 3 - Production

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Control System: Regen. Thermal oxidizer w/85000 scfm ventilation from enclosure for PUNB mold production

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan, controls,stack/duct			1260682	Vendor B Quote
Auxiliary Equipment/enclosure, make-up air units and ductwork			468818	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			1729500	
Instruments/controls	6.10	1.00	0	Included in quote
Taxes	0.05	1.00	86475	
Freight	0.05	1.00	86475	
Base Price:			1902450	
Installation costs, direct:	0.00	1.00	45010/	
Foundations/Supports	0.08	1.00	152196	
Erection/handling	0.14	1.00	200343	Eng Guide #46, Table 4-3
Bining	0.04	1.00	76030	Eng Guide #46, Table 4-3
Ingulation	0.02	1.00	10025	Eng Guide #46, Table 4-3
Painting	0.01	1.00	19025	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46. Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46. Table 4-3
			•	
Total Installation Costs:			570735	
TOTAL DIRECT COSTS (Base Pr	ice + Installation)=		2473185	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	95123	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	190245	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	190245	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	38049	Eng Guide #46, Table 4-3
Performance Test	0.006	1.00	11415	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	57074	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			582150	
				· · · · · · · · · · · · · · · · · · ·
TOTAL CAPITAL COSTS (Direct	+ Indirect)=		3055335	

Scenario 3 - Production

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Control System: Regen. Thermal oxidizer w/85000 scfm ventilation from enclosure for PUNB mold production

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:	·			
		_		
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	365	9125	(a) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Supervision(15% of labor)			1369	
			0	
Maintenance (general):				
Labor	27.5	365	10038	(b) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Materials (100% of labor)	L		10038	
Replacement parts (as required)			0	
Labor (100% of parts cost)		·	0	
	<u> </u>			
		1540000	00400	
Electricity (\$/KWHxKWH/yr)	\$0.06	1540000	92400	vendor(2/5 KWH x bounts/ yr)
Fuel oil (\$/ gal x gal/ yr)			0	
Gas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>9</sup> /yr)	\$4.00	47040	188160	vendor(8.5Mft3/Hrx 5600hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal			·	
Wastewater Treatment			0	
			011100	
TOTAL DIRECT OPERATING C	OSTS (A)=		311129	
Indirect operating (fixed) costs:			15000	
Overhead	80% of O & Milabor		10050	Eng. Guide #40, Table 5-1
Property Tax	1% of capital costs		30553	Eng. Guide #40, Table 5-1
Administration	1% of capital costs		61107	Eng. Guide #46, Table 5-1
Administration	2% 01 Capital COSIS	\$3.055.335	476622	Eng. Guide #40, Table 5-1
Capital Recovery CRF=	(9.0% for 10 years)	40,000,000	470032	Fra mide #46 Table 5.3
TOTAL EVED COSTS (B)-	(9.0% 101 10 years)		614176	
TOTAL FIXED COSTS (B)-			014170	
Credite				· · · · · · · · · · · · · · · · · · ·
Product measure				· · · · · · · · · · · · · · · · · · ·
Heat recovery				
TOTAL CREDITS (C)=			Ω	
TOTAL ANDILALIZED COSTS (	$A \rightarrow B = inver (1) =$		025204	
TOTAL ANNOAUZED COSTS (		'	723304	
	<u> </u>			
Uncontrolled Emissions Rate (ton	s⁄year)≖		13.4	
	L			· · · · · · · · · · · · · · · · · · ·
Overall (Capture & device eff.)Co	ntrol			
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=	<u> </u>		12.06	
Cost (\$/ton)=			76725	· · · · · · · · · · · · · · · · · · ·
		L		

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# Biofilter with 85,000 scfm

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Scenario 3 - Production

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\$.: . . Control System: Biofilter for 85,000 scfm/PUNB Mold Production

Cost Item         Cost Factor         Factor         Cost (\$6)         Basis of Costs           Direct Costs         Image: Cost (\$6)         Basis Enujment:         Image: Cost (\$6)         Basis Enujment:         Image: Cost (\$6)         Basis Costs           Basis Enujment:         Image: Cost (\$6)         235000         Lowest Quote - Vendor D           Auxillary Equipment/enclosure, make up air units & ductwork         46888         Eng. Estimate (Appendix E-3)           Total Equipment Costs:         Image: Cost (\$6)         100         Indude in quote           Taxes         0.10         100         Indude in quote           Taxes         0.05         1.00         140941           Freight         0.05         1.00         140941           Freight         0.05         1.00         Indude in quote           Ease Price:         Image: Cost (\$100)         Included in quote           Eases Price:         Image: Cost (\$100)         Imcluded in quote           Feeting/Image: Cost (\$100)         Imcluded in quote         Image: Cost (\$100		Average	Adjustment		
Direct Costs Bail: Equipment Bail: Equipment Bail: Equipment Bail: Equipment Bail: Equipment Bail: Equipment/endowney, Bail: Equipment/endowney, Bail: Equipment/endowney, Bail: Equipment/endowney, Bail: Equipment Costs:  Total Equipment Costs:  Data Equipment Costs:  Direct Costs: Dir	Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs Basic Equipment: Basic Equi					
Basic Equipment:     235000     Lowest Quote - Vendor D       Auxdiary Equipment/enclosure, nake up air units & ductwork     468818     Eng. Estimate (Appendix E.3)       Total Equipment Costs:     2818818       Total Equipment Costs:     2818818       Instruments/controls     0.10     1.00       Taxes     0.05     1.00       Taxes     0.05     1.00       Taxes     0.05     1.00       Instruments/controls     0.01     140941       Base Price     3100700       Installation costs, direct:	Direct Costs:				
Totofilter         2350000         Lowest Quote - Vendor D           Auxillary Equipment/enclosure, make up air units & ductwork         468818         Eng. Estimate (Appendix E-3)           Total Equipment Costs:         2818818	Basic Equipment:				
Auxiliary Equipment/endoure, make up air units & ductwork     468818     Eng. Estimate (Appendix E-3)       Total Equipment Coats:     2818818       Instruments/controls     0.10     1.00     0       Instruments/controls     0.05     1.00     100404       Tess     0.05     1.00     140941       Base Price:     3100700       Installation costs, direct:	"biofilter		-	2350000	Lowest Quote - Vendor D
Auxiliary Equipment/endosure, make up air units & ductwork     468818     Eng. Estimate (Appendix E-3)       Total Equipment Coats:     2818818       Total Equipment/controls     0.10     1.00       Instruments/controls     0.10     1.00       Trend     0.05     1.00       Base Price:     0.05     1.00       Feadations/Supports     0.08     1.00       Frequentiation (Supports)     0.08     1.00       Insulation (Supports)     0.08     1.00       Insulation     0.01     1.00       Insulation     0.05     1.00					
Attminity Equipment Query         468818         Eng. Estimate (Appendix E-3)           Total Equipment Costs:         2818818	A iliana Englanda anti (angle gung				
make up atr units a ductivors         -	Auxiliary Equipment/enclosure,			468818	Eng. Estimate (Appendix E-3)
Total Equipment Costs:         2818818           Instruments/controls         0.10         1.00         0           Instruments/controls         0.10         1.00         140941           Taxes         0.05         1.00         140941           Freight         0.05         1.00         140941           Base Price:         3100700         100         100           Installation costs, direct:         1         1         1           Foundations/Supports         0.08         1.00         0         Included in quote           Electrical         0.04         1.00         0         Included in quote           Electrical         0.04         1.00         0         Included in quote           Piping         0.02         1.00         0         Included in quote           Insulation         0.01         1.00         0         Included in quote           Painting         0.01         1.00         0         Included in quote           Site preparation         0.00         1.00         0         Included in quote           Total Installation Costa:         0         100         100         100           Installation costs, indirect:         1         1	make up air units & ductwork		. •	1	
Total Equipment Costs:         2818818           Instruments/controls         0.10         1.00         0           Instruments/controls         0.05         1.00         140941           Freight         0.05         1.00         140941           Freight         0.05         1.00         140941           Base Price:         3100700					
Instruments/controls         0.10         1.00         0           Instruments/controls         0.05         1.00         140941           Taxes         0.05         1.00         140941           Base Price:         3100700	Total Equipment Costs:			2818818	
Instruments/controls         0.10         1.00         Include in quote           Tares         0.05         1.00         140941           Freight         0.05         1.00         140941           Base Price:         3100700					
Instruments/controls         0.10         1.00         0         Include in quote           Taxes         0.05         1.00         140941					
Taxes         0.05         1.00         140941           Freight         0.05         1.00         140941           Base Price:         3100700	Instruments/controls	0.10	1.00	0	Include in guote
Freight         0.05         1.00         140941           Base Price:         3100700	Taxes	0.05	1.00	140941	
Base Price:         3100700           Installation costs, direct:	Freight	0.05	1.00	140941	
Base Price:         3100700           Installation costs, direct:					· · · · · · · · · · · · · · · · · · ·
Installation costs, direct:         Image: Construction field expenses           Foundations/Supports         0.08         1.00         0         included in quote           Erection/Inandling         0.14         1.00         0         included in quote           Electrical         0.04         1.00         0         included in quote           Figing         0.02         1.00         0         included in quote           Insulation         0.01         1.00         0         included in quote           Painting         0.01         1.00         0         included in quote           Site preparation         0.00         1.00         0         included in quote           Total Installation Costs:         0         0         1         0           TotAL DIRECT COSTS (Base Price + Installation)=         3100700         1         1           Installation costs, indirect:         0         1         1         1           Engineering/supervision         0.05         1.00         0         1         1         1           Construction/field expenses         0.10         1         0         1         1         1         1         1         1         1         1         1	Base Price:			3100700	
Installation costs, direct:					
Installation costs, direct:					
Foundations/Supports         0.08         1.00         0         included in quote           Erection/handling         0.14         1.00         0         included in quote           Electrical         0.04         1.00         0         included in quote           Fiping         0.02         1.00         0         included in quote           Insulation         0.01         1.00         0         included in quote           Painting         0.01         1.00         0         included in quote           Site preparation         0.00         1.00         0         included in quote           Facilities/buildings         0.00         1.00         0         included in quote           Total Installation Costs:         0         0         included in quote           TOTAL DIRECT COSTS (Base Price + Installation)=         3100700         1           Installation costs, indirect:	Installation costs, direct:				· · · · · · · · · · · · · · · · · · ·
Erection/handling         0.14         1.00         0         included in quote           Electrical         0.04         1.00         0         included in quote           Piping         0.02         1.00         0         included in quote           Painting         0.01         1.00         0         included in quote           Site preparation         0.00         1.00         0         included in quote           Site preparation         0.00         1.00         0         included in quote           Facilities/buildings         0.00         1.00         0         included in quote           Total Installation Costs:         0	Foundations/Supports	0.08	1.00	0	included in quote
Electrical         0.04         1.00         0         included in quote           Piping         0.02         1.00         0         included in quote           Insulation         0.01         1.00         0         included in quote           Painting         0.01         1.00         0         included in quote           Site preparation         0.00         1.00         0         included in quote           Facilities/buildings         0.00         1.00         0         included in quote           Total Installation Costs:         0	Erection/handling	0.14	1.00	0	included in quote
Piping       0.02       1.00       0       included in quote         Insulation       0.01       1.00       0       included in quote         Site preparation       0.00       1.00       0       included in quote         Facilities/buildings       0.00       1.00       0       included in quote         Total Installation Costs:       0       included in quote       0         TOTAL DIRECT COSTS (Base Price + Installation)=       3100700       0       included in quote         Total Installation costs, indirect:       0       0       included in quote         Installation costs, indirect:       0       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Model study       0.00       1.00       0       included in quote         Contingencies       0.03       5.00       465105       Eng Guide #46, Table 4.4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS (Direct + Indirect)=       3573557       3572557       357257	Electrical	0.04	1.00	0	included in quote
Instillation         0.01         1.00         0         Included in quote           Painting         0.01         1.00         0         Included in quote           Site preparation         0.00         1.00         0         Included in quote           Facilities/buildings         0.00         1.00         0         Included in quote           Total Installation Costs:         0         0         Included in quote           TOTAL DIRECT COSTS (Base Price + Installation)=         3100700         3100700           Installation costs, indirect:         0         0         Included in quote           Installation costs, indirect:         0         0         Included in quote           Construction/field expenses         0.10         1.00         0         Included in quote           Construction fee         0.10         1.00         0         Included in quote           Construction fee         0.10         1.00         0         Included in quote           Construction fee         0.10         1.00         0         Included in quote           Start-up         0.02         1.00         0         Included in quote           Contingencies         0.03         5.00         465105         Eng Guide #46, Table 4.	Piping	0.02	1.00	0	included in quote
Painting       0.01       1.00       0       included in quote         Site preparation       0.00       1.00       0       included in quote         Facilities/buildings       0.00       1.00       0       included in quote         Total Installation Costs:       0       0       included in quote         TOTAL DIRECT COSTS (Base Price + Installation)=       3100700	Insulation	0.01	1.00	0	included in quote
Site preparation       0.00       1.00       0       included in quote         Facilities/buildings       0.00       1.00       0       included in quote         Total Installation Costs:       0       0       0       included in quote         TotAL DIRECT COSTS (Base Price + Installation)=       3100700       0       included in quote         Installation costs, indirect:       0       0       included in quote         Installation costs, indirect:       0       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Performance Test       0.003       1.00       0       included in quote         Model study       0.00       1.00       0       included in quote         TOTAL INDIRECT COSTS=       472857       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS (Direct + Indirect)=       3573557       3573557	Painting	0.01	1.00	0	
Particles/ buildings       0.00       1.00       0       Induced in quote         Total Installation Costs:       0       0       0         TOTAL DIRECT COSTS (Base Price + Installation)=       3100700       0       0         Installation costs, indirect:       0       0       0         Installation costs, indirect:       0       0       0         Engineering/supervision       0.05       1.00       0       0         Construction/field expenses       0.10       1.00       0       0         Start-up       0.02       1.00       0       0       0         Performance Test       0.003       1.00       0       0       0         Model study       0.00       1.00       0       0       0         TOTAL INDIRECT COSTS=       472857       472857       0.03       5.00       465105       Eng Guide #46, Table 4.4, new application of control technology and guaranteed performance	Site preparation	0.00	1.00	0	included in quote
Total Installation Costs:       0         TOTAL DIRECT COSTS (Base Price + Installation)=       3100700         Installation costs, indirect:       3100700         Engineering/supervision       0.05         Construction/field expenses       0.10         0.02       1.00         Start-up       0.02         Performance Test       0.003         0.003       1.00         0       0         Inded in quote         Contingencies       0.03         0.03       5.00         465105       Eng Guide #46, Table 4.4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857	racinties/ buildings	0.00	1.00	<u> </u>	
TOTAL DIRECT COSTS (Base Price + Installation)=       3100700         Installation costs, indirect:       3100700         Engineering/supervision       0.05       1.00       0         Installation costs, indirect:       included in quote       included in quote         Engineering/supervision       0.05       1.00       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       included in quote         TOTAL INDIRECT COSTS=       472857       472857         TOTAL INDIRECT COSTS (Direct + Indirect)=       3573557	Tatal Installation Costs	1		0	· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT COSTS (Base Price + Installation)=       3100700         Installation costs, indirect:       Installation costs, indirect:         Engineering/supervision       0.05       1.00       0         Construction/field expenses       0.10       1.00       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       Included performance         TOTAL INDIRECT COSTS=       472857       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance	Total Installation Costs:	l			
Installation costs, indirect:       Installation         Engineering/supervision       0.05         Construction/field expenses       0.10         0.05       1.00         0       included in quote         Construction/field expenses       0.10         0.02       1.00         0       included in quote         Start-up       0.02         Performance Test       0.003         0.00       1.00         Contingencies       0.03         5.00       465105         Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857	TOTAL DIRECT COSTS (Reas Pr	ico de la stallation)=		3100700	
Installation costs, indirect:       Imstallation costs, indirect:       Imstallation costs, indirect:         Engineering/supervision       0.05       1.00       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       Installetion of control technology and guaranteed performance         TOTAL INDIRECT COSTS =       472857       472857       Installetion of control technology and guaranteed performance	TOTAL DIRECT COSTS (Dase IT	Ter + Instanation)-	· ·	5100700	
Installation costs, indirect:					
Instantion Costs, indirect       0.05       1.00       0       included in quote         Engineering/supervision       0.05       1.00       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       0       included in quote         Model study       0.00       1.00       0       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857       472857       Instruction for the second secon	Installation costs indirects				
Engineering/supervision       0.05       1.00       0       included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857       472857         IOTAL CAPITAL COSTS (Direct + Indirect)=       3573557	Instantation Costs, Indirect	μ.			
Inigneering/supervision       0.03       1.00       0       Included in quote         Construction/field expenses       0.10       1.00       0       included in quote         Construction fee       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       0       Included in quote         Model study       0.00       1.00       0       Included in quote         Contingencies       0.03       5.00       465105       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS =       472857       100       100       100         TOTAL CAPITAL COSTS (Direct + Indirect)=       3573557       3573557       100       100	Engineering / munomulation	0.05	1.00	0	included in mote
Construction/red expenses       0.10       1.00       0       included in quote         Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857       472857         TOTAL CAPITAL COSTS (Direct + Indirect)=       3573557	Construction/field expenses	0.05	1.00	0	included in quote
Start-up       0.02       1.00       0       included in quote         Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857       472857         TOTAL CAPITAL COSTS (Direct + Indirect)=       3573557	Construction fee	0.10	1.00	0	included in quote
Performance Test       0.003       1.00       7752       Estimate for Method 25A inlet/outlet         Model study       0.00       1.00       0         Contingencies       0.03       5.00       465105       Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance         TOTAL INDIRECT COSTS=       472857         TOTAL CAPITAL COSTS (Direct + Indirect)=       3573557	Start-up	0.07	1.00	<u> </u>	included in quote
Model study     0.00     1.00     0       Contingencies     0.03     5.00     465105     Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance       TOTAL INDIRECT COSTS=     472857       TOTAL CAPITAL COSTS (Direct + Indirect)=     3573557	Performance Test	0.003	1.00	7752	Estimate for Method 25A inlet/outlet
Note one of the second seco	Model study	0.00	1.00	0	
TOTAL INDIRECT COSTS = 472857 TOTAL COSTS (Direct + Indirect)= 3573557	Contingencies	0.03	5.00	465105	Eng Guide #46, Table 4-4, new application of control technology and
TOTAL INDIRECT COSTS = 472857					guaranteed performance
TOTAL CAPITAL COSTS (Direct + Indirect)= 3573557	TOTAL INDIRECT COSTS=	<u> </u>	1	472857	
TOTAL CAPITAL COSTS (Direct + Indirect)= 3573557					
TOTAL CAPITAL COSTS (Direct + Indirect)= 3573557			20.2		
	TOTAL CAPITAL COSTS (Direct	+ Indirect)=		3573557	

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Scenario 3 - Production

Control System: Biofilter for 85,000 scfm/PUNB Mold Production

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/ HK X HKS/ 1K)	25	0	0	
Supervision(15% of labor)		·	0	
Operating Materials			100100	Vender E estimate of annual media costa
Operating Materials			109100	
Maintenance (general):				· · · · · · · · · · · · · · · · · · ·
Labor	27.5	50	1375	Vendor D Quote
Materials (100% of labor)			1375	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
<u></u>				
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	430080	25805	Vendor E Estimate (76.8 KWH x 5600 hrs/yr)
Fuel oil (\$/gal × gal/yr)			0	
Gas (\$/10 <sup>3</sup> /t <sup>3</sup> x 10 <sup>3</sup> /yr)			0	
Water			0	
Steam			0	
Other			0	
F.F			0	
Waste Disposal				
14/2 stores to a Transfer and				· · · · · · · · · · · · · · · · · · ·
Wastewater Treatment				
TOTAL DIRECT OPER ATING CO			127655	
TOTAL DIRECT OPERATING CC	)515 (A)=		13/035	
Indirect operating (fixed) costs:				
Overbead	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		35736	
Insurance	1% of capital costs		35736	
Administration	2% of capital costs		71471	
Capital Recovery CRF=	0.11	\$3,573,557	393091	
·	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=	· · · · · · · · · · · · · · · · · · ·		537133	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A	+B minus C)=		674788	
Uncontrolled Emissions Rate (tons	/year)=		13.4	
Overall (Capture & device eff.)Con	trol			
System Efficiency (%)=			90	· · · · · · · · · · · · · · · · · · ·
			10.04	
Controlled Emissions (tons/year)=			12.06	
Cost (S/top)=			55052	
			10900	

# Concentrator/Oxidizer with 156,000 scfm

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Scenario 3 - Storage

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Control System: Concentrator/oxidizer w/156,000 scfm ventilation from enclosure for PUNB mold storage

. Г - Г		Average	Adjustment		
ු 🖌	Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
			:		
	Direct Costs:				
	Basic Equipment:				· · · · · · · · · · · · · · · · · · ·
Ĩ	adsorber/oxidizer, fan			0115005	Low Quote - Vendor F scaled (0.7 per eng. guide #46, section 3.2) for
$\frac{1}{2}$	controls, stack/duct			2115295	156,000 scfm
ÎΓ					
2 [	Auxiliary Equipment/enclosure,			386582	Eng Estimate (Annendix E-3)
Ľ	nake-up air units and ductwork to				
1					
	Total Equipment Costs:			2501877	
Ĺ					
<u>}</u>					
ţμ	Instruments/controls	0.10	1.00	0	Included in quote
۶.	Taxes	0.05	1.00	125094	
╷┝	Freight	0.05	1.00	125094	
1	Base Price:			2752065	
⊢					
, L					
1 1	Installation costs, direct:				
Η	Foundations/Supports	0.08	1.00	220165	Eng Guide #46, Table 4-3
┟	Erection/handling	0.14	1.00	385289	Eng Guide #46, Table 4-3
) –	Electrical	0.04	1.00	110083	Eng Guide #46, Table 4-3
)	Piping	0.02	1.00	55041	Eng Guide #46, Table 4-3
┝	Insulation	0.01	1.00	27521	Eng Guide #46, Table 4-3
7 L	Painting	0.01	1.00	27521	Eng Guide #46, Table 4-3
1 -	Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
۰	Facilities/ buildings	0.00	1.00	<u> </u>	Eng Guide #46, Table 4-3
<b>、</b> ト					
V -	Total Installation Costs:		_	825619	
				0.5555404	
┝	IOTAL DIRECT COSTS (Base Pri	ce + Installation)=	+	3577684	
¥ -					
۳Ľ	Installation costs, indirect:				
a L					
4 -	Engineering/supervision	0.05	1.00	137603	Eng Guide #46, Table 4-3
۰ ۲	Construction/ held expenses	0.10	1.00	275206	Eng Guide #46, Table 4-3
	Construction fee	0.10	1.00	275206	Eng Guide #46, Table 4-3
	Start-up	0.02	1.00	55041	Eng Guide #46, Table 4-3
÷ -	Performance Test	0.0035	1.00	9632	Estimate for Method 25a inlet/outlet
`  -	Model study	0.00	1.00	0	
<u> </u>	Contingencies	0.03	1.00	82562	Eng Guide #46, Table 4-3
-					
, از ۲	IUTAL INDIRECT COSTS=		<u> </u>	835252	
Ļ					
ŧ -					
ן ו	TOTAL CAPITAL COSTS (Direct	+ Indirect)=		4412936	

Scenario 3 - Storage

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### Control System: Concentrator/oxidizer w/156,000 scfm ventilation from enclosure for PUNB mold storage

,	Cost Item (\$/unit x units/ye	ear) COST			
100	Direct Operating Costs:				
្រា	Operating Labor:				
	Operator (\$/HR X HRS/YR) Supervision(15% of labor)	25	525	13125 1969	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 350 days/yr)
<u> </u>	Operating Materials			0	
e i	·····				
	Maintenance (general):				
$\sum_{i=1}^{n}$	Labor	27.5	40	1100	Vendor F Quote
	Materials (100% of labor)			1100	
	Replacement parts (as required)			0	Vendor F Quote
$\Box$	Labor (100% of parts cost)			0	Eng. guide #46
	Utilities:				
5	Electricity (\$/KWHxKWH/yr)	\$0.06	1486800	89208	Vendor F Quote scaled to 156,000 scfm (177KWH x 8400hrs/yr)
È.	Fuel oil (\$/gal x gal/yr)			0	
Sin 8	Gas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>3</sup> ft <sup>3</sup> /yr)	\$4.00	53760	215040	Vendor F Quote scaled for 156,000 scfm (6.4Mf <sup>3</sup> /hr x 8400 hrs/yr)
<b>6</b> .3	Water		[	0	
	Steam			0 .	
13	Other			0	
				0	
(A	Waste Disposal				
E.	Wastewater Treatment			0	
6.9					
1	TOTAL DIRECT OPERATING CO	OSTS (A)=		321542	
	Indirect operating (fixed) costs:				
. 112	Overhead	80% of O & M(labor)		11380	Eng. Guide #46, Table 5-1
	Property Tax	1% of capital costs		44129	Eng. Guide #46, Table 5-1
0.00	Insurance	1% of capital costs		44129	Eng. Guide #46, Table 5-1
antia.	Administration	2% of capital costs		88259	Eng. Guide #46, Table 5-1
	Capital Recovery CRF=	0.156	\$4,412,936	688418	· · · · · · · · · · · · · · · · · · ·
E.s.		( 9.0% for 10 years)		_	Eng. guide #46, Table 5-3
	TOTAL FIXED COSTS (B)=			876315	
N. T.					
1.5	Credits				
	Product recovery				
1	Heat recovery				
	TOTAL CREDITS (C)=			0	
	TOTAL ANNUALIZED COSTS (A	A +B minus C)=		1197857	
¥	Uncontrolled Emissions Rate (tons	s/year)=		25.2	
<b>1</b>		<u> </u>			
	Overall (Capture & device eff.)Con	ntrol			
Win J	System Efficiency (%)=			90	
ц					
ţ	Controlled Emissions (tons/year)=	1		22.68	
ŝ.	Cost (\$/ton)=			52816	
		<u></u>	1	· · · ·	1

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# Regenerative Thermal Oxidizer with 156,000 scfm

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Scenario 3 - Storage

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 Control System: Regen. Thermal oxidizer w/156000 scfm ventilation from enclosure for PUNB mold storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan, controls,stack/duct			3161433	Vendor A Quote for 165000 (scaling factor of 0.7 per Eng. Guide #46 section 3.2) for 156,000 scfm
Auviliant Equipment/anglogura				
make-up air units and ductwork			386582	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			3548015	
Instruments (controls	010	1.00	0	Included in quote
Taxos	0.10	1.00	177401	
Taxes	0.05	1.00	177401	
Freight	0.05	1.00	1//401	
Base Price:			3902817	· · · · · · · · · · · · · · · · · · ·
Installation costs, direct:				
Foundations/Supports	0.08	1.00	312225	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	546394	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	156113	Eng Guide #46, Table 4-3
Piping	0.02	1.00	78056	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	39028	Eng Guide #46, Table 4-3
Painting	0.01	1.00	39028	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	Eng Guide #46, Table 4-3
Facilities/buildings	0.00	1.00	0	Eng Guide #46, Table 4-3
Tetal Installer Costs			1170946	
Total Installation Costs:		<u>  </u>	1170845	· · · · · · · · · · · · · · · · · · ·
TOTAL DIRECT COSTS (Base Pri	ce + Installation)=		5073661	
		<u>├</u>		
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	195141	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	390282	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	390282	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	78056	Eng Guide #46, Table 4-3
Performance Test	0.005	1.00	19514	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	117084	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			1190359	
		┟		· · · · · · · · · · · · · · · · · · ·
		. – 1		

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Scenario 3 - Storage

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Control System: Regen. Thermal oxidizer w/156000 scfm ventilation from enclosure for PUNB mold storage

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	525	13125	(a) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Supervision(15% of labor)			1969	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	525	14438	(b) Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365 days/yr)
Materials (100% of labor)			14438	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	3948840	236930	(407 KWHx 8400hrs/yr) scaled from vendor quote for 156,000 cfm sys
Fuel oil (\$/gal x gal/yr)			0	
Gas $(\$/10^3 \text{ft}^3 \times 10^3/\text{yr})$	\$4.00	26880	107520	(3.2 Mft3/Hrx8400hrs/yr) scaled from vendor quote scaled for 156,00
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING C	OSTS (A)=		388419	
Indirect energies - (Gued) energy				
Indirect operating (fixed) costs:	80% of O to M(labor)		22050	Eng Cuido #46 Table 5.1
Broparty Tax	1% of capital costs		62640	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		62640	Eng Cuide #46 Table 5-1
Administration	2% of capital costs		125280	Eng Guide #46 Table 5-1
Capital Recovery CRE=	0 156	\$6,264,020	977187	
Capital Recovery CRI-	(90% for 10 years)	40,201,020	///10/	Eng. guide #46. Table 5-3
TOTAL FIXED COSTS (B)=	( ).0 % 101 10 years,		1249798	
Credits				
Product recovery				
Heat recovery			_	
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A	A +B minus C)=		1638217	
·		-		
Uncontrolled Emissions Rate (ton	s/vear)=		25.2	
Overall (Capture & device eff.)Co	ntrol			
System Efficiency (%)=			90	
Controlled Emissions (tone/vers)=	<b></b>		22.68	
	I			
Cost (\$/ton)≠			72232	
			L	

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# Biofilter with 156,000 scfm

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Scenario 3 - Storage

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Control System: Biofilter for 156,000 scfm/PUNB Mold Storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
		1.1		
Direct Costs:		_		
Basic Equipment:				
biofilter			4768535	Vendor D Quote scaled per eng. guide #46, section 3.2 (0.7 factor) from 165,500 to 156,000 scfm
Auxiliary Equipment/enclosure, make up air units & ductwork			386582	Included in quote (Appendix E-3)
Total Equipment Caster			5155117	
Total Equipment Costs.			0100117	
Instruments/controls	.0.10	1.00	0	Include in quote
Taxes	0.05	1.00	257756	
Freight	0.05	1.00	257756	
Base Price:			5670629	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	0	included in quote
Erection/handling	0.14	1.00	0	included in quote
Electrical	0.04	1.00	0	included in quote
Piping	0.02	1.00	0	included in quote
Insulation	0.01	1.00	0	included in quote
Painting	0.01	1.00	0	included in quote
Site preparation	0.00	1.00	0	included in quote
Facilities/buildings	0.00	1.00	0	included in quote
Total Installation Costs:			0	
TOTAL DIRECT COSTS (Base Pr	ice + Installation)=		5670629	
· · · · · · · · · · · · · · · · · · ·				
Installation costs, indirect:				
		1.00		
Engineering/supervision	0.05	1.00	0	included in quote
Construction/field expenses	0.10	1.00	0	included in quote
Construction fee	0.10	1.00	0	included in quote
Start-up	0.02	1.00	9504	Included in quote
Model abidu	0.002	1.00	000	
Contingencies	0.03	5.00	850594	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
TOTAL INDIRECT COSTS=			859100	
TOTAL CAPITAL COSTS (Direct	+ Indirect)=		6529729	

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Scenario 3 - Storage

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Control System: Biofilter for 156,000 scfm/PUNB Mold Storage

				_
Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
		· · · · · · · · · · · · · · · · · · ·		
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	0	0	
Supervision(15% of labor)			0	
			010/50	
Operating Materials			212450	Vendor E Quote
Maintenance (general):	27.5	50	1375	Vendor D Quota
Materials (100% of labor)	2/.0		1375	
			10/0	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	1192104	71526	Vendor E (141.9kwhx8400Hrs/yr) scaled from 165,000 cfm system
Fuel oil (\$/gal x gal/yr)			0	
Gas $(\frac{10^{3} \text{ ft}^{3} \times 10^{3}}{\text{ vr}})$			0	
Water			0	
Steam			0	
Other			0	
····			0	
Waste Disposal			1	
			-	
Wastewater Treatment			0	
TOTAL DIRECT OPERATING C	OSTS (A)≖		286726	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		65297	
Insurance	1% of capital costs		65297	
Administration	2% of capital costs		130595	
Capital Recovery CRF=	0.11	\$6,529,729	718270	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			980559	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (	A +B minus C)=		1267286	
Uncontrolled Emissions Rate (ton	s∕year)≖		25.2	
Overall (Capture & device eff.)Co	ontrol			
System Efficiency (%)=			90	
Controlled Emissions (tons/vear)	•		22.68	
Cost (\$/ton)=			55877	
(4)/				

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# Recuperative Thermal Oxidizer with 2000 scfm Ventilation from Core Machine

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Scenario 4 - Production Area

Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:		<u> </u>		
Basic Equipment				
oxidizer, fan		+	440000	
controls.stack/duct			110000	Lowest Quote - Vendor F
Auxiliary Equipment/duct to			12910	Ena Estimate (Amendix E 2)
oxidizer			15810	Eng. Esuitate (Appendix E-5)
Total Equipment Costs:			123810	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	6191	
Freight	0.05	1.00	6191	
Base Price:			136191	
Installation costs, direct:		1 00		
Foundations/Supports	0.08	1.00	10895	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	19067	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	5448	Eng Guide #46, Table 4-3
Piping	0.02	1.00	2/24	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	1362	Eng Guide #46, Table 4-3
Painting	0.01	1.00	1362	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
			40057	
Total Installation Costs:			40857	
			100040	
TOTAL DIRECT COSTS (Base	Price + Installation		177048	
<b>*</b> . <b>1</b> . <b>.</b> . <b>.</b>			· · · · · · · · · · · · · · · · · · ·	
Installation costs, indirect:				· · · · · · · · · · · · · · · · · · ·
	- 0.05	1.00	(010	The - Children 446 Table 4.2
Engineering/supervision	0.05	1.00	6810	Eng Guide #46, Table 4-3
Construction/held expenses	0.10	0.50	0810	small system/ lable 4-3
Construction ree	0.10	1.00	13019	Eng Guide #40, Table 4-5
Stan-up		1.00	4500	Eng Guide #40, Table 4-5
Model abudu	0	1.00	4500	Estimate for Method 25A Intel/ Outlet
Capting and a line	0.00	1.00	4086	Ener Christe #46 Table 4.3
Conungencies	0.05	1.00	4000	Eng Guide #40, 12018 4-5
TOTAL INDURFOT COOTO			20540	
TOTAL INDIRECT COSTS#		<b>├</b> ────┤	38348	
		<u>                                     </u>		
TOTAL CADITAL COOPER (D)			21550/	
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=		215596	

### Scenario 4 - Production Area Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

Cost Item	Cost(\$)/unit	Unite/waar	Cost	Basis of Costs
Cost Rem	Cosilayuuu	Onicsyyear	Cost	
Direct Operating Costs:				
Direct operading costs.				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	.365	9125	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 2 sht/day x 365 days/yr)
Supervision(15% of labor)			1369	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	365	10038	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 2 sht/day x 365 days/yr)
Materials (100% of labor)			10038	
Poplacement parts (as mauired)			0	
Labor (100% of parts cost)			<u> </u>	
Labor (100% of parts cost)				
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	40880	2453	Vendor F Ouote (7.0 KWH x 5840 hrs/vr)
Fuel oil (\$/gal x gal/yr)			0	
$Gas(\$/10^{3}ft^{3}x 10^{3}ft^{3}/vr)$	\$4.00	5840	23360	Vendor F Ouote (1Mft3/hr x 5840 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
	CO 0770 (1)			
TOTAL DIRECT OPERATING	COSTS (A)=		56382	
T. 3: 10 11 10 10				
Organized Operating (fixed) costs:	POW of O & Milabor		15220	Eng Cuido #46 Table 51
Droperty Tax	1% of capital costs	/	2156	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		2156	Eng Guide #46 Table 5-1
Administration	2% of capital costs		4312	Eng. Guide #46. Table 5-1
Capital Recovery CRF=	0.156	215596.05	33633	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46. Table 5-3
TOTAL FIXED COSTS (B)=			57587	
Credits				
Product recovery		_	0	
Heat recovery			0	
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	(A +B minus C)=		113968	
There is a second secon				· · · · · · · · · · · · · · · · · · ·
Uncontrolled Emissions Kate (fo	ons/year)⇒		4./	
Overall (Capture & device off)	Control			
System Efficiency (%)=			90	
- Joren Linerency (70)-	-	<u> </u>		
Controlled Emissions (tons/vear	;)=		4.23	
	<i>.</i>			
Cost (\$/ton)=			26943	

# Recuperative Catalytic Oxidizer with 2000 scfm

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 $\sum_{i=1}^{n} |f_i|^2 = \int_{0}^{\infty} |f_i|^2 dx^2  

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### Scenario 4 - Production Area

Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

-

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment	· · · ·	<u>                                      </u>		
oxidizer, fan		· · ·	1	
controls stack/duct			120000	Lowest Quote - Vendor F
contrais stacky that				
Auxiliary Equipment/duct to			12810	E - E-Handa (Amondur E 2)
oxidizer			13010	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			133810	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	6691	
Freight	0.05	1.00	6691	
Base Price:		1	147191	
		L		
		<u> </u>		
Installation costs, direct:				
Foundations/Supports	0.08	1.00	11775	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	20607	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	5888	Eng Guide #46, Table 4-3
Piping	0.02	1.00	2944	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	1472	Eng Guide #46, Table 4-3
Painting	0.01	1.00	1472	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			44157	
TOTAL DIRECT COSTS (Bas	e Price + Installatio	on)=	191348	
		T		
			1	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	7360	Eng Guide #46. Table 4-3
Construction/field expenses	0.10	0.50	7360	small capacity system/Table 4-3
Construction fee	0.10	1.00	14719	Eng Guide #46. Table 4-3
Start-up	0.02	1.00	2944	Eng Guide #46. Table 4-3
Performance Test	0	1.00	4500	Estimate of inlet/outlet using Method 25A
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	4416	Eng Guide #46. Table 4-3
TOTAL INDIRECT COSTS=			41298	
TOTAL CAPITAL COSTS (D)	rect + Indirect)=		232646	
to the chartene coord (bi			202010	

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# Scenario 4 - Production Area

Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

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Cost Hom	Cook (\$)/mit	Tinitakiaan	Cost	
Cost nem	Cost (sy unit	Omisyyear	CUSI	
Direct Operating Costs:				
Direct Operating Costs.				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	365	9125	Eng. Guide #46 Table 5-2 (.5 hrs/sht x 2 sht/day x 365 days/yr)
Supervision(15% of labor)			1369	
Operating Materials				
/Catalyst/amoritized			2028	Vandar F. Ouata 5 year catalyst life
(CCR=0.26) at 9% for 5 years			2020	Vendor r Quole - 5 year catalyst me
$(12ft_3 at 650/ft_3) =$				
Maintenance (general):				
Labor	27.5	365	10038	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 2 sht/day x 365 days/yr)
Materials (100% of labor)			10038	
Deale server to the test				
Keplacement parts (as required	aj			
Labor (100% of parts cost)				
Utilities:	\$0.04	40990	2452	Vender F. Owels (7.0 MMH w5940 hms /sm)
Electricity (\$/ KyyrixKyyri/y	30.00	40000	0	
rueron (5/gai x gai/yr)	¢4.00	1007		
Gas (\$/10°ft°x 10°ft°/yr)	\$4.00	1927	0	vendor F Quote (0.33Mit3/ nr x 5840 nrs/ yr)
Water				
Steam				
Marta Diana ant			0	· · · · · · · · · · · · · · · · · · ·
Waste Disposal				
Washaritakan Transferration				
wastewater Treatment			0	
TOTAL DIRECT ORERATING			42758	
Indirect operation (fixed) costs	G CO313 (A)-		42/30	
Church and	RON of O to M/labor		15220	Eng Cuide #46 Table 5.1
Property Tax	1% of capital costs	· · · · · · · · · · · · · · · · · · ·	2326	Eng. Guide #46, Table 5-1
	1% of capital costs		2326	Eng Guide #46 Table 5-1
Administration	2% of capital costs		4653	Eng Guide #46 Table 5-1
Capital Pacovary CRE	276 01 Capital COSIS	232646.05	36203	
Capital Recovery CRI-	(90% for 10 years)	202010.00	002/0	Eng guide #46 Table 5-3
TOTAL FIXED COSTS (B)=	1 2.0 % 101 10 / 0010/		60929	
101AL FIAED CO313 (B)-				
Credits				
Product recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COS	TS (A +B minus C)=		103686	
TO THE ANNOALIZED COS	10 (A + D minus C)		105000	
Uncontrolled Emissions Pote	(tonehuoon)-		A 7	
Cheontrolled Emissions Kate	(ionsy year)=		4./	
Overall (Capture & device eff	JControl		-	
System Efficiency (%)=			90	
Controlled Emissions (tons/ye	ear)=		4.23	
Cost (\$/ton)=			24512	

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# Carbon Absorption (Disposable/Rechargable) with 2,000 scfm Ventilation from Core Machine

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Scenario 4 - Production Area

Control System: Carbon adsorption (disposable/rechargeable) w/2000 scfm ventilation from core machine

.

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:	· · · · · · · · · · · · · · · · · · ·			
	· · · · · ·			Vendor G Quote at \$4000/unit X 2 units:
unit, fan controls,stack/duct			14320	ener est of \$5000 fan and \$1320 ductwork
				CALL ON OF GOOD ALL AND PISZO AUCTION
Auxiliary Equipment/duct to			10010	(4
oxidizer			13810	(Appendix E-3)
Total Equipment Costs:			28130	
Instruments/controls	0.10	1.00	0	
Taxes	0.05	1.00	1407	
Freight	0.05	1.00	1407	
Base Price:			30943	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	2475	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	4332	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	1238	Eng Guide #46, Table 4-3
Piping	0.02	1.00	619	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	309	Eng Guide #46, Table 4-3
Painting	0.01	1.00	309	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
			1	
Total Installation Costs:			9283	
TOTAL DIRECT COSTS (Base	Price + Installation	.)=	40226	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	1547	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	0.50	1547	small system/Table 4-3
Construction fee	0.10	1.00	3094	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	619	Eng Guide #46, Table 4-3
Performance Test	0	1.00	4500	Estimate 25A-inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	928	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			12236	······································
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=	1	52462	

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Scenario 4 - Production Area

Control System: Carbon adsorption (disposable/rechargeable) w/2000 scfm ventilation from core machine

Cost Item	\$/unit	units/year	COST	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/VR)	25	365	9125	Eng. Guide #46, Table 5-2 (.5 hrs/shft x 2
			120	shft/day x 365 days/yr)
Supervision(15% of labor)			1369	· · · · · · · · · · · · · · · · · · ·
Operating Materials			0	
Maintenance (general):				
Labor	27.5	365	10038	Eng. Guide #46, Table 5-2 (.5 hrs/shft x 2 shft/day x 365 days/yr)
Materials (100% of labor)			10038	
Replacement parts (as required)			0	
Utilities:	60.04	2014.0		
Electricity (\$/KWHxKWH/yr)	\$0.06	33110	1987	Pressure drop 12 inches and 7.6 BHP
$G_{ac} (\$/10^3 ft^3 x 10^3 / vr)$	\$4.00		0	
Water			0	
Steam			0	
Other			0	
Waste Disposal			301764	Vendor quote (\$2.92/lb x 103,344 lbs used)
Wastewater Treatment			0	
TOTAL DIRECT OPERATING	COSTS (A)=		334319	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		525	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		525	Eng. Guide #46, Table 5-1
Administration	2% of capital costs	52461 65	8184	Eng. Guide #46, Table 5-1
Capital Recovery CRI-	(9.0% for 10 years)	52401.05	0104	Eng. guide #46. Table 5-3
TOTAL FIXED COSTS (B)=			25612	
Credits				
Product recovery				
Heat recovery	<u> </u>			
TOTAL CREDITS (C)=			00	
TOTAL ANNUALIZED COSTS	6 (A +B minus C)=		359932	
Uncontrolled Emissions Rate (tons/year)=			4.7	
Overall (Canture & device off )	Control			· · · · · · · · · · · · · · · · · · ·
System Efficiency (%)=			90	
Controlled Emissions (ton-t	-)		4 02	
Controlled Emissions (tonsyyea)	.,- 		4.23	
Cost (\$/ton)=			85090	

# Concentrator Oxidizer with 58,000 scfm Ventilation from Enclosure Around PUCB Storage

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#### Annualized Cost Analysis Scenario 4 - Storage Area Control System: Concentrator/oxidizer w/58,000 scfm ventilation from enclosure around PUCB storage

.

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (Ss)	Rasis of Costs
			2001 (00)	
Direct Costs:	·			
Basic Equipment:		. ·		·
adsorber/oxidizer, fan			0(5000	
controls.stack/duct			965000	Vendor F Quote
Auxiliary Equipment/enclosure,			164288	Eng. Estimate (Appendix E-3)
make-up air and ductwork				
Total Equipment Costs:			1129288	
Total Equiphien, Costs.			112/200	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	56464	
Freight	0.05	1.00	56464	
••				
Base Price:			1242217	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	99377	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	173910	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	49689	Eng Guide #46, Table 4-3
Piping	0.02	1.00	10400	Eng Guide #46, 1able 4-3
Dainting	0.01	1.00	12422	Eng Guide #46, Table 4-3
Site preparation	0.01	1.00	0	Eng Guide #46, Table 4-5
Facilities/buildings	0.00	1.00	<u> </u>	
racinació bundingo	0.00			
Total Installation Costs:			372665	
TOTAL DIRECT COSTS (Base I	rice + Installation)=		1614882	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	62111	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	124222	Table 4-3
Construction fee	0.10	1.00	124222	Eng Guide #46, Table 4-3
Start-up	0.02	-1.00	24844	Eng Guide #46, Table 4-3
Performance Test	0.00	1.00	9000	Estimate for 25a inlet/outlet
Contingencies	0.00	- 1.00	27767	Ena Cuida #16 Table 1-2
Conungencies	0.05	1.00	37207	
TOTAL INDIRECT COSTS=			381665	
To monitor docto			001000	
t				
<b>TOTAL CAPITAL COSTS (Direc</b>	t + Indirect)=	1	1996547	

Scenario 4 - Storage Area

Control System: Concentrator/oxidizer w/58,000 scfm ventilation from enclosure around PUCB storage

Cost Item (\$/unit x units/	year) COST			
Direct Operating Costs:				
Openting Labor				
Operating Labor.	25	547	12675	Ener Critic #46 Table 5.2/5 has /able 2 able / dame 265
Operator (\$/ HK X HKS/ 1K)	<u></u>		2051	Eng. Guide #46, Table 5-2 (.5 nrs/ snt x 3 shts/ day x 365
Supervision(15% of labor)			_2051	
Operating Materials			0	
Operating Materials			0	
Maintenance (general):	-			
Labor	27.5	547	15043	Eng. Guide #46. Table 5-2 (.5 hrs/sht x 3 shts/day x 365
Materials (100% of labor)			15043	
			100 10	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	630720	37843	Vendor Quote (72 KWH x 8760 hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
Gas $(\frac{10^{3}}{10^{3}} \times 10^{3} \times 10^{3})$	\$4.00	4380	17520	Vendor Ouote (.5 Mft <sup>3</sup> /hr x 8760 hrs/yr)
Water			0	
Steam			0	
Other			0	
			<u> </u>	· · · · · · · · · · · · · · · · · · ·
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING	COSTS (A)≖		101174	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		22974	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		19965	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs	_	19965	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		39931	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1996546.9	311461	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			414297	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	(A +B minus C)=		515472	
	<u> </u>			
Uncontrolled Emissions Rate (to	ns/vear)=		9.9	
Querall (Canture & doules off)	iontrol			
Contant Capitale & device ell.JC	Unitor			
System Efficiency (%)*			90	
			0.01	
Controlled Emissions (tons/year	<u>,</u>		8.91	
		<b> </b>	E70E0	
Cost (3/ION)=		I	3/833	1

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# Regenerative Thermal Oxidizer with 58,000 scfm Ventilation from Enclosure for PUCB Storage

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Scenario 4 - Storage

Control System: Regenerative Thermal oxidizer w/58,000 scfm ventilation from enclosure for PUCB storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment		1.1 1		
oxidizer, fan			1145000	Lesent Orate Wester P
controls.stack/duct			1145000	Lowest Quote-Vendor B
Auxiliary Equipment/enclosure,			164288	Eng. Estimate (Appendix E-3)
make-up air and ductwork				
Tabal Faultane and Gaster			1200200	
Total Equipment Costs:			1309266	
Instruments / controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	65464	
Freight	0.05	1.00	65464	
Base Price:			1440217	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	115217	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	201630	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	57609	Eng Guide #46, Table 4-3
Piping	0.02	1.00	28804	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	14402	Eng Guide #46, Table 4-3
Painting	0.01	1.00	14402	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/ buildings	0.00	1.00	0	
Total Installation Costs			422065	
Total Installation Costs.			452000	
TOTAL DIRFCT COSTS (Base	Price + Installation	<u></u>	1877287	
TOTHE DIRECT COOTO (DUSC	THE THE	-/	107 22.02	
Installation costs, indirect:				
Anounation costs, maneer				······································
Engineering/supervision	0.05	1.00	72011	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	144022	Table 4-3
Construction fee	0.10	1.00	144022	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	28804	Eng Guide #46, Table 4-3
Performance Test	0	1.00	9000	Estimate for 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	43207	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			441065	
ITUTAL CAPITAL COSTS (Dire	ct + indirect)=		2313347	

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#### Annualized Cost Analysis Scenario 4 - Storage Control System: Regenerative Thermal oxidizer w/58,000 scfm ventilation from enclosure for PUCB storage

Cost Item (\$/unit x units	/year) COST			
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	547	13675	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 365 days/yr
Supervision(15% of labor)			2051	
			0	
Maintenance (general):				
Labor	27.5	547	15043	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 365 days/yr
Materials (100% of labor)			15043	
· · · · · ·				
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
······································				
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	1112520	66751	vendor guote (127 KWH x 8760 hrs/yr)
Fuel oil (\$/gal x gal/vr)			0	
Cas (\$/10 <sup>3</sup> ft <sup>3</sup> x 10 <sup>3</sup> /ym)	\$4.00	37668	150672	vendor(4.3 Mft3/Hrx 8760 hrs/yr)
Water	φ1.00	0,000	1000/2	
Storm				
Other			0	
Ouler			0	
14/a ata Diana ana 1			0	
waste Disposal				
147 Turnet				
wastewater Treatment			0	
	000TT (1)-		0(000	
TOTAL DIRECT OPERATING	COS15 (A)=		263234	
Indirect operating (fixed) costs:		<u> </u>		
Overhead	80% of O & M(labo	er)	22974	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		23133	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		23133	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		46267	Eng. Guide #46, Table <u>5-</u> 1
Capital Recovery CRF=	0.108	2313346.88	249841	
	(9.0% for 20 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B) <sup>∞</sup>			365349	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
				······
TOTAL ANNUALIZED COSTS	5 (A + B minus C) =		628584	
	<b></b>			
Upgonteollad Emissions Rate (tr			0.0	
Cheoninoned Emissions Kale (I	Jinay year ja		7.9	
Overall (Capture & device eff.)	Control			
System Efficiency (%)=			98	
Controlled Emissions (tons/vear	r)=		9.70	
	<u>′</u>			······································
Cost (\$/top)=			64789	
			0,00	

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# Biofilter with 58,000 scfm for PUCB Core Storage

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#### Annualized Cost Analysis Scenario 4 - Storage Control System: Biofilter w/58000 scfm for PUCB Core Storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
			<u></u>	
Direct Costs:				
Basic Equipment:				
Di-Ch			1000040	Interpolation of Vendor D cost per cfm exhaust for 36,000 and
biofilter			1988240	85.000 cfm systems (\$34.28/1000 cfm)
Auxiliary				
Equipment/enclosure/make-up			164288	Eng. Estimate (Appendix E-3)
air units/ductwork				
Total Equipment Costs:			2152528	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	107626	
Freight	0.05	1.00	107626	
			00/0000	
Base Price:			2367781	
Installation costs, direct:		1.00		
Foundations/Supports	0.08	1.00	0	Included in vendor quote
Erection/handling	0.14	1.00	0	Included in vendor quote
Electrical	0.04	1.00	0	Included in vendor quote
Piping	0.02	1.00	0	Included in vendor quote
Insulation Deinting	0.01	1.00		Included in vendor quote
Site memoration	0.01	1.00	0	Included in vendor quote
Site preparation	0.00	1.00	0	Included in vendor quote
Facilities/ buildings		1.00	0	
Total Installation Costs:			0	
Total listaliation Costs.		·		
TOTAL DIRECT COSTS (Bage	Price + Installatio	n)=	2367781	
TOTAL DIRECT COOTS (Dase	The Thomas		2007/01	
Installation costs indirect				
motanation costs, mairea				
Engineering (supervision	0.05	1.00	0	Included in vendor quote
Construction / field expenses	0.00	1.00	0	Included in vendor quote
Construction fee	0.10	1.00	0	Included in vendor quote
Start-up	0.02	1.00	0	Included in vendor quote
Performance Test	0	1.00	9000	Est. for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Casting	0.02	5.00	2551/5	Eng Guide #46, Table 4-4, new application of control technology
Contingencies	0.03	5.00	355167	and guaranteed performance
TOTAL INDIRECT COSTS=			364167	
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=		2731948	

#### **Annualized Cost Analysis**

#### Scenario 4 - Storage

Control System: Biofilter w/58000 scfm for PUCB Core Storage

Cost Item (\$/unit x units	/year) COST			
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	0	0	Vendor D Estimate
Supervision(15% of labor)			0	
Operating Materials			0	Vendor D Estimate
Maintenance (general):				
Labor	27.5	50	1375	Vendor D Estimate
Materials (100% of labor)			1375	
Replacement parts (as required)			74250	Vendor E Estimate (\$1.28/cfm) for annual media costs
Labor (100% of parts cost)			74250	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	394200	23652	Scaled from 37,000 scfm system (45 KWHx8760hrs/yr))
Fuel oil (\$/gal x gal/yr)			0	
Gas $(\frac{10^3 \text{ ft}^3 \times 10^3}{\text{ vr}})$			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal			_	
Wastewater Treatment			0	
TOTAL DIRECT OPERATING	COSTS (A)=		174902	
Indirect operating (fixed) costs:				
Overhead	0% of O & M(labor	·)	1100	
Property Tax	1% of capital costs		27319	
Insurance	1% of capital costs		27319	
Administration	2% of capital costs		54639	
Capital Recovery CRF=	0.11	\$2,731,948	300514	
	(9.0% for 20 years)			Vendor E estimate of equipment life
TOTAL FIXED COSTS (B)=			410892	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	5 (A +B minus C)=		585794	
	<b></b>			
Uncontrolled Emissions Rate (to	ons/vear)=		9.9	
Overall (Canture & device off)	Control			······································
System Efficier and (0/)-				
System Efficiency (%)=			- 70	
	Ļ			
Controlled Emissions (tons/year	<u>()</u>		8.91	
	<u> </u>			
Cost (\$/ton)=			65746	

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# Concentrator/Oxidizer with 127,500 scfm Ventilation from Enclosure for PUNB Mold Production

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#### Annualized Cost Analysis Scenario 5 - Production

Control System: Concentrator/oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (Ss)	Basis of Costs
			C03. (40)	
Direct Coster				
Basic Fouinment	· · · · · · · · · · · · · · · · · · ·			
ovidizer, fan				
		1	1530000	Vendor F Quote
Controis.stack/ duct	·			
Auxiliary Equipment/enclosure	·····		100 (01	
make-up air units and ductwork			492621	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			2022621	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	101131	
Freight	0.05	1.00	101131	
Base Price:			2224883	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	177991	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	311484	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	88995	Eng Guide #46, Table 4-3
Piping	0.02	1.00	44498	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	22249	Eng Guide #46, Table 4-3
Painting	0.01	1.00	22249	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			667465	
TOTAL DIRECT COSTS (Base P	rice + Installation)	<b>=</b>	2892348	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	111244	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	222488	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	222488	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	44498	Eng Guide #46, Table 4-3
Performance Test	0.006	1.00	9000	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	66746	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			676465	
		_		
TOTAL CAPITAL COSTS (Direct		3568813		

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# Regenerative Thermal Oxidizer with 127,500 scfm Ventilation for PUNB Mold Production

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### Annualized Cost Analysis

Scenario 5 - Production

Control System: Concentrator/oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor				
Operating Labor.				Eng. Guide #46. Table 5-2 (5 hrs/shift x 2
Operator (\$/HR X HRS/YR)	25	365	9125	shifts/day x 365 days/yr)
Supervision(15% of labor)			1369	
Operating Materials			0	
	· · · · · · · · · · · · · · · · · · ·			
Maintenance (general):				Eng Cuido #46 Table 5 2 (5 hm/shift) 2
Labor	27.5	365	10038	shifts/day x 365 days/yr)
Materials (100% of labor)			10038	
Penlacement narts (as required)			0	
Labor (100% of parts cost)		·	0	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	905200	54312	Vendor Quote (155 KWH x 5840 hrs/yr)
Fuel oil (\$/ gal x gal/ yr)	£4.00	(10)	0	
Gas (\$/10 ft*x 10 ft*/yr)	\$4.00	0424	25696	Vendor Quote (1.1 Mft3/Hr x 5840 hrs/yr)
Steam	· · · · · · · · · · · · · · · · · · ·		0	
Other			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING	COSTS (A)=		110577	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		35688	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		35688	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		71376	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	\$3,568,813	556735	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			714817	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	6 (A +B minus C)=		825394	· · ·
Uncontrolled Emissions Pote (	one/vear)m		21.2	
Cheontroned Entissions Rate (it		41,2		
Overall (Capture & device eff.)	Control			
System Efficiency (%)=			90	
Controlled Emissions (tons/year	r)=		19.08	
Cost (\$/ton)=			43260	

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:	· · · · · · · · · · · · · · · · · · ·			
Basic Equipment:				
oxidizer, fan.			0050000	
controls stack/duct			2250000	Lowest quote-vendor B
connoisinger ader				
Auxiliary Equipment/enclosure			402621	Eng Ectimate (Appendix E 2)
make-up air units and ductwork			472021	Eng. Esuitate (Appendix E-5)
Total Equipment Costs:			2742621	
Instruments/controls	0.10	1.00	00	Included in quote
Taxes	0.05	1.00	137131	
Freight	0.05	1.00	137131	· · · · · · · · · · · · · · · · · · ·
Base Price:			3016883	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	241351	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	422364	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	120675	Eng Guide #46, Table 4-3
Piping	0.02	1.00	60338	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	30169	Eng Guide #46, Table 4-3
Painting	0.01	1.00	30169	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			905065	
TOTAL DIRECT COSTS (Base	Price + Installation	)=	3921948	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	150844	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	301688	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	301688	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	60338	Eng Guide #46, Table 4-3
Performance Test	0	1.00	9000	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	90506	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			914065	
TOTAL CAPITAL COSTS (Dire	ect + Indirect)≖		4836013	

#### Annualized Cost Analysis

Scenario 5- Production

Control System: Regen. Thermal oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

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Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	.365	9125	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365
Supervision(15% of labor)			1369	· · · · · · · · · · · · · · · · · · ·
			0	
Labor	275	365	10038	Fra Cuida #16 Table 5.2 (5 bre /abift x 2 abifts /days v 2/5
Materials (100% of labor)	<i>La</i> , 0	505	10038	Eng. Guide #46, Table 3-2 (.5 lus/ shut x 2 shuts/ day x 365
			10000	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	1635200	98112	vendor(280 KWH x 5840 hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
Gas $(\$/10^3 \text{ft}^3 \times 10^3/\text{yr})$	\$4.00	55480	221920	vendor (9.5 Mft3/Hr x 5840 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIDECT OPED ATTAIC	005TC (1)-		250(01	
TOTAL DIRECT OPERATING	C0315 (A)=		350601	
Indirect energy (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Fng Guide #46 Table 5-1
Property Tax	1% of capital costs		48360	Eng. Guide #46. Table 5-1
Insurance	1% of capital costs		48360	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		96720	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.108	\$4,836,013	522289	
	(9.0% for 20 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			731060	
· ·				
Credits				
Product recovery				
Heat recovery	-			
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	5 (A +B minus C)=		1081661	
Uncontrolled Emissions Rate (to	ons/year)=		21.2	
Overall (Capture & device eff.)	Control			
System Efficiency (%)=			98	
Controlled Emissions (tons/year	-) es		20.78	
Cost (\$/ton)=			52063	

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# Biofilter for 127,500 scfm from PUNB Mold Production

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Annualized Cost Analysis Scenario 5 - Production Control System: Biofilter for 127,500 scfm/PUNB Mold Production

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
'biofilter			3637280	Interpolation of cost per cfm for 85,000 and 165,000 cfm systems for Vendor D (28.64/cfm)
Auxiliary Equipment/enclosure,			492621	Eng Ectimate (Annendix E.2)
make up air units & ductwork			472021	Eng. Estimate (Appendix E-5)
Total Equipment Costs:			4129901	
	0.10	1.00	0	
Instruments/controls	0.10	1.00	206495	
Freight	0.05	1.00	200495	
riegia	0.00	1.00	2004/0	
Base Price:			4542891	
		-		
	······································			
Installation costs, direct:				
Foundations/Supports	0.08	1.00	0	included in quote
Erection/handling	0.14	1.00	0	included in quote
Electrical	0.04	1.00	0	included in quote
Piping	0.02	1.00	0	included in quote
Insulation	0.01	1.00	0	included in quote
Painting	0.01	1.00	0	included in quote
Site preparation	0.00	1.00	0	included in quote
Facilities/buildings	0.00	1.00	0	included in quote
M + 11 + 11 + 1 - C +				
Total Installation Costs:			0	
TOTAL DURFOT COSTS (P	Durant Installation		4540901	
TOTAL DIRECT COSTS (Dase	Frice + Installation	/ <del>↑</del>	4042071	
Installation costs indirect				
matanation costs, muneci.		<u> </u>		
Engineering/supervision	0.05	1.00	0	included in quote
Construction/field expenses	0.10	1.00	0	included in quote
Construction fee	0.10	1.00	0	included in guote
Start-up	0.02	1.00	0	included in quote
Performance Test	0.003	1.00	9000	Estimate for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	5.00	681434	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
		-		
TOTAL INDIRECT COSTS=			690434	
TOTAL CAPITAL COCTO	at + Indine +1)-	╉┈╼╌┈━┨	5022205	
IOTAL CAPITAL COSTS (Dire	ct + indirect)=		523325	

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#### Annualized Cost Analysis Scenario 5 - Production

Control System: Biofilter for 127,500 scfm/PUNB Mold Production

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	0	0	
Supervision(15% of labor)			0	
Operating Materials			0	
Maintenance (general):	07 F	50	1275	Vender D. Oveta
Labor	27.5		1375	
Materials (100% or labor)			1375	
Replacement narts (as required)			162560	Vendor E estimate for annual media replacement costs
Labor (100% of parts cost)			162560	tender Bestandte for andrald Bledda reparetilterit costo
Eabor (100% of parts cost)			101000	
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	570568	34234	Scaled from 85000 cfm system (97.7 KWH x 5840 hrs/vr)
Fuel oil (\$/gal x gal/yr)			0	
$Gas(5/10^3 ft^3 x 10^3 / vr)$			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
			2(2104	
TOTAL DIRECT OPERATING	COSIS (A)≝		362104	
Indirect operating (fixed) costs:	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		52333	
	1% of capital costs		52333	
Administration	2% of capital costs		104666	
Capital Recovery CRF=	0.108	\$5,233,325	565199	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			775632	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	5 (A +B minus C)=		1137736	
Uncontrolled Emissions Rate (to	ons/year)=		21.2	
Overall (Capture & device eff.)	Control			
System Efficiency (%)=			90	
Controlled Emissions (tons/year	r)=		19.08	
Cost (\$/ton)=			59630	

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### Concentration/Oxidizer with 234,500 scfm Ventilation form Enclosure for PUNB Mold Storage

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Control System: Concentrator/oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Coortican	-			
Direct Costs:	-			
Basic Equipment				·······
adsorber/oxidizer_fan				
controls stack / dust			2800000	Vendor F Quote
Auxiliary Equipment/enclosure/			5/0000	
make-up air units and ductwork			562330	Eng. Estimate (Appendix E-3)
· · · · · · · · · · · · · · · · · · ·				
Total Equipment Costs:			3362330	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	168117	
Freight	0.05	1.00	168117	
Base Price:			3698563	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	295885	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	517799	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	147943	Eng Guide #46, Table 4-3
Piping	0.02	1.00	73971	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	36986	Eng Guide #46, Table 4-3
Painting	0.01	1.00	36986	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			1109569	
TOTAL DIRECT COSTS (Base	Price + Installation)=		4808132	
Installation costs, indirect:			·	
Engineering/supervision	0.05	1.00	184928	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	369856	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	369856	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	73971	Eng Guide #46, Table 4-3
Performance Test	0.0035	1.00	9000	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	110957	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			1118569	
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=		5926701	

#### Annualized Cost Analysis

#### Scenario 5 - Storage

Control System: Concentrator/oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

Cost item         (Syunit x unity/ear)         COS1           Direct Operating Costs:					
Direct Operating Costs:	Cost Item (\$/unit x units	year) COST			
Direct Operating Costs:					
Operating Labor:         Operating (J/RX × HES/YR)         25         547         13675         Eng. Guide #46, Table 5-2 (.5 hrs/shift × 3 shifts/day × 365 days)           Operating Materials         0         201         2	Direct Operating Costs:				
Operating Labor:         Operator (5/1) KR X HIS/YR)         25         547         13675         Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 ghifts/ day x 365 days)           Supervision(15% of labor)         2051         2051         2051         2051           Maintenance (general):         0         2051         2051         2051         2051           Labor         0         1100         Vendor Quote         2051         20					
Operation (\$/HR X HRS/YR)         25         547         13675         Eng. Guide #46, Table 5-2 (5 hrs/shift x 3 shifts/day x 365 days)           Supervision(15% of labor)         2051         2051         2051           Operating Materials         0         0         0           Maintenance (general):         0         0         0           Labor         27.5         40         1100         Vendor Quote           Materials (100% of labor)         0         0         0         0           Labor (100% of parts cost)         0         0         0         0           Utilities:         0         0         0         0         0           Electricity (5/KWHxKWHyr)         50.06         2479080         148745         Vendor Quote (283KWH x 8760hrs/yr)           Oass (5/10 <sup>2</sup> H², 10 <sup>2</sup> H	Operating Labor:				
Supervision(15% of labor)         2051           Operating Materials         0           Maintenance (general):         0           Labor         1100           Materials (100% of Jabor)         0           Labor (10% of parts cost)         0           Tenel oil (5/4, 13/4)         0           Free oil (5/4, 13/4)         50.06           Vendor Quote (20 Mf3/hr x 8760/hrs/yr)           Free oil (5/4, 13/4)           Valer         0           Steam         0           Other         0           Waster Disposal         0           Vaster Disposal         0           TOTAL DIRECT OPERATING COSTS (A)=         236751           Indirect operating (fixed) costs:         59267           Property Tax         1% of capital costs         59267           Tortal Likecovery CRF         0.156         559267           Capital costs         559267         Eng. Guide #46, Table 5-1           Insurance         1% of capital costs         559267           Capital Recovery CRF         0.156         55.926701 <tr< td=""><td>Operator (\$/HR X HRS/YR)</td><td>25</td><td>547</td><td>13675</td><td>Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 365 days/</td></tr<>	Operator (\$/HR X HRS/YR)	25	547	13675	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 365 days/
Operating Materials         0           Maintenance (general):         0           Labor         27.5         40         1100           Materials (100% of labor)         1100         Vendor Quote           Materials (100% of labor)         0         1100           Materials (100% of parts cost)         0         0           Labor (100% of parts cost)         0         0           Utilities:         0         0           Steam         0         0           Other         0         0           TOTAL DIRECT OPERATING COSTS (A)=         23677         Eng. Guide #46, Table 5-1           Property Tax         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Insurance         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Insurance         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Capital Recovery CRF=         0.156         59267         Eng. Guide #46, Table 5-1	Supervision(15% of labor)			2051	
Operating Materials         0           Maintenance (general):					
Maintenance (general):         Z7.5         40         1100         Vendor Quote           Materials (100% of labor)         1100         0         0           Materials (100% of pairs cost)         0         0         0           Labor (100% of pairs cost)         0         0         0           Labor (100% of pairs cost)         0         0         0           Utilities:         0         0         0           Electricity (\$/KWH:xKWH/yr)         \$0.06         2479080         148745           Vendor Quote (283KWH x 8760hrs/yr)         0         0           Gas (\$/10 <sup>4</sup> K x 10 <sup>4</sup> ft/yr)         \$4.00         17520         70080           Vendor Quote (20 Mf3/hr x 8760 hrs/yr)         0         0           Steam         0         0         0           Other         0         0         0           Waste Disposal         0         0         0           Indirect operating (fixed) costs:         0         0         0           Overhead         80% of O & M(labor)         11820         Eng. Guide #46, Table 5-1           Insurance         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Oredits         59267         Eng. Guide	Operating Materials			0	
Maintenance (general):         40         Vendor Quote           Materials (100% of labor)         27.5         40         1100         Vendor Quote           Materials (100% of labor)         0         0         0         0           Replacement parts (as required)         0         0         0         0           Labor (100% of parts cost)         0         0         0         0           Utilities:         0         0         0         0         0           Bectricity (5/ KWHxKWH/yr)         \$0.06         247980         148745         Vendor Quote (283KWH x 8760hrs/yr)           Gas (5/ 107 kr 107 kr / yr)         \$4.00         17520         70080         Vendor Quote (2.0 Mft3/hr x 8760 hrs/yr)           Waster         0         0         0         0         0           Waster         0         0         0         0         0           Waster         0         0         0         0         0         0           Waster         100         246751         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0         0					
Labor         27.5         40         1100         Vendor Quote           Materials (100% of labor)         1100         1100         1100         1100           Replacement parts (ar required)         0         0         0         0         0           Labor (100% of parts cost)         0	Maintenance (general):				mini =
Materials (100% of labor)       1100         Replacement parts (as required)       0         Labor (100% of parts cost)       0         Utilities:       0         Extricity (5/KWH:xKWH/yr)       \$0.06         2479080       148745         Vendor Quote (283KWH x 8760hrs/yr)         Gas (5/10 <sup>4</sup> fx 10 <sup>4</sup> ft <sup>2</sup> yr)         Water       0         Cass (5/10 <sup>4</sup> fx 10 <sup>4</sup> ft <sup>2</sup> yr)         Water       0         Other       0         Other       0         Wastewater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       226751         Indirect operating (fixed) costs:       59267         Overhead       80% of O & M(labor)         This20       59267         Capital costs       59267	Labor	27.5	40	1100	Vendor Quote
Replacement parts (as required)         0           Labor (100% of parts cost)         0           Utilities:         0           Electricity (5/KWHxKWH/yr)         \$0.06           Cas (5/10 <sup>4</sup> /t × 10 <sup>4</sup> /t / yr)         \$4.00           Water         0           O         0           Steam         0           Other         0           Water         0           Water         0           Other         0           Water         0           Other         0           Water Disposal         0           Wastewater Treatment         0           Verhead         236751           Indirect operating (fixed) costs:         59267           Overhead         80% of 0 & M(labor)           Insurance         1% of capital costs           Stepator         59267           Eng. Guide #46, Table 5-1           Property Tax         1% of capital costs           Stepator         59267           Eng. Guide #46, Table 5-1           Administration         2% of capital costs           Stepator         59267           Stepator         15834           Eng. Guide #46, Table 5-1	Materials (100% of labor)			1100	
Replacement parts (as required)       0         Labor (100% of parts cost)       0         Utilities:       0         Electricity (5/KWH:kKWH/yr)       \$0.06         Zas (5/10 <sup>4</sup> /t <sup>2</sup> , 10 <sup>4</sup> /yr)       \$4.00         Gas (5/10 <sup>4</sup> /t <sup>2</sup> , 10 <sup>4</sup> /t <sup>2</sup> , 10 <sup>4</sup> /yr)       \$4.00         Water       0         Steam       0         Other       0         Waste Disposal       0         Wastewater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       226751         Indirect operating (fixed) costs       59267         Overhead       80% of O & M(labor)         Torrat Direct operating (fixed) costs       59267         Copital Recovery CRF=       0.156         Capital Recovery CRF=       0.156         TOTAL FIXED COSTS (B)=       1173453         TOTAL FIXED COSTS (B)=       1173453         TOTAL CREDITS (C)=       0         Credits       0         Product recovery       1173453         TOTAL CREDITS (C)=       0         Controlled Emissions Rate (tons/year)=       36.27					
Labor (100% of parts cost)       0         Utilities:       0         Electricity (\$/KWH:KWH/yt)       \$0.06         Cas (\$/10 <sup>4</sup> fx 10 <sup>4</sup> f/yr)       \$4.00         Water       0         Steam       0         Other       0         Waster Steam       0         Waster Treatment       0         Waster Treatment       0         Wastewater Treatment       0         Vernderd       0         Wastewater Treatment       0         Overnead       80% of O & M(labor)         Property Tax       1% of capital costs         Overnead       80% of O & M(labor)         Property Tax       1% of capital costs         Steam       59267         Insurance       1% of capital costs         Overnead       80% of O & M(labor)         11820       Eng. Guide #46, Table 5-1         Administration       2% of capital costs         Step26701       Step268         Eng. Guide #46, Table 5-1         (9.0% for 10 years)       Eng. Guide #46, Table 5-1         Credits       59267.01         Product recovery       1173453         Credits       0         TOTAL EXED CO	Replacement parts (as required)			0	
Utilities:         Image: Constraint of the second sec	Labor (100% of parts cost)			0	
Utilities:         2479080         148745         Vendor Quote (283KWH x 8760hrs/yr)           Electricity (5/KWHxKWH/yr)         \$0.06         2479080         148745         Vendor Quote (20 Mft3/hr x 8760 hrs/yr)           Gas (5/10*ft* 10*ft*/yr)         \$4.00         17520         70080         Vendor Quote (2.0 Mft3/hr x 8760 hrs/yr)           Water         0         0         0         0         0           Steam         0         0         0         0         0           Waster Disposal         0         0         0         0         0           Wastewater Treatment         0         0         0         0         0           TOTAL DIRECT OPERATING COSTS (A)=         236751         11820         Eng. Guide #46, Table 5-1         0           Property Tax         1% of capital costs         59267         Eng. Guide #46, Table 5-1         0           Property Tax         1% of capital costs         59267         Eng. Guide #46, Table 5-1         0           Capital Recovery CRF=         0.156         \$5,926,701         Eng. Guide #46, Table 5-3         0           Corabital costs         59267         Eng. guide #46, Table 5-3         0         0         0         0         0         0         0 <t< td=""><td></td><td></td><td></td><td></td><td></td></t<>					
Electricity (\$/KWH±xKWH/yr)       \$0.06       2479080       148745       Vendor Quote (283KWH x 8760hrs/yr)         Fuel oil (\$/gal x gal/yr)       0       0       0         Gas (\$/10/fx' 10/fx') 0/fx' 10/fx' 10/f	Utilities:				
Fuel oil (\$\[xet x \text{pal} x \text{pal} x \text{part}]       0       0         Gas (\$\[xet y \text{part}] x 10^4 fx' 10^4 f	Electricity (\$/KWHxKWH/vr)	\$0.06	2479080	148745	Vendor Ouote (283KWH x 8760hrs/yr)
Status         Status         17520         70080         Vendor Quote (2.0 Mft3/hr x 8760 hrs/yr)           Water         0         0         0         0         0           Other         0	Fuel oil (\$/gal x gal/yr)			0	
Case (a) (b) (c) (c) (c) (c) (c) (c) (c) (c) (c) (c	Cas (\$ /10 <sup>3</sup> 4 <sup>3</sup> × 10 <sup>3</sup> 4 <sup>3</sup> /)	\$4.00	17520	70080	Vendor Quote (2.0 Mft3/hr x 8760 hrs/yr)
Trace       0         Other       0         Waste Disposal       0         Wastevater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       236751         Indirect operating (fixed) costs:       0         Overhead       80% of O & M(labor)         Property Tax       1% of capital costs         Insurance       1% of capital costs         System       59267         Eng. Guide #46, Table 5-1         Insurance       1% of capital costs         1% of capital costs       59267         Capital Recovery CRF=       0.156         (9.0% for 10 years)       Eng. Guide #46, Table 5-1         Credits	Water	41.00			
Steam         0           Other         0           Waste Disposal         0           Waste Disposal         0           Wastewater Treatment         0           TOTAL DIRECT OPERATING COSTS (A)=         236751           Indirect operating (fixed) costs:         0           Overhead         80% of O & M(labor)         11820           Property Tax         1% of capital costs         59267           Insurance         1% of capital costs         59267           Capital Recovery CRF=         0.156         55,926,701           Y24565         Eng. Guide #46, Table 5-1           Credits         118234         Eng. Guide #46, Table 5-1           Product recovery         (9.0% for 10 years)         Eng. Guide #46, Table 5-3           TOTAL FIXED COSTS (B)=         1173453         Eng. guide #46, Table 5-3           TOTAL CREDITS (C)=         0         0           TOTAL CREDITS (C)=         0         0           TOTAL ANNUALIZED COSTS (A +B minus C)=         1410204         0           Uncontrolled Emissions Rate (tons/year)=         40.3         0           Overall (Capture & device eff.)Control         90         0           System Efficiency (%)=         90         0 </td <td>Steam</td> <td></td> <td>·</td> <td>0</td> <td></td>	Steam		·	0	
Other         0           Waste Disposal         0           Wastewater Treatment         0           TOTAL DIRECT OPERATING COSTS (A)=         236751           Indirect operating (fixed) costs:         0           Overhead         80% of O & M(labor)         11820           Property Tax         1% of capital costs         59267           Insurance         1% of capital costs         59267           Administration         2% of capital costs         118334           Capital Recovery CRF=         0.156         \$5,926,701           Yeather         0         1173453           TOTAL FIXED COSTS (B)=         1173453           TOTAL CREDITS (C)=         0           TOTAL CREDITS (C)=         0           TOTAL ANNUALIZED COSTS (A +B minus C)=         1410204           Uncontrolled Emissions Rate (tons/year)=         40.3           Overall (Capture & device eff.)Control         90           System Efficiency (%)=         90           Controlled Emissions (tons/year)=         36.27	Other			0	· · · · · · · · · · · · · · · · · · ·
Waste Disposal     0       Wastewater Treatment     0       TOTAL DIRECT OPERATING COSTS (A)=     236751       Indirect operating (fixed) costs:     0       Overhead     80% of O & M(labor)       Property Tax     1% of capital costs       Insurance     1% of capital costs       Capital Recovery CRF=     0.156       YS of capital costs     59267       Eng. Guide #46, Table 5-1       Capital Recovery CRF=     0.156       YS of capital costs     59267       Eng. Guide #46, Table 5-1       Capital Recovery CRF=     0.156       YS of capital costs     118234       Eng. guide #46, Table 5-1       Capital Recovery CRF=     0.156       YS of Capital costs     118234       Eng. guide #46, Table 5-3       TOTAL FIXED COSTS (B)=     1173453       Credits     1173453       Product recovery     1       Heat recovery     1       Heat recovery     1       Uncontrolled Emissions Rate (tons/year)=     40.3       Overall (Capture & device eff.)Control     90       System Efficiency %)=     90	Otter			0	
Waster Disposal       0         Wastewater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       236751         Indirect operating (fixed) costs:       0         Overhead       80% of O & M(labor)       11820         Property Tax       1% of capital costs       59267         Insurance       1% of capital costs       59267         Administration       2% of capital costs       59267         Capital Recovery CRF=       0.156       \$5,926,701         924565       Eng. Guide #46, Table 5-1         Capital Recovery CRF=       0.156       \$5,926,701         924565       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits	Marcha Diana and			0	
Wastewater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       236751         Indirect operating (fixed) costs:       236751         Overhead       80% of O & M(labor)       11820         Property Tax       1% of capital costs       59267         Insurance       1% of capital costs       59267         Administration       2% of capital costs       59267         Capital Recovery CRF=       0.156       \$5,926,701         924565       (9.0% for 10 years)       Eng. Guide #46, Table 5-1         TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       1         Heat recovery       1         Heat recovery       1         Induct recovery       1         Intorance       0         TOTAL CREDITS (C)=       0         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90         Controlled Emissions (tons/year)=       36.27	waste Lisposal				
Wastewater Treatment       0         TOTAL DIRECT OPERATING COSTS (A)=       236751         Indirect operating (fixed) costs:       236751         Overhead       80% of O & M(labor)       11820         Property Tax       1% of capital costs       59267         Insurance       1% of capital costs       59267         Administration       2% of capital costs       59267         Capital Recovery CRF=       0.156       \$\$,926,701         9.0%       \$\$,926,701       \$2455         Capital Recovery CRF=       0.156       \$\$,926,701         9.0%       \$\$,926,701       \$2455         Credits       1173453       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       0       1173453         Product recovery       0       1173453         TOTAL CREDITS (C)=       0       0         TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3       0         Overall (Capture & device eff.)Control       90       90         System Efficiency (%)=       36.27       0	TAT - to - To - to - t			0	
TOTAL DIRECT OPERATING COSTS (A)=       236751         Indirect operating (fixed) costs:       0         Overhead       80% of O & M(labor)       11820         Property Tax       1% of capital costs       59267         Insurance       1% of capital costs       59267         Administration       2% of capital costs       59267         Capital Recovery CRF=       0.156       \$5,926,701         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits	wastewater Treatment			0	
Indirect OPERATING COSTS (A)       236751         Indirect operating (fixed) costs:		200772 (A)-		00/751	
Indirect operating (fixed) costs:	TOTAL DIRECT OPERATING	COSIS (A)=		236/51	
Indirect operating (fixed) costs:       0       11820       Eng. Guide #46, Table 5-1         Overhead       80% of O & M(labor)       11820       Eng. Guide #46, Table 5-1         Property Tax       1% of capital costs       59267       Eng. Guide #46, Table 5-1         Insurance       1% of capital costs       59267       Eng. Guide #46, Table 5-1         Administration       2% of capital costs       118534       Eng. Guide #46, Table 5-1         Capital Recovery CRF=       0.156       \$5,926,701       924565         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       1       1173453         Product recovery       0       1         Heat recovery       0       1         Internet Costs       1410204       1         Uncontrolled Emissions Rate (tons/year)=       40.3       0         Overall (Capture & device eff.)Control       90       90         System Efficiency (%)=       90       90					
Overhead         80% of O & M(labor)         11820         Eng. Guide #46, Table 5-1           Property Tax         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Insurance         1% of capital costs         59267         Eng. Guide #46, Table 5-1           Administration         2% of capital costs         59267         Eng. Guide #46, Table 5-1           Capital Recovery CRF=         0.156         \$5,926,701         924565           (9.0% for 10 years)         Eng. guide #46, Table 5-3           TOTAL FIXED COSTS (B)=         1173453           Product recovery         Product recovery           Heat recovery         0           TOTAL CREDITS (C)=         0           TOTAL ANNUALIZED COSTS (A +B minus C)=         1410204           Uncontrolled Emissions Rate (tons/year)=         40.3           Overall (Capture & device eff.)Control         90           System Efficiency (%)=         90	Indirect operating (fixed) costs:				
Property Tax       1% of capital costs       59267       Eng. Guide #46, Table 5-1         Insurance       1% of capital costs       59267       Eng. Guide #46, Table 5-1         Administration       2% of capital costs       118344       Eng. Guide #46, Table 5-1         Capital Recovery CRF=       0.156       \$5,926,701       924565         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       1         Heat recovery       0         TOTAL CREDITS (C)=       0         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90	Overhead	80% of O & M(labor)		11820	Eng. Guide #46, Table 5-1
Insurance       1% of capital costs       59267       Eng. Guide #46, Table 5-1         Administration       2% of capital costs       118534       Eng. Guide #46, Table 5-1         Capital Recovery CRF=       0.156       \$5,926,701       924565         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       1         Heat recovery       0         TOTAL CREDITS (C)=       0         Incontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90	Property Tax	1% of capital costs		59267	Eng. Guide #46, Table 5-1
Administration       2% of capital costs       118534       Eng. Guide #46, Table 5-1         Capital Recovery CRF=       0.156       \$5,926,701       924565         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       1173453         Heat recovery       0         TOTAL CREDITS (C)=       0         TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90	Insurance	1% of capital costs		59267	Eng. Guide #46, Table 5-1
Capital Recovery CRF=       0.156       \$5,926,701       924565         (9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       0         Heat recovery       0         TOTAL CREDITS (C)=       0         TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90	Administration	2% of capital costs		118534	Eng. Guide #46, Table 5-1
(9.0% for 10 years)       Eng. guide #46, Table 5-3         TOTAL FIXED COSTS (B)=       1173453         Credits       Image: Control in the image: Contro	Capital Recovery CRF=	0.156	\$5,926,701	924565	
TOTAL FIXED COSTS (B)=       1173453         Credits       1173453         Product recovery       0         Heat recovery       0         TOTAL CREDITS (C)=       0         TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90         Controlled Emissions (tons/year)=       36.27		(9.0% for 10 years)			Eng. guide #46, Table 5-3
Credits	TOTAL FIXED COSTS (B)=			1173453	
Credits   Product recovery   Heat recovery   TOTAL CREDITS (C)=   0   TOTAL CREDITS (C)=   0   TOTAL ANNUALIZED COSTS (A +B minus C)=   1410204   Uncontrolled Emissions Rate (tons/year)=   40.3   Overall (Capture & device eff.)Control   System Efficiency (%)=   90   Controlled Emissions (tons/year)=   36.27					
Product recovery       Image: Constraint of the second secon	Credits				
Heat recovery       0         TOTAL CREDITS (C)=       0         TOTAL CREDITS (C)=       0         TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90         Controlled Emissions (tons/year)=       36.27	Product recovery				
TOTAL CREDITS (C)= 0   TOTAL ANNUALIZED COSTS (A +B minus C)= 1410204   Uncontrolled Emissions Rate (tons/year)= 40.3   Overall (Capture & device eff.)Control 90   System Efficiency (%)= 90   Controlled Emissions (tons/year)= 36.27	Heat recovery				
TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90         Controlled Emissions (tons/year)=       36.27	TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=       1410204         Uncontrolled Emissions Rate (tons/year)=       40.3         Overall (Capture & device eff.)Control       90         System Efficiency (%)=       90         Controlled Emissions (tons/year)=       36.27					
Uncontrolled Emissions Rate (tons/year)=  Uncontrolled Emissions Rate (tons/year)=  Overall (Capture & device eff.)Control  System Efficiency (%)=  Controlled Emissions (tons/year)=  36.27	TOTAL ANNUALIZED COSTS	i (A +B minus C)=		1410204	
Uncontrolled Emissions Rate (tons/year)= 40.3 Overall (Capture & device eff.)Control System Efficiency (%)= 90 Controlled Emissions (tons/year)= 36.27					
Uncontrolled Emissions Rate (tons/year)=     40.3       Overall (Capture & device eff.)Control	11 11 - 1 T			40.2	
Overall (Capture & device eff.)Control       System Efficiency (%)=       90       Controlled Emissions (tons/year)=       36.27	Uncontrolled Emissions Kate (to	onsy year).	·	40.3	
Overall (Capture & device eff.)Control     90       System Efficiency (%)=     90       Controlled Emissions (tons/year)=     36.27					
System Efficiency (%)=     90       Controlled Emissions (tons/year)=     36.27	Overall (Capture & device eff.)	Control			
Controlled Emissions (tons/year)= 36.27	System Efficiency (%)=			90	
Controlled Emissions (tons/year)= 36.27					
	Controlled Emissions (tons/vear			36.27	
Cost (\$/ton)= 38881	Cost (\$/ton)=			38881	

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# Regenerative Thermal Oxidizer with 234,500 scfm Ventilation from Enclosure for PUNB Mold Storage

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E. Walder

#### Annualized Cost Analysis

Scenario 5 - Storage

Control System: Regen. Thermal oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:		x.*	<u> </u>	· · · · · · · · · · · · · · · · · · ·
oxidizer, fan,			450000	
controls.stack/duct			3500000	Lowest Quote vender B
Auxiliary Equipment/enclosure			562220	Eng Estimate (Annondix E 2)
make-up air units and ductwork				Eng. Esuitate (Appendix E-5)
Total Equipment Costs:		<u> </u>	4062330	
Technic and a factor back	0.10	1 1 00		
Instruments/controis	0.10	1.00	0001117	included in quote
Freight	0.05	1.00	203117	
	0.05	1.00	205117	
Base Price		-	4468563	
Dase I like.		<u> </u>	400505	
Installation costs direct		+		
Foundations (Supports	0.08	1.00	357485	Eng Guide #46 Table 4-3
Frection / handling	0.00	1.00	625599	Eng Guide #46 Table 4-3
Flectrical	0.04	1.00	178743	Eng Guide #46, Table 4-3
Piping	0.02	1.00	89371	Eng Guide #46. Table 4-3
Insulation	0.01	1.00	44686	Eng Guide #46. Table 4-3
Painting	0.01	1.00	44686	Eng Guide #46. Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
		Í	•	
Total Installation Costs:			1340569	
TOTAL DIRECT COSTS (Base	Price + Installation	ı)=	5809132	
(				
Installation costs, indirect:				
			·	
Engineering/supervision	0.05	1.00	223428	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	446856	Eng Guide #46, Table 4-3
Construction fee	0.10	1.00	446856	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	89371	Eng Guide #46, Table 4-3
Performance Test	00	1.00	9000	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	134057	Eng Guide #46, Table 4-3
		<u>                                     </u>		
TOTAL INDIRECT COSTS=		┦────┤	1349569	
		I		
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=		7158701	

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#### Annualized Cost Analysis Scenario 5 - Storage

Control System: Regen. Thermal oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

Cost Item	\$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	547	13675	Eng. Guide #46. Table 5-2 (.5 hrs/shift x 3 shifts/day x 365
Supervision(15% of labor)			2051	
			_	
Operating Materials			0	
Maintenance (general):			<u> </u>	
Labor	27.5	547	15043	Eng. Guide #46. Table 5-2 (.5 hrs/shift x 3 shifts/day x 365
Materials (100% of labor)			15043	
		· · · · · · · · · · · · · · · · · · ·		
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity (\$/KWHxKWH/vr)	\$0.06	4520160	271210	vendor (516 KWHx 8760hrs/yr)
Fuel oil (\$/gal x gal/yr)		1040100	0	
Cae (\$/10 <sup>3</sup> ft <sup>3</sup> v 10 <sup>3</sup> /vm)	\$4.00	153300	613200	vendor (17.5 Mft3/Hr x 8760hrs/vr)
Water			0.0200	
Steam			0	
Other			0 -	
Ouler			0	
Waste Disposal				
	· · · ·		i	
Wastewater Treatment			0	
TOTAL DIRECT OPERATING			020221	
IOTAL DIRECT OPERATING	CU315 (A)=		930221	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		22974	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		71587	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		71587	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		143174	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.108	\$7,158,701	773140	
	(9.0% for 20 years)			
TOTAL FIXED COSTS (B)=			1082462	
Cradite				l
Product recovery				
Heat recovery				· · · · · · · · · · · · · · · · · · ·
TOTAL CREDITS (C)=			0	h
				·····
TOTAL ANNUALIZED COSTS	(A +B minus C)=		2012683	
Uncontrolled Emissions Rate (to	ons/year)=		40.3	
Overall (Capture & device eff.)C	Control			
System Efficiency (%)=			98	
Controlled Emissions (tons/year	·)==		39.49	
			500(0	
Lost (\$/ton)=			50962	

### Biofilter for 234,500 scfm from PUNB Mold Storage

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	Average	Adjustment		
Cost Item	Cost Factor	Factor	Cost (\$s)	Basis of Costs
Direct Costs:				
Basic Equipment:		X.1		
'biofilter			6136937	Scaled from Vendor D quote for 165,000 cfm system
Auxiliary Equipment/enclosure,			562330	Eng Estimate (Annendix E-3)
make up air units & ductwork			502550	Eng. Estimate (Appendix 2-0)
Total Equipment Costs:			6699267	
		1.00		
Instruments/controls	0.10	1.00	0	Include in quote
Taxes	0.05	1.00	334963	
Freight	0.05	1.00	334963	
		<u> </u>	72(0104	
Base Price:			7369194	
				· · · · ·
Installation costs, direct:	0.00	1.00		induded in quoto
Foundations/Supports	0.08	1.00	0	included in quote
Erection/handling	0.14	1.00	0	included in quote
Electrical	0.04	1.00	0	lineluded in quote
Piping	0.02	1.00	0	included in quote
Insulation	0.01	1.00	0	included in quote
Fainting	0.01	1.00	0	included in quote
Site preparation	0.00	1.00	0	included in quote
Factures/ buildings		1.00	<u> </u>	Induce In quote
Total Installation Costs:			0	
Total Installation Costs.				
TOTAL DIRECT COSTS (Base	Price + Installation	))22 	7369194	
TOTAL DIRECT CODID (Dase	THE Photemation	·/	1007171	
Installation costs indirect				
mistanation costs, munect.				
Engineering/supervision	0.05	1.00	0	included in quote
Construction/field expenses	0.10	1.00	0	included in quote
Construction fee	0.10	1.00	0	included in quote
Start-up	0.02	1.00	0	included in quote
Performance Test	0.000	1.00	9000	Estimate for 25A inlet/outlet
Model study	0.00	1.00	0	
	0.02	5.00	1105270	Eng Guide #46, Table 4-4, new application of control
Contingencies	0.05	5.00	1100579	technology and guaranteed performance
TOTAL INDIRECT COSTS=			1114379	
TOTAL CAPITAL COSTS (Dire	ct + Indirect)=		8483573	

#### Annualized Cost Analysis Scenario 5 - Storage Control System: Biofilter for 234,500 scfm/PUNB Mold Storage

C	£1		0	
Cost Item	\$/unit	units/yr	Cost	
			·····	
Direct Operating Costs:			ļ	
Operating Labor:				
Operator (\$/HR X HKS/YR)	2	U	0	Vendor D Quote
Supervision(15% of labor)			<u> </u>	
			<u> </u>	
Operating Materials			<u> </u>	
Maintenan (non and)			<u> </u>	
Iviaintenance (general):	27.5	50	1275	Vander D. Oueb
Materials (100% of labor)	27.5		1375	
Materials (100 % Of labor)			15/5	
Replacement parts (as required)			300160	Vendor F Quote for annual media costs (\$1.28 (cfm)
Labor (100% of parts cost)			300160	Vendor E Quote for annual media costs (\$1.26/ Chil)
Labor 100 % of parts cost				
[]tilities			· · · · · · · · · · · · · · · · · · ·	
Electricity (\$/KWHyKWH/yr)	\$0.06	1594320	95659	165000 cfm system (182.0 kwh x 8760 Hrs/yr)
Fuel oil (\$/gal x gal/yr)	<b>\$0.00</b>		0	
$C_{22} = \frac{(10^3)^2}{(10^3)^2} + \frac{(10^3)^2}{(10^3)^$				
Water				
Storm				
Other			- <del>0</del>	
Waste Disposal			· · · · ·	
Waste Disposat				
Wastewater Treatment			1 0	
The second and an excellent				
TOTAL DIRECT OPERATING	COSTS (A)=		698729	
Indirect operating (fixed) costs:			<u> </u>	
Overhead	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		84836	
Insurance	1% of capital costs		84836	
Administration	2% of capital costs		169671	
Capital Recovery CRF=	0.108	\$8,483,573	916226	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			1256669	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS	(A +B minus C)=		1955398	
Uncontrolled Emissions Date (b)			40.2	
Cheonuoneu Emissions Mate (10	niay year j-		10.5	
			<del> </del>	
Overall (Capture & device eff.)	_ontrol			
System Efficiency (%)=			90	
Controlled Emissions (tons/year	r)≖		36.27	
Cost (\$/ton)=			53912	

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Appendix E-2

Vendor Quotes

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#### Pages: (8) Including this cover sheet

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This fax is in response to your letter dated July 25, 1997, and our discussion last week. For each of the six scenarios, we have provided information for the oxidizer control equipment. Even though we have worked with other ancillary types of equipment such as concentrators and biofiltration, we will leave those areas for others for your current study needs. The attached sheets have been completed per your request, and we have several comments which are noted below.

Scenarios 1, 3, and 5 are more production related, and we do have concerns about potential particulate loading to the oxidizer. For these cases, we assume that particulate control will be provided by others. Scenarios 2, 4, and 6 are storage related, where particulate and odor control are not expected to be a concern.

Scenario 1 has several VOC components, including Dimethlyethlyamine (DMEA). This is a concern based on our experience with DMEA creating odor problems. Odor control is not listed as an objective of the emissions control equipment, and with only 90 percent destruction efficiency, DMEA odor could remain a problem even with the control equipment installed.

The ambient temperature for all cases is assumed to be 100°F. Please note that destruction efficiencies much higher than 90% can be obtained using the same oxidizers if the thermal efficiency requirements are lower than those stated. The ductwork prices shown are budget values for fabricated ductwork, and do not include installation since the actual site conditions and layout required are unknown.

We trust that this information will assist your evaluations. Please contact this office if you have questions or need additional information.

Sincerely,

	Sce	ario 1	
E	Phenolic Urethane Cold F	ox (PUCB) Core Pro	duction
Vestilation mton 20			Temperature= amble
Daily operation sch	edule= 8 hours /day and 7 day	s/week	
Average VOC/OC (	missions rate= 1.6 lbs/hour		
Max. hourly VOC/C	C emissions rate= 1.6 lbs/hou	(inlet to controls appro:	( 40 ppmv)
Annual VOC/OC er	nīssions= 2.3 tons/year		•••
OCNOC compositi	on ranges=Petroleum Distillate	s CAS# 68477-31-6/84	42-95-6 (approx 43% b
	-potential	onstituents (xylene, cun	ene, trimethylbenzene a
	mesitylene	;	
	Petroleum Distillat	s CAS# 647-742-94-5 (	approx. 43% by weight)
	-potential c	onstituents (napthalene,	trimethylbenzene, xylen
	biphenyi)		
Guarantood Doola	- I flethylamine of D	methylethylamine (appr	ox. 14 % by weight
suaranteed Lesig	h control removal requireme	nt 90% removal by we	ignt (using USEPA
for cites test inter			
Control equipmen	ttype#1:		
Rocimenti	ve thermal oxidizer (w/ 50% re-		
Equipment	Costs: Oxidizer = 4	210,000	
	Supporting Controls = 1	ncluded above	
	Fan =	21,000	
	ductwork (\$/ft) =_	55	
	Total =	•	
Operating 1	electrical use (Kwh) =2	900 (All scenarios 5 kw x 8 x 365 = 73	based on 950 BIU/SC ,000 kwh (Annual)
Control equipmen	t type #2:		
Recuperativ	<u>re Catalvic oxidizer</u>	70,000	·
Equipment	Supporting Controls		
	Fan = "		
	ductwork (\$/ft) =	55	
	Total =		
	( ) (10)		
Operating II	ino. houriy gas usage (ft.) =99	0	
	electrical use (NWR) 225	$kw \times 8 \times 365 = 73,0$	000 kwh (Annual)
Control Equipmen	1#3 - By Others		
<u>Laidon ads</u>	orbiton with on-sile disposal:		
Equipment	Supporting Controls =		
	ran =		
	ductwork (\$/ft) =		
	ductwork (\$/ft) =_ Total =		
	ductwork (S/ft) =_ Total =	   	
Operating i	ductwork (\$/ft) =_ Total = 16. hourly gas usage (ft3) =		
Operating is	ductwork (\$/ft) = Total = 16. hourly gas usage (ft3) = electrical use (Kwh) =		

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	<u>Scenario</u> <u>Phenolic Urethane Cold Box (PUCB) Core Storage</u>				
,					
	Ventilation rate= 37,000 scfm Temperature= ambient Daily operating schedule= 19.5 hours /day and 7 days/week				
	Average VOC/OC emissions rate= 1,4 lbs/hour				
	Annual VOC/OCemissions= 5.0 tons/year				
	OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-5/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, curnene, trimethylbenzene and				
р. П	mesnylene); Petroleum Distillates CAS# 647-742-94-5 (approx: 50% by weinbt)				
A CONTRACTOR	-potential constituents (napthalene, trimethylbenzene, xylene, biphenyl)				
	Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))				
	<u>Control equipment type #1:</u> – By Others <u>Concentrator</u>				
<b>E</b> 21	Equipment Costs: adsorber/Oxidizer =				
	Fan =				
	ductwork (\$/ft) =				
	Total =				
	Operating info. houtiy gas usage (fG) =				
5	electrical use (Kwh) =				
	annual adsorbent cost (\$) = annual maintenance (man-hours)=				
	Control equipment type #2:				
	Regenerative Catalytic oxidizer (w/min. 98% heat recovery)				
	Supporting Controls = Included above				
	Fan $= 50,000$				
	ductwork (\$/ft) = $210$				
	10(a) =				
	Operating info, hourly gas usage (ff3) = 990				
夏印度了	electrical use (Kwh) = 130 ky x 19 5 x 365 = 925,275 kwh (Annual)				
	expected catalyst life = 3-5 years				
	<u>Control Equipment #3</u> – By Others				
	Biofiltration:				
i.	Equipment Costs Biotilier/structure =				
<b>6</b> 300 -	Supporting Controls =				
	Fan 🗲				
<u>k</u> .J	ductwork (S/ft) =				
<b>₹</b> 3.	i q⊡i ≈ Operatino info, electrical use (Kwh) =				
	annual media costs (\$) =				
	annual maintenance (man-hrs) =				
	estimated size (length x width) =				

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<u>Scenario 3</u>	
Phenolic Urethane No Bake (PUNB)	Core Production

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OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/84742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumere and timethylbenzene); Petroleum Distillates CAS# 6477-31-67-82-95-6 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene); Petroleum Distillates CAS# 6477-742-95-6 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene); Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference text methods (40 CFR, Part 50)) Control equipment type #11 - By Others Cancentrator Equipment Costs: adsorber/Oxidizer = Supporting Controls = Fan = ductwork (\$rft) = into annual edsorbent cost (\$) = annual maintenance (man-hours)= Control equipment type #2: Regenerative Catalvite coldizer (w/min. 98% heat recovery) Equipment Costs: Catalvite coldizer (w/min. 98% heat recovery) Total = Operating info. hourly gas usage (ff3) = gas5 electrical use (Kwh) = 190 Total = Operating info. hourly gas usage (ff3) = gas5 electrical use (Kwh) = 110 kw x 19.5 x 365 = 782,925 kwh (Annual.) expected catalyst fife =3-5 years Control Equipment Costs: Biofilter/supports = fan = ductwork (\$fft) = Fan = ductwork (\$fft) = fan = ductwork (\$fft) = annual media costs (\$) = annual	Ventilation rate= 30,500 scfm , $\sqrt[6]{,0}$ Daily operating schedule= 19,5 hours /day and 7 days/week Average VOC/OC emissions rate= 1.7 lbs/hour Max. hourly VOC/OC emissions rate= 1.7 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OC emissions= 2.5 tons/year
Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 50)) <u>Control equipment type #1:</u> - By Others <u>Concentrator</u> Equipment Costs: adsorber/Oxidizer = Supporting Controls = Fan = ductwork (\$/n) = annual maintenance (man-hours)= <u>Control equipment type #2:</u> Regenerative Catalytic oxidizer (w/min_98% heat recovery) Equipment Costs: Oxidizer = \$950,000 Supporting Controls = Included above Fan = \$50,000 ductwork (\$/n] =	OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/84742-95-6 (approx, 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 847-742-94-5 (approx, 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)
Control equipment type #1: - By Others         Concentrator         Equipment Costs: adsorber/Oxidizer =         Supporting Controls =         Fan =         ductwork (\$/R)         Total =         Operating info. hourly gas usage (ft3) =         electrical use (Kwh) =         annual adsorbent cost (\$) =         Supporting Controls =         Fan =         Operating info. hourly gas usage (ft3) = 885         electrical use (Kwh) =         Total =         Operating info. hourly gas usage (ft3) = 885         electrical use (Kwh) =         installation         costs: Biofilter/supports =         installation Costs (tumkey) =         Supporting Controls =         fan =         outwork (\$/R)         installation Costs (tumkey) =         Supporting Controls =	Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))
Operating info. hourly gas usage (ft3) = electrical use (Kwh) = annual adsorbent cost (\$) = annual maintenance (man-hours)= Control equipment type #2: Regenerative Catalytic oxidizer (w/min. 98% heat recovery) Equipment Costs: Oxidizer =\$950,000 Supporting Controls = Included above Fan = 50,000 ductwork (\$/ft) =	<u>Control equipment type #1:</u> - By Others <u>Concentrator</u> Equipment Costs: adsorber/Oxidizer = Supporting Controls = Fan = ductwork (\$/ft) = Total =
Control equipment type #2: Regenerative Catalytic oxidizer (w/min, 98% heat recovery) Equipment Costs: Oxidizer = \$950,000 Supporting Controls = Included above Fan = 50,000 ductwork (\$/ft) = 190 Total = Operating info. hourly gas usage (ft3) = 885 electrical use (Kwh) = 110 kw x 19.5 x 365 = 782,925 kwh (Annual) expected catalyst life = 3-5 years Control Equipment #3 - By Others Biofiltration: Equipment Costs: Blofilter/supports = Installation Costs (turnkey) = Supporting Controls = Fan = ductwork (\$/ft) = Total = Operating info. electrical use (Kwh) = annual meintenance (man-hrs) = estimated size (length x width) =	Operating info, hourly gas usage (ft3) = . electrical use (Kwh) = annual adsorbent cost (\$) = annual maintenance (man-hours)=
Operating info. hourly gas usage (ft3) = 885 electrical use (Kwh) = 110 kw x 19.5 x 365 = 782,925 kwh (Annual) expected catalyst life =3-5 years Control Equipment #3 - By Others Biofiltration: Equipment Costs: Biofilter/supports = Installation Costs (tumkey) = Supporting Controls = Fan = ductwork (\$/ft) = Total = Operating info. electrical use (Kwh) = annual media costs (\$) = annual media costs (\$) = estimated size (length x width) =	Control equipment type #2:         Regenerative Catalytic oxidizer (w/min. 98% heat recovery)         Equipment Costs: Oxidizer       = \$950,000         Supporting Controls       = Included above         Fan       = 50,000         ductwork (\$/ft)       = 190         Total       =
Control Equipment #3 - By Others         Biofiltration:         Equipment Costs: Biofilter/supports         Installation Costs (tumkey)         Supporting Controls         Fan         ductwork (\$/ft)         Total =         Operating info. electrical use (Kwh)         annual media costs (\$)         annual maintenance (man-hrs)         estimated size (length x width) =	Operating info. hourly gas usage (ft3) = 885 electrical use (Kwh) =110 kw x 19.5 x 365 = 782,925 kwh (Annual) expected catalyst life =3-5 years
	Control Equipment #3 - By Others         Biofiltration:         Equipment Costs: Biofilter/supports         Installation Costs (tumkey)         Supporting Controls         Fan         ductwork (\$/ft)         Total         Operating info. electrical use (Kwth)         annual media costs (\$)         annual media costs (\$)         estimated size (length x width) =

	<i></i> 7
	: Scenario 4 Phenolic Urethane No Bake (PUNB) Core Storage
	Ventilation rate= 36,000 scim
	Daily operating schedule= 19.5 hours /day and / days/week Average VOC/OC emissions rate= 1.4 lbs/hour Max, hourly VOC/OC emissions rate= 2.3 lbs/hour (control iniet approx, 10 ppmy)
a star	Annual VOC/OCemissions= 4.8 tons/year
2 2	OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
الم المحمد ا	-potential constituents (napthalene, trimethylbenzene, xylene)
and	Guaranteed Design control removal requirement  90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))
	<u>Control equipment type #1:</u> – By Others <u>Concentrator</u> Equipment Costs: adsorber/Oxidizer =
	Supporting Controls = Fan = ductwork (\$/ft) = Total =
	Operating info. hourly gas usage (ft3) = electrical use (Kwh) =
marine and	annual adsorbent cost (\$) ► annual maintenance (man-hours)= .
	Control equipment type #2: Regenerative Catalytic oxidizer (w/min. 98% heat recovery) Equipment Costs: Oxidizer = \$950,000 Supporting Controls = 7 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 - 2 -
	Fan = 50,000 ductwork (\$/ft) =205
e time	Operating info, hourly gas usage (ft3) = 990 electrical use (Kwh) = 130 x 19.5 x 365 = 925,275 kwh (Annual) expected catalyst life = 3-5 years
	Control Equipment #3 - By Others Biofiltration
	Equipment Costs Biofilter/supports = Installation Costs (tumkey) = Supporting Costmis =
	Fan = ductwork (\$/ft) =
Ĵ.	Operating info. electrical use (Kwh) = annual media costs (\$) =
	annual maintenance (man-hrs) = estimated size (length x width) =

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	Scenario 5 Phenolic Urethane No Bake (PUNB) Mold Making
	Ventilation rate= 85,000 scfm Temperature= ambient Daily operating schedule= 18.0 hours /day and 7 days/week Average VOC/OC emissions rate= 4.8 lbs/hour Max. hourly VOC/OC emissions rate= 4.8 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 14.1 tons/year
	OCNOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-8 (approx, 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx, 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)
	Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))
	Control cauloment type #1:- By Others Concentrator Equipment Costs: adsorber/Oxidizer = Supporting Controls = Fan = ductwork (\$/ft) = Total =
	Operating info. hourly gas usage (ft3) = electrical use (Kwh) = annual adsorbent cost (\$) = annual maintenance (man-hours)=
	Control gauipment type #2:         Regenerative Catalytic oxidizer (w/min. 93% heat recovery)         Equipment Costs: Oxidizer       =\$1,750,000         Supporting Controls       =Included above         Fan       =       125,000         ductwork (\$/ft)       =       475         Total =
	Operating info. hourly gas usage (ft3) = 2100 electrical use (Kwh) = 280 kw x 16 x 365 = 1,635,200 kwh (Annual) expected catalyst life = 3-5 years
	Control Equipment #3 - By Others         Biofiltration!         Equipment Costs: Biofilter/supports         Installation Costs (tumkey)         Supporting Controls         Fan         ductwork (\$/ft)         Total         Operating Info. electrical use (Kwh)         annual media costs (\$)         annual maintenance (man-hrs)         estimated size (length x width)

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4.4	Phenolic Uremane No bake (PUNB) Molo Storage				
897 1	Vertilation man (FE ED) of m				
	Venualion rate= 105,500 schilt remperature= ampient				
	Average VOCIOC emissions rates A Albs/hour				
	Mar, houdy VOC/OC emissions rate= 10.0 lbs/hour (control inlet approx, 10 ppmy)				
	Annual VOC/OCemissions= 25.1 tons/year				
en (cm					
	OCNOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-85-6 (approx, 50% by weight)				
	-potential constituents (xviene, cumene and trimethylbenzene);				
	Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)				
	-potential constituents (napthalene, trimethylbenzene, xylene)				
•					
mal -	Guaranteed Design control removal requirement 90% removal by weight (using USEPA				
è-3	reference test methods (40 CFR, Part 60))				
	Control partinement type #1:				
	Conceptizion				
	Equipment Casts: adsorber/Oxidizer =				
	Supporting Controls				
Ø (	Fan =				
	ductwork (\$/ft) =				
****	Total =				
·					
·	Operating info, houriy gas usage (ft3) ==				
	electrical use (Kwh) =				
19 f	annual adsorbent cost (\$) =				
1 1	annuel maintenance (man-hours)=				
1922 - A					
(197	Control equipment type #2:				
	Equipment Costs: Oxidizer $= $3,075,000$				
ru í	Supporting Controls - Included above				
	$\frac{1}{220,000}$				
ניי ו מי					
	Operating info. hourly gas usage (ft3) = 3350				
) !	electrical use (Kwh) = 490 kw x 24 x 350 = 4,116,000 kwh (Annual)				
	expected catalyst life = 3-5 years				
:	Control Equipment#3 - By Others				
	Biofiltration:				
	Equipment Costs: Biofilter/supports =				
1	Installation Costs (turkey) =				
	Supporting Controls =				
1	Fan =				
1					
	Operaung into. electrical use (Kwn) =				
i .	annual media costs ( $\varphi$ ) =				
	espinateo size (lengin x wion) =				

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This fax is in response to your memo to Ken Tabellion dated February 16, 1998.

We have completed the information requested using our previous submittal as a guideline. Please contact Ken Tabellion or this office if you have any questions.

Sincerely,

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### Scenario 4 Phenolic Urethane Cold Box (PUCB) Core Storage

Ventilation rate=58,000 scfm Temperature=ambient Daily operating schedule=24.0 hours/day and 365 days/year

Max hourly VOC/OC emissions rate-34 lbs/hour (control inlet approx 5.0 ppmv) Annual VOC/OC emissions=9.9 tons/year 9.9

OC/VOC composition ranges-Petroleum Distillates CAS#68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, currene, trimethylbenzene and menitylene): Petroleum Distillates CAS#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalene, trimethylbenzene, xylene, hiphenyl)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Fart 60))

#### Control Equipment Type #1:

X

Concentrator		•
Equipment Costs: Adsorber/Orddizer	a	BY OTHERS
Supporting Controls	28	•
Fan	28	
Ductwork (\$/ft)	12	
Total	<b>Ant</b>	

Operating Info. Hourly Gas Usage (fG) =

electrical us (Kwh) =

annual adsorbent cost (\$) =

annual maintenance (man-hours) =

#### Control Equipment Type #2:

Regenerative Thermal Oridizer (w/min 98% heat recovery)				
Equipment Costs:	Oxidizer =	1,000,000		
- <b>.</b> 5.	apporting Controls -	Included		
	Fan -	100,000		
	Ductwark (\$/ft) =	325		
	Total =			

Operating Into. Hourly Gas Usage (H3) = 2,560 electrical us (Kwh) = 350 kw x 24 x 365 = 3,066,000 kwh (annual) expoceed catalyst life = N.A.

Equipment Supplier Name SMITH ENVIRONMENTAL CORPORATION B01-97-127

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### Scenario 5 Pluenolic Urethane No Bake (PUNB) Mold Production

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Ventilation rate=127,500 scfm Temperature=ambient 21.5 Daily operating schedule=16.0 hours/day and 350 days/year Max. hourly VOC/OC emissions rate-7.3 Ibs/hour (control inlet approx. 5.0 ppmv) Annual VOC/OC emissions=20.5 tons/year 21.2 OC/VOC composition ranges=Petroleum Distillates CA5#68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalene, trimethylbenzane and xylene) Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60)) Control Equipment Type #1: Concentrator Equipment Costs: Adsorber/Oxidizer = BY OTHERS Supporting Controls = Fan = Ductwork (\$/ft) = Total = Operating Info. Hourly Gas Usage (ft3) = electrical us (Kwh) = annual adsorbent cost (\$) = annual maintenance (man-hours) = Control Equipment Type #2: Regenerative Thermal Oxidizer (w/min. 98% heat recovery) Equipment Costs: Oxidizer = 1,800,000 Supporting Controls = Included Fan = 200,000 Ductwork (5/ft) = 600 Total 🖷 5,260 Operating Info. Hourly Gas Usage (ft3) = electrical us (Kwh) = 700 kw x 350 x 16 = 3,920,000 kwh (annual) expected catalyst life = N.A.

Equipment Supplier Name SMITH ENVIRONMENTAL CORPORATION

E-WPCOLVETO0-02110422211048.DOC 00/18/98

### 5 <u>Scenario</u> <u>Phenolic Urethane No Bake</u> (PUNB) Mold Storage

Ventilation rate=234,500 scfm 365 Temperature=ambient Daily operating schedule=24.0 hours/day and 350 days/year Max. hourly VOC/OC emissions rate-13.8 lbs/hour (control inlet approx. 5.0 ppmv) Annual VOC/OC emissions=38.6 tors/year do.3

OC/VOC composition ranges=Petroleum Distillates CAS#68477-31-6/64742-95-6 (approx, 50% by weight) -potential constituents (xylene, cumeno and trimethylbenzene); Petroleum Distillates CA5#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalene, trimethylbenzene and xylene)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Control Equipment Type #1:

 $\mathcal{A}_{\mathcal{A}}$ 

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•	Concentrator		
	Equipment Costs: Adsorber/Oxidizer	<b>m</b>	BY OTHERS
	Supporting Controls	#	
	Fan	Ħ	•
	Ductwork (\$/ft)	8	
	Total	a	
	Operating Info. Hourly Gas Usage (ff3)	9	
	electrical us (Kwh)	=	•

annual adsorbent cost (\$) =

annual maintenance (man-hours) =

Control Equipment Type #2:

Regenerative Thermal Oxidizer (w/min 98% heat recovery)				
Equipment Costs:	Oxidizer		2,600,000	
	Supporting Controls	<b>53</b>	Included	
	Fan	u	300,000	•
	Ductwork (\$/ft)	*	4840	
•	Total	=		•

Operating Info. Hourly Gas Usage (ft3) = 8,850 electrical us (Kwh) = 1,300 kw x 350 x 24 = 10,920,000 kwh (annual) expected catalyst life = N.A.

Equipment Supplier Name SMITH ENVIRONMENTAL CORPORATION B01-97-127

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	• •		V EN Dore
Facsimile	Transmission		
Date:	August 4, 1997	Reference Number.	Budgetary Scenar
•			
			i
Number of pag	ges (including cover sheet):	7 Copy to:	•
Subject:	Phenolic Urethane Core I	Budgetary Analysis	
Thank you the budgets any addition to hearing a	for your interest In and it' ary numbers that you inquired nal information or cutsheets th about any progress that may tr	s products. I am pleased t about. Please do not hesit at I can supply for your rep ranspire from the data.	o provide you with ate to call if there is port. I look forward
Thank you the budgets any additio to hearing a Sincerely	for your interest In and it' ary numbers that you inquired nal information or cutsheets th about any progress that may tr /1/l	s products. I am pleased t about. Please do not hesit at I can supply for your rep ranspire from the data.	o provide you with ate to call if there is port. I look forward
Thank you the budgets any additio to hearing a Singerely	for your interest In and it' ary numbers that you inquired nal information or cutsheets th about any progress that may ti /1/I	s products. I am pleased t about. Please do not hesit at I can supply for your rep ranspire from the data.	o provide you with ate to call if there is port. I look forward
Thank you the budgets any additio to hearing a Singerely	for your interest In and it' ary numbers that you inquired nal information or cutsheets th about any progress that may tr /1/I	s products. I am pleased t about. Please do not hesit at I can supply for your rep ranspire from the data.	o provide you with ate to call if there is bort. I look forward
Thank you the budgets any additio to hearing a Sincerely	for your interest In and it' ary numbers that you inquired nal information or cutsheets th about any progress that may tr /1/l	s products. I am pleased t about. Please do not hesit at I can supply for your rep ranspire from the data.	o provide you with ate to call it there is bort. I look forward

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<u>Scenario 1</u>				
Phenolic Urethane Cold Box (PUCB) Core Production				

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Ventilation rate= 2000 scfm Daily operating schedule= 8 hours /day and 7 Average VOC/OC emissions rate= 1.6 lbs/nc Max. hourly VOC/OC emissions rate= 1.6 lbs Annual VOC/OC emissions= 2.3 tons/year	Temperature our whour (inlet to controls approx 40 ppmv)	= ambient
OC/VOC composition ranges=Petroleum Dist -poten mesity Petroleum Dis -poten bipher Triethylamine Guaranteed Design control removal requir reference test methods (40 CFR, Part 60))	tillates CAS# 68477-31-6/64742-95-6 (approx tial constituents (xylene, cumene, trimethylbe ylene); stillates CAS# 647-742-94-5 (approx. 43% by v ntial constituents (napthalene, trimethylbenzen enyl) or Dimethylethylamine (approx. 14 % by weig rement 90% removal by weight (using US)	<.43% by weight) nzene and weight) e, xylene, ht) EPA
Control equipment type #1:	• • •	· ·
Recuperative thermal oxidizer (w/ 509 Equipment Costs: OxIdizer Supporting Controls Fan ductwork (\$/ft) Total	$\frac{\% \text{ recovery}}{= 132,000} = 15,000$ $= 3,000$ $= 150,000$	
Operating Info. hourly gas usage (ft3) electrical use (Kwh)	) = 1.35 mmbtu = 5.34	· · ·
Control equipment type #2!		
<u>Recuperative Catalytic oxidizer</u> Equipment Costs: Oxidizer Supporting Controls Fan ductwork (\$/ft) Total		
Operating info. hourly gas usage (ft3) electrical use (Kwh) expected catalyst life	) = = =	
Control Equipment #3		:
Carbon adsorotion with off-site dispose Equipment costs: carbon adsorber Supporting Controls Fan ductwork (\$/ft) Total	<u>sal:</u> = = = = =	
Operating info. hourly gas usage (ft3) electrical use (Kwh) annual carbon usage (lbs)	) =	

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Scenario 7	
Phenolic Urethang Cold Box (PUCB) Core Stormer	•
Ventilation rate= 37,000 scfm Temperature Daily operating schedule= 19.5 hours /day and 7 days/week Average VOC/OC emissions rate= 1.4 lbs/hour	ambient
Annual VOC/OC emissions rate= 2.4 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 5.0 tons/year	
OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-8/64742-85-6 (appro -potential constituents (xylene, cumene, trimethylbe mesitylene); Petroleum Distillates CAS# 647-742-94-5 (approx, 50% by -potential constituents (napthalene, trimethylbenzen biphenvl)	x. 50% by weight) nzene and weight) e, xylene.
Guaranteed Design control removal requirement 90% removal by weight (using US) reference test methods (40 CFR, Part 60))	EPA
Control equipment type #1:	• •
	: :
Equipment Costs: adsorber/Oxidizer = 752,716	
Supporting Controls = $18,982$	1
Fan = 10,000	1
ductwork (S/ft) =	
Total = 781,698	i
Occurring info how $(1,2,2,2,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,3,$	:
electrical use (Kwb) = 68	÷
annual adsorbent cost (\$) $= 0.00$	; (self-regenerative
annual maintenance (man-hours)= 60	
	1
Control equipment type #2: Thermal	i .
Regenerative Satavia oxidizer (w/min. 98% heat recovery)	;
Equipment Costs: Oxidizer = 560,000	1
Supporting Controls = 18,982	1
Fan = 12,800	:
	:
10(a) = 591,782	;
Operating info hourly gas usage $(f3) = 3.67$ mmbtu	:
electrical use (Kwh) = 121	1
expected satesyst life = 7 yrs	
/media	
Control Egylpment #3 Biofiltration:	
Equipment Costs Biofilter/structure =	
Installation Costs (Lunkey)	
Supporting Controls =	1
raii	
Total =	
Operating info. electrical use (Kwh)	
annual media costs (\$) =	
annual maintenance (man-hrs) =	:
estimated size (length x width) =	1
	: •

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### Scenario 3 Phenolic Urethane No Bake (PUNB) Core Production

Ventilation rate= 30,500 scfm Temperature= ambient Daily operating schedule= 19.5 hours /day and 7 days/week Average VOC/OC emissions rate= 1.7 lbs/hour Max. hourly VOC/OC emissions rate= 1.7 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 2.5 tons/year

OCNOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-84-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)

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Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

<u>Control_equipment type #1:</u> Concentrator
Equipment Costs: adsorber/Oxidizer = 727,325 Supporting Controls = 18,982 Fan = 9,000 ductwork (\$/ft) = Total = 755,307
Operating info. hourly gas usage (ft3) = 1.4 mmbcu electrical use (Kwh) = 57 annual adsorbent cost (\$) = 0.00 annual maintenance (man-hours)= 60
Control equipment type #2:
Regenerative Quadratic oxidizer (w/min. 98% heat recovery)         Equipment Costs: Oxidizer       = 542,000         Supporting Controls       = 18,982         Fan       = 10,800         ductwork (\$/ft)       =         Total       = 571,782
Operating info. hourly gas usage (fi3) = 2.92 mmbtu electrical use (Kwh) = 99 expected catalyst life = 7 yrs
Control Equipment #3
Biofiltration: Equipment Costs: Biofilter/supports = installation Costs (turnkey) = Supporting Controls = Fan = ductwork (\$/ft) = Total =
Operating Info. electrical use (Kwh) = annual media costs (\$) = annual maintenance (man-hrs) = estimated size (length x width) =

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	Scenario 4
`	Phenolic Urethane No Bake (PUNB) Core Storage
,	Ventilation rates 36 000 scim
	Daily operating schedule= 19.5 hours /day and 7 days/week
	Average VOC/OC emissions rate= 1.4 lbs/hour
	Max. hourly VOC/OC emissions rate= 2.3 lbs/hour (control inlet approx. 10 ppmv)
<b>}</b>	
e mare a	OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-8/64742-95-8 (approx, 50% by weight)
	-potential constituents (xylene, cumene and timethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx, 50% by wolden)
•	-potential constituents (naphalene, trimethylbenzene, sylene)
	Our sector and the sector prover postime and post sector by unlable (unlaw 11000)
	reference test methods (40 CFR, Part 60))
63	Control equipment type #1:
	Concentrator
	Equipment Costs: adsorber/Oxidizer = 738,372
	Fan = 9.800
14日本 14日本 14日本 14日本 14日本 14日本 14日本 14日本	ductwork (\$/ft) =
<b>8</b> .75.5	Total = 767, 154
	Operating info. hourly gas usage (fl3) = 1.8 mmbtu
	electrical use (Kwh) = $64$
	annual maintenance (man-hours) = $60$
	Control equipment type #2: thermal
	Equipment Costs: Oxidizer = 551,000
	Supporting Controls = 18,982
670	Fan = 11,500
	Total = 581,482
1973 :	
101	Operating into nouny gas usage (its) = $3.63 \text{ mmbtu}$ electrical use (Kwh) = 118
	expected satelyst life = 7 yrs
	Control Equipment #3
	Biofiltration:
	Equipment Costs Biofilter/supports =
N	Supporting Controls =
	Fan =
99a, * **	ductwork (S/R) =
	Operating Info. electrical use (Kwh) =
с	annual media costs (5) =
artis	estimated size (length x width) =
1	
final (	
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### Scenario 5 Phenolic Urethane No Bake (PUNB) Mold Making

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Ventilation rate= 85,000 scfm Temperature= ambient Daily operating schedule= 16.0 hours /day and 7 days/week Average VOC/OC emissions rate= 4.8 lbs/hour Max. hourly VOC/OC emissions rate= 4.8 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 14.1 tons/year OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx, 50% by weight) -potential constituents (napitalene, trimethylbenzene, xylone) Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60)) Control equipment type #1: Concentrator Equipmentl Costs: adsorber/Oxidizer = 1,300,000 18,982 Supporting Controls = 32,000 = Fan ductwork (\$/ft) Total = 1,350,982 Operating info, hourly gas usage (ft3) ≈ 4.28 mmbtu electrical use (Kwh) 161 Ξ annual adsorbent cost (\$) = 0.00 annual maintenance (man-hours)= 80 Control equipment type #2: , thermal Regenerative Catabric bridizer (w/min, 98% heat recovery) = 1,200,000Equipment Costs: Oxidizer 18,982 Supporting Controls = 41,700 = Fan ductwork (\$/ft) Total = 1,260,682Operating info, hourly gas usage (ft3) = 8,48 mmbtu = 275 electrical use (Kwh) expected sales tife = 7 yrs /media Control Equipment #3 Blofiltration: Equipment Costs: Biofilter/supports = Installation Costs (tumkey) = Supporting Controls = Fan = ductwork (\$/ft) Total = Operating info. electrical use (Kwh) = Ξ annual media costs (\$) = annual maintenance (man-hrs) estimated size (length x width) =

### Scenario 6

### Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 165.500 scfm Temperature= amble Daily operating schedule= 24.0 hours /day and 350 days/year Average VOC/OC emissions rate= 6.0 lbs/hour Max. hourly VOC/OC emissions rate= 10.0 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 25.1 tons/year OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-85-8 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene): Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene) Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR. Part 60)) Control equipment type #1: Concentrator Equipment Costs: adsorber/OxIdizer = 2,400,000 32,000 Supporting Controls Ξ ....56,000 Fan 488,000 Hourly Fuel = 8.67 mmbtu Hourly Electric 317 kw

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 Inc.			) ) Pax		
Facsimile T	ransmission	•			
Date:	March 11, 1998	Reference	e Number:	•••	
То:	Dave Newsad	From:			
Company:	Residuals Managen Tech., Inc.	ient Departme	ent:		
Phone:	614-793-0026	Phone:			
Fax:	614-793-0151	Fax:			
Number of pages	(Including cover sheet):	4 Copy to:	•••••		
Subject:	Budgetary analysis	for additional scenari	o's		
Dear Mr. Nev	vsad,				
The attached forwarded to analysis of th	are the budgetary quo Karl. As with all abate e process stream bein	ites for the additional ment equipment, all o g treated.	scenarios that levices are con	you had tingent of final	
lf you have a	ny questions regarding	the control devices	or numbers pre	sented, please	
give me a ca Best regards,				: . ·. ·	
$\sum_{i=1}^{n}  \psi_{i}  \leq \frac{1}{2}  \psi_{i}  \leq \frac{1}{2}$		· · ·	· · .:		
Marketing Co	ordinator	•••			
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		Scenario 4		
- 1940	Phenolic Urethane	Cold Box (PUCB)	Core Storage	
	Ventilation rate=58 000 soft		Tam name to make an bian to	
	Daily operating schedule=24.0 hours/da	v and 365 days/year	x chiperature-autorette	•
	Max. hourly VOC/OC emissions rate-3.4	Ibs/hour (control inle	tapprox. 5.0 ppmv)	
	Annual VOC/OC emissions=9.9 tons/ye	18		
		•••		
	OC/VOC composition ranges=Petroleum Di	stillates CAS#68477-31-6/	64742-95-6 (approx. 50% by weight)	
	-potential core Robologum Dia	stuents (xylene, cumene,	trianelly benzenc and mosity lene);	
	-potential cons	dituents (naphalene, trim	chylenzene, sylene, hipherryl)	
		and the family served		
2°)	Guaranteed Design control removal req	uirement 90% remova	by weight (using USEPA	
	reference test methods (40 CFR. Part 60)	)		
3-23				
F33	Control Equipment Type #1:		• · · · · · · ·	
	Concentrator/OUD12CE	1100 00		
livé.	Equipment Costs: Adsorber/Ox	$\frac{1012er}{1012er} = \frac{1}{1010}$		
· · · ·	Supporting Co	$Fan = \sqrt{1/1}$	·	
	Ductwork	(\$/ft) =		and the second second
- SAC		Total = 1.150.000		
1010				
	Operating Info. Hourly Gas Usag	e (1) = 0.4 mmBT	U/HR	•
	electrical us (	KWA) = 36 kuh		
50 a -	annual adsorbent c	ost (\$) = 0.00		£
	annual maintenance (man-f	iours) = 70 Hes	• • • •	
r. 54			• • • • • • • • • • • • • • • • • • • •	
	Control Egyinment Tone #2	ς.	· · · · ·	•
<u>ن</u>	Regenerative Thermal Oxidizer	winin 98% DESTRIC	TIDL EFFIC.	•
	Equipment Costs: Ox	idizer = 1.145.00		· •
	Supporting Co	ntrols = INICL.		
		.Fan = , MCL		
	Ductwork	(5/ft) =		
		Total = 1, 145,00	0	
J.			an an taon an t	i sa kata
	Operating Info. Hourly Gas Usag	e ( 7.3 mm	BTU/HR	•
	electrical us (	Kwh) = 127 KK/h		
<u> </u>			•	
		· ,	•	
	Equipment Supplier Name			•
di <b>se s</b> e s	- 7 K. us			
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# Scenario 5 Phenolic Urethane No Bake (PUNB) Mold Production Ventilation rate=127,500 scfm Temperature=ambient Daily operating schedule=16.0 hours/day and 350 days/year Max. hourly VOC/OC emissions rate-7.3 lbs/hour (control thet approx 5.0 ppmv) Annual VOC/OC emissions=20.3 tons/year OC/VOC composition ranges=Petroleam Distillates CAS#68477-31-6/64742-95-6 (approx 50% by weight) -potential constituents (sylene, cumene and trimethylbenzene); Petroleum Distillates CAS#6647742-94-5 (approx 50% by weight) -potential constituents (naphalene, trimethylbenzene and sylene) Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60)) Control Equipment Type #1; Concentrator

Concentration		<b>6</b>	
Equipment Costs	: Adsorber/Oxidizer	= 2,400,000	2
- <b>A</b>	Supporting Controls	= ILCL	
	Fan	= INICL.	•
	Ductwork (\$/ft)	R	
•	Total	= 2,400,000	
Operating Info. H ann annual main	Iourly Gas Usage (23) electrical us (Kwh) uual adsorbent cost (\$) menance (man-hours)	= 0,9 mm8 = 122 kuh = 0.00 = 140,+25	тЦия_

·	÷	Control	Equipment Type #2:	

۰.	Regenerative Thermal	Dridizer (w/min. 98% heat recovery)
• .	Equipment Costs:	Oxidizer = 2,250,000
	Supp	orting Controls = 12/62.
		Fan = INICL.
• •	I	Ductwork (\$/ft) =
		Total = 2 250 DOO

Operating Info. Hourly Gas Usage (KS) = 9.5 mm BTU/HR electrical us (Kwh) = 280 Kuh coperational catalyst life = NIA

### Equipment Supplier Name

COLVP.MOD-02211104/22211048.DOC 02/16/81

### <u>Scenario 5</u> <u>Phenolic Urethane No Bake</u> (PUNB) Mold Storage

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Ventilation rate=234,500 scfm	Terminemannient
	- carparater c - manier (c
Daily operating schedule-24.0 hours/day and 350 days/year	
Max hourly VOC/OC emissions rate-13.8 lbs/hour (control inle	tapprox. 5.0 ppmy)
Annual VOC /OC emissions=38.6 tons/year	I I I I I I I I I I I I I I I I I I I
OC/VOC composition ranges Petroleum Distillates CAS#68477-31-6/6	54742-95-6 (anning 50% by welchil)
-motontial constitution (milene automain	and Anima maharily and a star
The last constituents (xy tere, cutiletter	and munethyldenzena);
Petroleum Distuines CASP647-742-94-5	(approx. 50% by weight)
-potential constituents (naphalene, trime	thylbenzene and xylene)
an balan sa sana sa karang karang karang sa karang Karang sa karang karang sa karan	
Currenteed Design control removal requirement 90% your gual	La model has foreing TICT A
Chandleed Design Conder Temeral Tequicentent 50/8 Telliov2	by weight losing USEPA
reference test methods (40 CFR, Part 60))	
Control Equipment Trans #1:	
Control Equipment Type #1.	
Concentrator	
Equipment Costs: Adsorber/Oxidizer = 3,500 00	0
Contraction Contraction Contraction	-
supporting controls = 1/22.	
$Fan = M/L_{L_{n}}$	
Ductorer (S/ff) =	• • •
	· · ·
Total = /MCL	
	1.0.
Operating into, nourly Gas Usage (no) =1.6 mm 1371	U/HR
electrical us (Kwh) = 225 kub	
annual adaptions cost (\$) = $0.00$	
annual maintenance (man-hours) = 250 H25.	•
	,
Control Fagiament Type #2:	
Regenerative Thermal Chridinas (when in 000/ hash	
Regenerative Inernal Oxforzer (W/min. 50% near recov	
Equipment Costs: Orddizer = 3, 450,000	
Supporting Controls = 11/CL.	
For - ula	
ran = /A/CL.	
Ductwork (\$/ft) =	
Total = 3 dec as	
$x \partial a = a + T D , O C$	
Operating Info. Hourly Gas Usage 1991 = 17.5 mm B	TULLE
electrical us (KWR) = 5/6 EULA	
expected catalyst life NA	
A man and a second s	
Equipment Supplier Name	1
	· · · · · · · · · · · · · · · ·
	FIMPCOLUTIO-02211/04/22211048.00C 02/16/35

Vendor C

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### FACSIMILE COVERSHEET

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COMPANY:					
FAX NO:			<b>.</b>		
FROM:					
RE:	_uuc/uc	EQUIPMENT	Cast	ESTIMATE	REQUE
VOTE:					
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Scenario 1
Phenolic Urethane Cold Box (PUCB) Core Production

Temperature= ambient Ventilation rate= 2000 scfm Delly operating schedule= 8 hours /day and 7 days/week Average VOC/OC emissions rate= 1.6 lbs/hour Max, hourly VOC/OC emissions rate= 1.6 lbs/hour (inlet to controls approx 40 ppmv) Annual VOC/OC emissions= 2.3 tons/year

OC/VOC composition ranges=Petroleum Distillates CAS# 88477-31-8/64742-95-6 (approx.43% by weight) -potential constituents (xylene, cumene, trimethylbenzene and mesitylene);

Petroleum Distillates CAS# 647-742-94-5 (approx. 43% by weight) -potential constituents (napthalene, trimethylbenzene, xylene, biphenyl)

Triethylamine or Dimethylethylamine (approx. 14 % by weight) Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

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Control equipment typo #1:

Recuperative thermal oxidizer (w/ 60% recovery) -Equipment Costs: Oxidizer 120,000 Supporting Controls Fan ductwork (\$/ft) Total = 1,00,000 Operating Info. hourly gas usage (ft3) = electrical use (Kwh)

Control equipment type #2:



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		Scenar	l rio Z			
E	Phenolic Urethan	e Cold B	ox (PI	JCB) Core	Storage	
Ventiletion roles 37 (					Temperahi	re≍ amblen
Daily operating sched	dule≕ 19.5 hours /da	y and 7 day	ys/weel	ĸ	( disperate	ic. Elleich
Average VOC/OC en	nissions rate= 1.4 lb:	s/hour			10	
Max, hourly VOC/OC Annual VOC/OCamis	sions= 5.0 tons/vea	ips/nour (c r		niet approx.	10 ppmv)	
OCNOC composition	1 ranges=Petroleum   -nc	Distillates ( tential con	CAS# 6 stitueol	18477-31-6/8 Is (xylene i ci	14742-95-6 (appl Imene trimathylt	ox. 50% by
	me	sitylene);		5 (x)icito, ec	anone, annourga	
	Petroleum	Distillates (	CAS# 6	347-742-94-5	5 (approx. 50% b	y weight)
	-po bir	tential cons phenvl)	stituent	s (napinalen	ie, metnyibanzo	ene, xylene
Guaranteed Design reference test meth	control removal rec ods (40 CFR, Part 6	uirement.	90% r	emoval by v	weight (using U	SEPA
		-77				
Concentrator	<u>type #1:</u>					
Equipment Co	osts: adsorber/Oxidi	zer = 🔨				
	Supporting Contro	$ s = \langle +$	650,0	j0 ≥		
	Fan	. = )				
	ductwork (S/ft)	an <u></u>				
					8 7 . 1 8 10 m	
Operating Info	>, hourly gas usage (f	t3) \	*	190,000	signe	
	annual adsorbent c	; :ost (\$)	-	18000		
	annual maintenanc	e (man-hou	urs)=			
Control equipment t	voe #2:					
Reconcrative	Catalytic oxidizer (w/	min. 98% i	heat rec	overy)		
Equipment Co	osts: Oxidizer	=				
	Supporting Control	s =				
	ductwork (\$/ft)	×	_			
	To	tal =				
Operating info	, hourly gas usage (f	(3) =				
	electrical use (Kwh)	=				
	expected catalyst lif	2 =				
control Equipment	1 <u>3</u> .					
Biofiltration:	rta Blasitariata		_			
Equipment Co	Installation Costs (h	umkevi	a . 6			
	Supporting Control	S	=			
	Fan		*			
		Total				
Operating Info	, electrical use (Kwh)		=			
Operating Info ar	, electrical use (Kwh) nnual media costs (\$)		M II			

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		Scenario	<b>≱</b>	
P	henolic Urethane N	o Bake (P	UNB) Core Pr	oduction
Ventilation rate= 30,8	500 scfm &			Témperature= ambient
Dally operating sche	dule= 19.5 hours /day s	ind 7 days/W	leek	
Average VOC/OC er	nissions rate= 1.7 lbs/r Cemissions rate= 1.7 lb	iour =/hour (cont	ml inlat sporov	10 ppmy)
	slons= 2,5 tons/year		to metappiox.	
OC/VOC compositio	n ranges=Petroleum Di -pota Petroleum Di -pote	stillates CAS ntial constitu atillates CAS ntial constitu	# 68477-31-6/6- lents (xylene, cu \$# 647-742-94-5 lents (napthaleni	4742-95-6 (approx, 50% by we mene and trimethylbenzene); (approx, 50% by weight) e, trimethylbenzene, xylene)
Guaranteed Design	control removal requ	irement 90	% removal by v	velght (using USEPA
reference test meth	ods (40 CFR, Part 60))	1	,	
Control equipment	type #1:			
Concentrator				
Equipment C	osta: adsorber/Oxidizer Supporting, Controls	= 2 16	50 000	
	Fan	= 5	- ,	
	ductwork (\$/ft)			
	Tota			
Operating Inf	o, hourly gas usage (ft3	) :	م <i>ن</i> ح رد ه- ز	57 41.12
	electrical use (Kwh)	:	= /77	
	annual accordent cos annual maintenance	ar (S) (man-hours)	= <b>\$</b> 8,200	
Control equinment (	Vne #2.			
Regenerative	Catalytic oxidizer (w/m	in. 98% haa	trecovery)	
Equipment Co	osts: Oxidizer	m		
	Supporting Controls	Л		
	ductwork (\$/ft)	=		
	Tota	=		
Operating info	), hourly gas usage (π3)	=		
_	electrical use (Kwh)	=		
	expected catalyst me			
Control Equipment	3			
Biolilization: Equipment Co	ets: Riofilter/supports	=		
Equipment Of	Installation Costs (tun	ıkey) ⊐		
	Supporting Controls	=		
	han ductwork (\$/#)	2		
_		Total =	*	
Operating info	electrical use (Kwh)	2		
9 17	nnual meute costs (\$) Inual maintenance (mar	= n-hrsì =		
61		· ······		

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	- 7
:	Scenario d'
in i	Phenolic Urethane No Bake (PUNB) Core Storage
<b>1</b> 111	
	Ventilation rate= 38,000 scfm Temperature= ambient
<b>新</b> 代43	Daily operating schedule= 19.5 hours /day and 7 days/week
	Max, hourly VOC/OC emissions rate= 2.3 lbs/hour (control inlet approx. 10 ppmv)
à i t	Annual VOC/OCemissiona= 4.8 tons/year
÷	OCN/OC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx 50% by weight)
	-potential constituents (xylene, currene and trimethylbenzene);
G 1	Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
$\Box$	-potential constituents (napthalene, trimethylbenzene, xylene)
	Guaranteed Design control removal requirement 90% removal by weight (using USEPA
81°**	reference test methods (40 CFR, Part 60))
	Control aquinment type #1:
u (v B	Concentrator
	Equipmenti Costs: adsorber/Oxidizer = ) # 650,000
A A A A A A A A A A A A A A A A A A A	Fan Supporting Controls = C
8	ductwork (\$/ft) =
	Total ≕
Barra d	Operating info, hourly gas usage (ft3) = 500,000 BTU/AR.
	electrical use (Kwh) = 144
E.	annual adsorbent cost (\$) a 98, 000
	annual maintenance (man-nours)=
	Control equipment type #2:
·	Regenerative Catalytic oxidizer (w/min_98% heat recovery) PS 0.57 BOYE C
	Supporting Controls =
	Fan =
≹≪ †	ductwork (S/fi) =
** )	Operating info. hourly gas usage (ft3) =
	electrical Use (KWh) = expected cetalVst life =
6.2.,	
₹1£	Control Equipment #3
1	Equipment Costs Biofilter/supports =
£≻^1	Installation Costs (rumkey) =
	Supporting Controls =
200	ductwork (\$/ft) =
म ह	
e E	ennual media costs (\$) =
ί.	annual maintenance (man-hrs)
	estimated size (length x width) =
N 1	

### 3, Scenario 5 Phenolic Urethane No Bake (PUNB) Mold Making

Ventilation rate= 85,000 scfm Temperature= ambient Daily operating schedule= 16.0 hours /day and 7 days/week Average VOC/OC emissions rate= 4.8 lbs/hour

Max. hourly VQC/OC emissions rate= 4,8 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 14.1 tons/year

OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-5/64742-95-5 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Control equipment type #1: Concentrator Equipmenti Costa: adsorber/Oxidizer = Supporting Controls =  $\begin{cases} 1, 300, 000 \\ 0, 000 \\$ Fan ductwork (\$/ft) Total = 1,200,000 Operating info, hourly gas usage (ft3) electrical use (Kwh) 340 annual adsorbent cost (\$) = 40,000 annual maintenance (man-hours)= Control equipment type #2: Regenerative CataMtlc oxidizer (w/min. 98% heat recovery) Equipment Costs: Oxidizer Supporting Controls = Fan ductwork (\$/ft) = Total = Operating info, hourly gas usage (fl3) = electrical use (Kwh) = expected catalyst life = Control Equipment #3 **Blofiltration:** Equipment Costs: Biofilter/supports z Installation Costs (turkey) Supporting Controls = Fan = ductwork (\$/ft) Total # Operating Info, electrical use (Kwh) annual media costs (\$) annual maintenance (man-hrs) estimated size (length x width) =

12 1.35.73





Thank you for the opportunity to work with you on the VOC/OC equipment cost estimate for "PUCB" Core Storage. Based on the data provided, we have developed costs for the biofilter. These are estimated costs and include installation. The cost for electrical usage is minimal. The cost would include pump and blower costs which due to the low pressure drop (10" max), requirements are kept low. The annual maintenance manhours average 50 MH/yr. The following are the installed costs for each of the scenarios:

Scenario 2	37,000 ACFM	\$1.5 x 10 <sup>-6</sup>
Scenario 3	30,500 ACFM	\$1.19 x 10 <sup>-6</sup>
Scenario 4	36,000 ACFM	\$1.47 x 10 <sup>-6</sup>
Scenario 5	85,000 ACFM	\$2.35 x 10 <sup>-6</sup>
Scenario 6	165,000 ACFM	\$4.97 x 10 <sup>-6</sup>

Should you have any additional questions, please feel free to call.

Very truly yours,

GM:ew

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Lines?

August 4, 1997

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### fax TRANSMITTAL

Date: July 28, 1997

Number of Pages: 06

Please find attached the quotations you requested for your BACT analysis. I am also sending you some literature describing biofiltration technology.

If you have any question, please feel free to contact me at (903) 758-3395.

Sincerely,

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### Scenario Z Phenolic Urethane Cold Box (PUCB) Core Storage

Ventilation rate= 37,000 scfm Daily operating schedule= 19.5 hours /day and 7 days/week Average VOC/OC emissions rate= 1.4 lbs/hour Max. hourly VOC/OC emissions rate= 2.4 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 5.0 tons/year

39

OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene, trimethylbenzene and mesitylene);

Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene, biphenyl)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Contro	<u>Concentrator</u>	/pe #1:				
	Equipment Co:	sts: adsorber/( Supporting C	Oxidizer	=		
		Fan	0111015	2		
		ductwork (S/ft)	)	<b>=</b> .	• •	
			' Total	ш		
	Operating info.	hourly gas us	age (ft3)		=	
		electrical use	(KWN)	(\$)	-	
		annual mainte	enance (n	(a) nan-hou	rs)=	
Contro	l equipment ty	pe #2:				
	Regenerative (	atalytic oxidiz	er (w/min	. 98% 6	eat recover	נע
	Equipment Cos	sts: Oxidizer		<b>z</b> .		
		Supporting C	ontrois	-		
		ran duchuck (S/A)	<b>`</b>	_		
		DUCIMON (ANI)	/ Total	= .		
	Operating Info.	hourly gas us:	age (ft3)	=		
		electrical use	(Kwh)	Ħ		
		expected cata	lyst life	2		
Contro	Equipment #:	3.				
	Biofiltration:			•	FINGLO	00 00
	Equipment Cos	sts Biofilter/str	ucture		= 1, 1 4,0	
		Installation CC	iontrole	Keyj	- 120	
		Supporting C	OUTLIOIS		- INC-	
		duchvork (\$/ff)	۱		= NIA	
		DUCLAPOIN (WIL)	,	Total	= 1.496.00	20 20
	Operating Info.	electrical use	(Kwh)	10101	= 343	A0
	an	nual media co	sts (S)		\$47,500	
	ani	ual maintenar	nce (man	-hrs)	= 100	,

estimated size (length x width) = 60 × 114

### 2 Scenario 3 Phenolic Urethane No Bake (PUNB) Core Production

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Ventilation rate= 30,500 scfm	Temperature= ambient
Daily operating schedule= 19.5 hours /day ar	nd 7 days/week
Average VOC/OC emissions rate= 1.7 lbs/hd	pur
Max. hourly VOC/OC emissions rate= 1.7 lbs	/hour (control inlet approx. 10 ppmv)
Annual VOC/OCemissions= 2.5 tons/year	
OC/VOC composition ranges=Petroleum Dist -poten Petroleum Dis -poten	tillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) tial constituents (xylene, cumene and trimethylbenzene); tillates CAS# 647-742-94-5 (approx. 50% by weight) tial constituents (napthalene, trimethylbenzene, xylene)
Guaranteed Design control removal requi reference test methods (40 CFR, Part 60))	rement 90% removal by weight (using USEPA
<u>Control_eaulament type #1:</u>	
Concentrator	
Equipment Costs: adsorber/Oxidizer	=
Supporting Controls	E
Fan	8 ·
ductwork (\$/ft)	=
Total	=
Operating info, hourly gas usage (ft3)	z
electrical use (Kwh)	
annual adsorbent cost	t (5) =
annual maintenance (	man-hours)=
Control equipment type #2.	n 08% haat raanvand
Regeneraliye Caldivil Oxidizer (With	IL 3076 NBALLECOVERY
Equipmant Costs, Oxidizer	
	• •
Fd() ductucele (\$/#)	-
Total	
Operating info, hourly gas usage (fl3)	<b>2</b>
electrical use (Kwh)	=
expected catalyst life	=
Control Equipment #3	
Biofiltration:	K
Equipment Costs: Biofilter/supports	$= \frac{1}{3}, \frac{3}{10}, \frac{3}{10}, \frac{3}{10}$
Installation Costs (turn	(key) = mc
Supporting Controls	= /NC-
Fan	
ductwork (\$/ft)	= N/A
	Total = I / 370,000
Operating info. electrical use (Kwh)	= 26.5
annual media costs (5)	=\$39,1500
annual maintenance (mar	n-hrs) ≈ 100 ,
estimated size (length	$x$ width) = $60' \times 94'$

.

### Scenario 4 Phenolic Urethane No Bake (PUNB) Core Storage

Temperature= ambient

Ventilation rate= 36,000 scfm Daily operating schedule= 19.5 hours /day and 7 days/week Average VOC/OC emissions rate= 1.4 lbs/hour Max. hourly VOC/OC emissions rate= 2.3 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 4.8 tons/year

OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumone and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)

e.

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Control equipment type #1;

Concentrator

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Equipmentl Co	sts: adsorber/O	xidizer	Ξ	
	Supporting Cor	ntrols	╘	
	Fan		=	
	ductwork (\$/ft)		=_	
		Total	1	
Operating info	hourly day usad	(A3)		

Operating info, hourly gas usage (ft3) electrical use (Kwh) × annual adsorbent cost (\$) = annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min\_98% heat recovery)

Equipment Costs: Oxidizer	n
Supporting Control	IS =
Fan	<b>=</b> .
ductwork (\$/ft)	=
То	otal =

Operating info. hourly gas usage (ft3) =

electrical use (Kwh) =

expected catalyst life =

Control Equipment #3

Disflitzations

DIDITITI AUDIT		*
Equipment Costs E	Biofilter/supports	= 1,933,000
Ins	(allation Costs (turnkey)	= INC-
Sur	oporting Controls	= I all
Far		- INC
( C)		- w/e
auc	twork (\$/IT)	= N/A
	Total	=#1,455,000=
Operating Info. ele	ctrical use (Kwh)	= 32.8
annua	il media costs (S)	= 46,200
annual	maintenance (man-hrs)	= 100
est	imated size (length x width)	) = 60'x111'

### Scenario 5 Phenolic Urethane No Bake (PUNB) Mold Making

Ventilation rate= 85,000 scfm Temperature= ambient Daily operating schedule= 16.0 hours /day and 7 days/week Average VOC/OC emissions rate= 4.8 lbs/hour Max. hourly VOC/OC emissions rate= 4.8 lbs/hour (control inlet epprox. 10 ppmv) Annual VOC/OCemissions= 14.1 tons/year OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, curnene and trimethylbenzene); Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene) Guaranteed Design control removal regulrement 30% removal by weight (using USEPA reference test methods (40 CFR, Part 60)) Control equipment type #1: Concentrator Equipmentl Costs: adsorber/Oxidizer = Supporting Controls Fan ductwork (\$/ft) Total = Operating info, hourly gas usage (ft3) = electrical use (Kwh) z annual adsorbent cost (\$) = annual maintenance (man-hours)= Control equipment type #2: Regenerative Catalytic oxidizer (w/min. 98% heat recovery) Equipment Costs: Oxidizer z Supporting Controls = Fan = ductwork (\$/ft) Total = Operating info. hourly gas usage (ft3) = electrical use (Kwh) expected catalyst life = Control Equipment #3 **Biofiltration:** ="2,946,000 Equipment Costs: Biofilter/supports Installation Costs (turnkey) TAC = ZNC Supporting Controls = Tur. Fan = N/H ductwork (\$/ft) Total = 2,946,000 768 Operating info, electrical use (Kwh) =1107,100 20 annual media costs (\$) annual maintenance (man-hra) = 200 estimated size (length x width) = /30' × 13/

	- 3					
	Scenario 6					
	Phenolic Urethane No Bake (PUNB) Mold Storage					
	Ventilation rate= 165,500 scfm Daily operating schedule= 24,0 hours /day and 350 days/year Average VOC/OC emissions rate= 6,0 lbs/hour Max, hourly VOC/OC emissions rate= 10,0 lbs/hour (control inlet approx, 10 ppmv) Annual VOC/OCemissions= 25,1 tons/year					
	OCNOC composition ranges=Patroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbanzene); Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylene)					
E.	Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))					
	Control equipment type #1: Concentrator					
	Equipment Costs: adsorber/Oxidizer = )					
	ductwork (\$/ft) = Total =					
	Operating Info, hourly gas usage (ft3) = よ, Yoo, coo electrical use (Kwh) = 640 annual adsorbent cost (\$) = ようこのに annual maintenance (man-hours)=					
	Control equipment type #2: Regenerative Catalytic oxidizer (w/min. 98% heat recovery)					
	Supporting Controls = Fan = ductwork (\$/tt) =					
	Total =					
	electrical use (Kwh) = expected catalyst life =					
	<u>Conrol Foulpment #3</u> <u>Biofiltration:</u>					
	Equipment Costs: Biofilter/supports = Installation Costs (turnkey) = Supporting Controls =					
	Fan = ductwork (\$/ft) =					
	Operating info. electrical use (Kwh) ← annual media costs (\$) ≈ annual maintenance (man-hrs) ≈ estimated size (length x width) =					

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		V J'D A NEWTERTON	
		A I ANSIMISSIUM	
То:	:	DATE: AUGUST 5, 1997	
COMPANY:			
PHONE:		FAX: (614) 793-0151	
From:	•	NUMBER OF PAGES, INCLUDING THIS PAGE: 7	
SUBJECT:	BUDGET QUOTES	PROPOSAL NO. 97-199	

As per your request to ched are the bid forms with pricing and utility information. You will note that I have not been able to provide information on the regenerative catalytic or biofiltration systems. Please call if you require additional information.

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	Phenolic Urethane Cal	Box (PUCB) C	ore Production
Ventilation rate= 2 Daily operating so	2000 sofm hedule= 8 hours /day and 7 (	lays/week	Temperature= ambient
Average VOC/OC Max. hourly VOC/ Annual VOC/OC (	OC emissions rate= 1.6 lbs/hol OC emissions rate= 1.6 lbs/h emissions= 2.3 tons/year	r our (inlet to control	s approx 40 ppmV)
OG/VOC compos	ition ranges≃Petroleum Distii -potenti mesityle	ates CAS# 68477- al constituents (xyle ne):	31-6/64742-95-6 (approx.43% by welg me, cumene, trimethylbenzene and
	Petroleum Dist -potent biphon	lates CAS# 847-74 al constituents (nap	2-94-5 (approx. 43% by weight) thalene, trimethylbenzene, xylene,
Guaranteed Dos reference test m	Triethylamine o ign control removal require ethods (40 CFR, Part 60))	Dimethylethylami ment 90% remov	ne (approx. 14 % by weight) al by weight (using UBEPA
Control equipme	nttype #1:	5%	
<u>Recuperà</u> Equipmer	tive thermal oxidizer (w/ 58%) It Costs: Oxidizer Supporting Controls Fan ductwork (\$/ft) Total	10,000	
Operating	info. hourly gas usage (ft3) electrical use (Kwh)	. 1000 = 17	
Control equipms	nt type #2:		· •
Recupera Equipmer	tive Catalytic oxidizer t Coste: Oxidizer Supporting Controls Fan ductwork (\$/īt) Total	# 120,000	
Operating	info. hourly ges usage (ft3) electrical use (Kwh) expected catelyst life	= 330 7 = 5 yr.	
Control Equipme	ent #3	·	
<u>Carbon a</u> Equipmen	isorption with off-site dispose it costs: carbon adsorber s Supporting Controls Fan ductwork (\$/ft) Total		NA
Operating	info. hourly gas usage (ft3) electrical use (Kwh) annual carbon usage (ibs)	6. M	

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	Scenario Z
	Phenolic Urethane Cold Box (PUCB) Core Storage
Ventilatio	n rate= 37,000 scfm Temporature= emblent
Daily ope	rating schedula= 19.5 hours /day and 7 days/week
Average May hor	voc/oc emissions rate≓ 2.4 lbs/hour (control injet approx, 10 pomy)
Annual V	OC/OCemissions 5.0 tons/year
ocvoc	composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx, 50% by we
	-potenlial constituents (xylene, cumene, trimethylbenzene and
	mesitylene);
	Peroleum Distiliates CAS# 647-742-94-3 (approx, 50% by Weight)
	biphenyl)
Guarant	ed Design control removal requirement 90% removal by weight (using USEPA
referenc	a test methods (40 CFR, Part 60))
Gontrol	eaulpment type #1:
2	oncentrator
E	quipment Costs: adsorber/Oxidizer =
	ductwork (5/ft)
	Total = 71,050,000
-	1180
C	perating into, hourly gas lisage (fis) = 7470
	annual maintenähce (man-hours)=
Control	
R	egenerative Catalytic oxidizer (w/min. 98% heat recovery)
Ē	aulpment Costs: Oxidizer
	Supporting Controls =
	Fan =
0	perating info. hourly gee usage (ft3) =
	electrical use (Kwh) =
	expected catalyst life =
Control I	auloment #3
	ullament Costs Blofilter/structure = A
-	Instellation Costs (turnkey) =
	Supporting Controls -
	Fan =
n	porating into electrical use (Kwh) =
Ŭ	annual media costs (\$)
	ennual maintenance (man-hrs) 😑
	ostimated size (length x width) =

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### 2 Scenario 3 Phenolic Urethane No Bake (PUNB) Core Production

Temperature= amblent

Daily operating schedule= 19,5 hours /day and 7 daya/week Average VOC/OC emissions rate= 1.7 lbs/hour Max, hourly VOC/OC emissions rate= 1.7 lbs/hour (control inlet approx. 10 ppmv) Annual VOC/OCemissions= 2.5 tons/year

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n: -

100

E.S. Maria

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ر... کریں مید Ventilation rate= 30,500 scfm

OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS# 647-742-84-5 (approx. 50% by weight) -potential constituents (napthalene, trimethylbenzene, xylenc)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Control_equipment type #1:
Concentrator
Equipment Costs: adsorber/Oxidizer 😐
Supporting Controls =
Fan 😕
ductwork (\$/ft)
Total = \$ 785000
Operating to bourty and using (113) - 1220
annual maintenance (man-hours)= $40$
Control aquipment type #2:
Regenerative Catalytic oxidizer (w/min_98% heat recovery)
Equipment Costs: OxIdizer =
Supporting Controls =
Fan
duchuark (5/H)
i otar -
Operating info, hourly gas Usage (ft3) =
electrical use (Kwh) =
• expected catalyst life =
Control Equipment #3
Bloffiration:
Equipment Costs: Biofilter/supports =
installation Costs (tumkey) 🛛 🛥
Supporting Controls =
Fan 🕨
duatwork (\$/ft) =
Total =
Operating into, electrical use (Kwh)
annual media costs (\$)
annual maintenance (man-bra)
astimated cize (Internated wildth) w
Colligence and fundative and a

	<u>^</u>
Scena	
Phenolic Urethane No Bat	(6 (PUNB) Core Storage
Ventilation rate= 36,000 actm Doity operating schedule= 19.5 hours /day and 7 day	iemperature ampient
Average VOC/OC emissions rate= 1.4 lbs/hour	
Max. hourly VOC/OC emissions rate= 2.3 lbs/hour (c	control iniet approx. 10 ppmv)
Annual VOC/OCemissions= 4.8 tons/year	• •
DC/VOC composition ranges=Petroleum Distillates (	CAS# 68477-31-8/84742-95-8 (approx. 50% by weigh
-polonțial con	stituents (xylene, cumona and trimethylberzena);
Petroleum Distilizador	slituents (naphalene, trimethylbenzene, xylene)
Guaranteed Design control removal requirement	90% removal by weight (using USEPA
leisience fest memode (40 CLV' Lout soll	
Control equipment type #1:	
<u>Concentrator</u> Equipmenti Costs: edsorbet/Oxidizer =	
Supporting Controls =	· · ·
Fan =	
ductwork (\$/R)	1050 000
Operating info. hourly gas usage (ft3)	- 1470
electrical USe (KWR) annual adsorbent coal (S)	
annual maintenance (man-ho	urs)= 40
Control equipment type #2:	
Regenerative Catalytic oxidizer (w/min 98%	heat recovery)
Equipment Costs: Oxidizer =	
Supporting Controls =	NIA
ductwork (\$/fi) 😕	
· fotal =	·
Operating info, hourly das usade (ft3) =	
electrical use (Kwh) =	
expected catalyst life 💌	
Control Equipment #3	·
Blofiltration:	~ /
Equipment Costs Biointer/Bupports	- NIA ·
Supporting Controls	= . ////
Fan	<b>н</b> (
ductwork (\$/1) Tota	22   be
Operating Info, electrical use (Kwh)	<b>2</b>
annual media cosis (5)	-
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		Scenario 8	
	Phonolic Urethane	IO Bake (PUNB) N	old Storage
Ventilation rate= 18 Daily operating sch	5,500 scfm edule= 24.0 hours /day ar	id 350 days/year	Temperature≃ ambi
Average VOC/OC e	missions rate× 8.0 lbs/ho	bur	
Max. nourly VOC/O Annual VOC/OCem	lasions= 25.1 tons/year	osinour (control iniet a	ipprox, 10 ppmv)
OCNOC compositi	on ranges≃Petrolaum Disi -poten	illates CAS# 68477-3 ligi constituent: (xvier	1-8/84742-95-8 (approx. 50%) be, cumpne and trimethylbenze
	Petroleum Dis	tillates CAS# 847-742	-94-5 (approx. 50% by weight)
	-poten	ual constituents (napt	halene, trimethylbenzene, xylei
Guaranteed Decig reference tost met	n control removal requir hods (40 CFR, Part 60))	ement 90% remova	l by weight (using USEPA
Control equipmen	it type #1:		
Concentrate	2. Conta: adsother/Oxidizer	-	
Edolburont,	Supporting Controls	F	
	Fan	= .	
	ductwork (\$/ft) Total	= = = = = = = = = = = = = = = = = = = =	20
		1 6,000,0	
Operating Ir	ifo, hourly gas usage (ft3)	= 0,10	1.
	annual adsorbant coat	(\$) = 02	
	annual maintenance (r	nan-hours)= 40	>
Control equipmen	type#2:		
Regeneration Fouloment	<u>e Catalytic oxidizer (w/mlr</u> Casta: Oxidizer	1. 88% heat recovery)	
and a charteness of	Supporting Controls	8	NIA
	Fan	M	NA.
	ductwork (\$/11) Total	°	(***
Operating in	lio. hourly gas usage (ff3) electrical use (Kwh)	7	
	expected catelyst life	r ·	•
	. #2		
Biofiltration:			
Equipment	Costs: Blofilter/supports	<b>=</b> .	. 1
	Installation Costs (tum	key) =	NA
	Fan	=	/-//
	ductwork (S/II)		
Oneration	to electrical use (Kuh)	Total ×	
Operating II		=	
	annual maintenance (man	-hrs) =	
	estimated size (length )	(width) =	
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Date: February 20, 1998

RMT, Inc. Mr. David Newsad Phone: 614-793-0026 Fax: 614-793-0151

From:

To:

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## Pages: 4

### Subject: Budget Quotes-CSM Proposal No. 97-199A

The attached quotation sheets are provided in response to your request of February 16, 1998. Please contact me if you require additional information.

### Scenario 4 Phenolic Urethane Cold Box (PUCB) Core Storage

Ventilation rate=58,000 scfm

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143333 14333 1433 Temperature=ambient

Daily operating schedule=24.0 hours/day and 365 days/year Max. hourly VOC/OC emissions rate-3.4 lbs/hour (control inlat approx. 5.0 ppmv) Annual VOC/OC emissions=9.9 hous/year

9.9

OC/VOC composition ranges=Petroleum Distillates CA5#68477-31-6/64742-95-6 (approx. 80% by weight) -potential constituents (xylene, cumene, trimethylbenzene and mesitylene); Petroleum Distillates CAS#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalene, trimethylbenzene, xylene, biphenyl)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA reference test methods (40 CFR, Part 60))

Control Equipment Type #1:

Concentrator		
Equipment Costs: Adsorber/Oxidizer	*	
Supporting Controls	=	
Fan	-	
Ductwork (\$/ft)		
Total	<b>m</b>	\$965,000
Operating Info. Hourly Gas Usage (ft3) electrical us (Kwh)	· H	504 72
annual adsorbent cost (\$) • annual maintenance (man-hours)	anni Mitta	0 40

Control Equipment Type #2:

Regenerative Thermal Oxidizer (w/min. 98% heat recovery)	
Equipment Costs: Oxidizer =	
Supporting Controls =	
Fan =	٢
Ductwark (\$/ft) =	l
Total =	
Operating Info, Hourly Gas Usage (ft3) =	
electrical us (Kwh) =	
expected catalyst life =	
Parloments II Dr. CSM FUNIPO, MCNTAL SUCTION	

FINPCOUPTODODITONIZITONE, DOG DOVINS

<u>S</u>	icenario 5	
Phenolic	Urethane No Bak	e
(PUNB)	Mold Production	
Ventilation rate=127,500 scfm	365 and 350 days / year	Temperature=ambient
Max. hourly VOC/OC emissions rate-7.3 ll Annual VOC/OC emissions=20.3 tons/yes 21.2	bs/hour (control inlet)	approx. 5.0 <del>p</del> pmv)

OC/VOC composition ranges-Petroleum Distillates CAS#68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylene, cumene and trimethylbenzene); Petroleum Distillates CAS#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalane, trimethylbenzene and xylene)

Guaranteed Design control removal requirement 90% removal by weight (using USHPA reference test methods (40 CFR, Part 60))

Control Equipment Type #1:

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Concentrator		
Equipment Costa: Adsorber/Oxidizer	=	
Supporting Controls		
Fan	-	
Ductwork (\$/ft)		
Total	-	\$1,530,000
Operating Info. Hourly Gas Usage (ft3)	80	1111
electrical us (Kwh)		155
annual adsorbent cost (\$)	-	Q <sup>-</sup>
annual maintenance (man-hours)	-	40

Control Equipment Type #2:



Equipment Supplier Name CSMENVIRONMENTAL SYSTEMS

FINPCOLVETTOD-CZ1110422211048.00C OMINA

### <u>Scenario 5</u> <u>Phenolic Urethane No Bake</u> <u>(PUNB) Mold Storage</u>

Ventilation rate=234,500 scfm

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Temperature=amblent

Daily operating schedule=24.0 hours/day and 350 days/year

Max. hourly VOC/OC emissions rate-13.8 lbs/hour (control inlet approx. 5.0 ppmv)

Annual VOC/OC emissions=38.6 tons/year

OC/VOC composition ranges-Petroleum Distillates CAS#68477-31-6/64742-95-6 (approx. 50% by weight) -potential constituents (xylens, cumere and trimethylbenzere); Petroleum Distillates CAS#647-742-94-5 (approx. 50% by weight) -potential constituents (naphalene, trimethylbenzere and xylene)

Guaranteed Design control removal requirement 90% removal by weight (using USEPA' reference test methods (40 CFR, Part 60))

Control Equipment Type #1: Concentrator Equipment Costs: Adsorber/Oxidizer = Supporting Controls = Fan = Ductwork (\$/ft) = \$ 2,800,000 Total = 2039 Operating Info. Hourly Gas Usage (ft3) = 283 electrical us (Kwh) -O annual adsorbent cost (S) = 40 annual maintenance (man-hours) =

Control Equipment Type #2:



Operating Info. Hourly Gas Usage (ft3) =

electrical us (Kwh) 🛏

expected catalyst life =

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### FACSIMILE MESSAGE

TO:

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### FROM:

DATE:	August 11, 1997	TIME:	4:30 pm
FAX #:	(614) 793-0151	PAGE:	l of 3

SUBJECT: ACTIVATED CARBON UNIT

Based on this information you faxed earlier today, we would like to offer the following unit:

UNIT TYPE: VF-2000 Each unit handles 1,000 cfm 2,000 lb. reactivated carbon included

PRICING: \$4',000.00/unit need Zunits

AVAILABILITY: 4 weeks after receipt of order

FOB POINT: Columbus, Ohio

VALIDITY: This quote is valid for 60 days

TERMS: Net 30 days to approved accounts

Included with this fax is a drawing for the unit quoted along with a product information sheet for the type of carbon normally included with this unit.

I will be out of the office for the rest of the week, but Bruce Wells will available to assist you in my absence.

Thanks for your interest.

Sincerely,

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Curtomer;	1	
Address	,	
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Atm:		
FAX:		614-7
Date:		8-13-

614-793-0151		•	•
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### **DH-SITE GAC EXCHANGE SERVICES**

On-site Carbon Exchange can be utilized for any smaller (i.e. < 10,000 lbs.) carbon system, provided there is a means (such a top manway) to remove the spent carbon and recharge it with fresh carbon.

Typically, spent carbon is vacuumed out the top manway of the vessel directly into metal 55-gallon drums. (Ultimately, it is returned to Calgon Carbon in these metal drums or supersects or type bins.)

Recharging the vessels is accomplished via supersacks and erane on the carbon service truck, or via anapying druces or smaller bags.

smaller bags. On-site tarbon exchange is usually coordinated from one of the closest service centers. Some of the service centers have seven (7) day permits for the storage of hazardous materials. Prior to the return of any spent carbon (and preferably before conducting the site services), Carbon Acceptance Testing most be completed and approved. A Carbon Acceptance Kit is sent for this purpose. The charge for this Carbon Acceptance Testing is: \$400.00 for Non-Hazardous (Non-BCRA) DR \$1,000.00 if RCRA Hazardous (BCRA).

### The following information is required to estimate the costs for maduction on

	ine lonowing information is ledaned to estimate the co	is the completing of successfully excitating set time
10.00	1. SITE LOCATION	lumbra Dhio 43210
S.	2. TYPE OF CARBON REDUIRED O Lie	in Vapor - Wirgin CReactivated
	3. NUMBER OF VESSELS	
	POUNDS OF CARBON PER VESSEL 20	00 165
	LOCATION OF VESSELS	de EDurside
	VESSEL ACCESSIBLE	D No (Provide sketch of vessel layout.)
!	4 SPENT LABRON TO BE	Hazardona II RERA Hazardona
- 1. - 1	Blease provide the above information to your Calena F	the Responsible to physic a protection for providing Do-Site
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	Laroon exchange services a 3,05/16 60 2,00	0/25
1		s Art Include Any Applicable Sales 13x.
	NCLUDES: A The price for Service Only.	
	The price of Fresh Carbon and the	breight charges.
į	The price of the Containers used t	Betom the Spent Carbon. 10 Metal 410ms
	The Carbon Acceptance Fes. On	TIME FEE - \$400,00 NON-RCAIL
	The price of the Freight Charges	to ship the Spent Carloop to one of the Reactivation Centers
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# Appendix E-3 Enclosure, Ductwork and Make-Up Air Cost Estimates

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## **COMPUTATION SHEET**

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## **COMPUTATION SHEET**

	SHEET 7 of7
150 N. Patrick Blvd. Brookfield, WI 53045 (414) 879-1212 FAX: (	: (414) 879-1220
PROJECT / PROPOSAL NAME	PREPARED CHECKED PROJECT / PROPOSAL NO.
COMA- COOC STOCK	Leo 1816197 Jab 88 00.02211.09
ESTIMATED COSTS FOR	DEENALIO = 3 (Scenario 2 + Production
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0-6 30'	14 10' 79 11 259 11
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7,72,35) (5)	
	· 34 (3) (1.15) (1.15) - + 41 (6.5V
· COULDMENT ENCLO	05.07.6
- FROM SKETCH	ON PELVIOUS PACE AREA
OF EQUIP	MENT ENCLOSURG:
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(56 x 71.12	21 = 3983 FT = 1
- US/ZO HEIGHT	VOUME = 77,600 FTS
i Estimation	(NTS = (76, 10 - 5)(3) - 3)
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Data: 8-17-97 To: RHT Atra: ubject: LEO TRAMM QHO PROJECT PLEASE FIND QUICES FOR A-BIC AS Nou INDICATED ON THE PHONE. THESE BUDGET PRICES ARE ABOUT WHAT WE WOULD QUOTE TO AN INSTALLING CONTRACTOR. YOU WOULD HAVE TO ADD EST. FREIGHT AS FollowS A. ADD APROX. 1,400.00 73. ADD " \* 1,800.00 11 # 2,700.00 C. ADD WOULD BID THIS JOB AT A BETTER PRICE WHEN WE KNEW WHAT COMBINATIONS YOU MIGHT We 115%

[otal Pages Being Transmitted Including The Cover Sheet \_\_\_\_\_\_. Please Respond By: \_\_\_\_\_\_.

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98117127 07.05 FAX 4145335390 LEE RAIT ON (A) 17,000 CFM (2) 580-215 HASTNUGS 8,500 CFMCA QUOTATION. Date: 8-7-97 To: Project Eur. Quote: HASTINGS MODEL NO. SBD-218 CFM 8,500 . ISP / 35. TEMP RISE 90 MBH 893 DIRECT FIRED GAS OPTIONS: C ROOF CURE EREMOTE PANEL CONTROL TRANSFORMER SERVICE PLATFORM NAT. GAS @ 1-5 POUNDS \_\_\_\_ INCHES (YEXTENDED GREASE LINES DOI20 MIX' RETURN AIR/O.A. W/ROOM SENSOR 🗆 VARIABLE VOLUME WITH: , MOD.DISCHARGE DAMPER DFREQ. DRIVE FINSULATED BLOWER DE BURNER FA-FILTER SECTION 🗆 HORIZONTAL UNIT TO VERTICAL UNIT ON STAND TUEATHERPROOF D INFAKE HOOD & SCREEN **VUR-2 SCREEN** I'V" BANK FILTER SECTION Ø 2" TA 🖸 PERMANENT 🗇 EXTENDED SURFACE motorized inlet damper @ Discharge damper \_ DOWN DISCHARGE 🗇 DISCHARGE LOUVERS: 🗋 HORIZONTAL 🗂 DOUBLE DEFLECTION PRE-PURGE HAUX. STARTER CONTACT CIRCUIT ANALYZER DOW OUTLET TEMP. CUT-OFF TO CLOGGED FILTER LIGHT DULTRA-VIOLET FLAME SENSOR D, DAY-NITE MOTOR HP. 5 VOLTAGE 4/00-3-60 DODP ETERC DHIEFF. TVARIABLE PITCH SHEAVE DISCONNECT SWITCH HI GAS REGULATOR 🗇 Ş¥ANDARD CONTROLS 🛛 IRI APPROVAL FM APPROVAL MAXITROL 14 ELECTRONIC DISCHARGE CONTROL WIREMOTE SET POINT T MAXITEOL SERIES 44 WITH ABOVE AND ROOM SENSOR. m WIS. CODE ADDITIONAL OPTIONS: NET PRICE FREIGHT INCLUDED 20,640. FACTORY START UPADD

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UTATION (B) (2) B,000 CFH = 16,000 CFH (2) 5,250 CFH = 10,500.QUOTATION Date: To: Atta: Project: 165 NO. 5BD-215 (FM 8,000 TSP. 1.35 S MODEL NO. SRD-115 \_ CFM 5250. ISP /. 35 . DIRECT FIRED GAS MBH TEMP RISE 634 OPTIONS:: - Andrews THE REMOTE PANEL TO CONTROL TRANSFORMER C ROOF CURB SERVICE PLATFORM NAT. GAS @\_\_\_\_\_ POUNDS \_\_\_\_ INCHES EXTENDED GREASE LINES
 NO 80/20 MIX RETURN AIR/0.A. W/ROOM SENSOR 🗇 VARIABLE VOLUME WITH: D MOD.DISCHARGE DAMPER OFREQ. DRIVE PINSULATED BLOWER BURNER FILTER SECTION VERTICAL UNIT ON STAND HORIZONTAL UNIT C VEATHERPROOF □ INTAKE HOOD & SCREEN **VUR-2 SCREEN** ☑ "V" BANK FILTER SECTION ☑ 2" TA, □ PERMANENT □ EXTENDED SURFACE m MOTORIZED INLET DAMPER D'DISCHARGE DAMPER D DOWN DISCHARGE DICHARGE LOUVERS: HORIZONIAL DOUBLE DEFLECTION VIERATION ISOLATERS I INTERNAL FAN ISOLATION IN PRE-PURGE AUX. STARTER CONTACT CIRCUIT ANALYZER DIOW OUTLET TEMP. CUT-OFF CLOGGED FILTER LIGHT DULTRA-VIOLET FLAME SENSOR DAY-NITE MOTOR HP. 5 VOLTAGE 460-3-60 DODP DIEFC DHI-EFF. O VARIABLE PITCH SHEAVE ODISCONNECT SWITCH WHI GAS REGULATOR STANDARD CONTROLS
 IRI APPROVAL FM APPROVAL MAXITROL 14 ELECTRONIC DISCHARGE CONTROL W/REMOTE SET POINT MAXITROL SERIES 44 WITH ABOVE AND ROOM SENSOR. m WIS. CODE ADDITIONAL OPTIONS: 4 UNITS 368640 NET PRICE FREIGHT INCLUDED-

FACTORY START UP ADD

QUOTATION (C) 145,000 CFM (2) SBD-233 (272,500 En-65,500 CFM (2) SBD-221 (2) 32.750 En-65,500 CFM (2) SBD-221 (2) 32.750 En-Date: To: Attn.: Project NO. 5BD-233 CFH. 72,500 Eq. TEMP RISE 90 MeH 10265. DIRECT FIRED GAS 3,000 DIRECT FIRED GAS Second Co OPTIONS: T REMOTE PANEL CONTROL TRANSFORMER C ROOF CURB SERVICE PLATFORM NAT. GAS @\_\_\_\_\_ POUNDS \_\_\_\_\_ INCHES 🗆 EXTENDED GREASE LINES 🛛 🔲 80/20 MIX RETURNAIR/0.A. W/ROOM SENSOR 🔿 VARIABLE VOLUME WITH: D MOD.DISCHARGE DAMPER DFREQ. DRIVE □ INSULATED BLOWER □ BURNER **FILTER SECTION** U VERTICAL UNIT ON STAND 🗆 HORIZONTAL UNIT 🗀 WEATHERPROOF □ INTAKE HOOD & SCREEN UUR-2 SCREEN □ "V" BANK FILTER SECTION □ 2" TA □ PERMANENT □ EXTENDED SURFACE 🗂 MOTORIZED INLET DAMPER 📋 DISCHARGE DAMPER 📋 DOWN DISCHARGE DISCHARGE LOUVERS: C HORIZONTAL DOUBLE DEFLECTION 🗂 VIBRATION ISOLATERS 🗂 INTERNAL FAN ISOLATION 🕧 PRE-PURGE AUX. STARTER CONTACT CIRCUIT ANALYZER LOW OUTLET TEMP. CUT-OFF CLOGGED FILTER LIGHT C ULTRA-VIOLET FLAME SENSOR C DAY-NITE motor HP.\_\_\_\_ Voltage\_\_\_\_ DODP DIEFC DHI-EFF. O VARIABLE PITCH SHEAVE O DISCONNECT SWITCH O HI GAS REGULATOR □ STANDARD CONTROLS □ IRI APPROVAL [] FM APPROVAL MAXITROL 14 ELECTRONIC DISCHARGE CONTROL W/REMOTE SET POINT IT MAXITROL SERIES 44 WITH ABOVE AND ROOM SENSOR. T WIS. CODE Cara-Sec. ADDITIONAL OPTIONS: SAME ACESSORIES NET PRICE FREIGHT INCLUDED PP.2P2,00FACTORY START UPADD

DATE:		0		1	*****			
CONTRACTOR:		. 0			QUOTE			
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PPOJECT:		0		WEIGHT	L	IST		
MODEL SBD-22	7 HASTINGS	DIRECT FIRED		#		\$		
32 750 CFM	TR	S0 3.498 MBH		3685	24	1837		·1
MOTOR	25	460/3/60		230	2	2340		
DISCONNECT S	WITCH			25		399		
VUR-2 VERTICA	L UNIT			400	4	1626		
ROOF CURB				0		0		
EXTENDED GRE	ASE LINES					234		
INSULATED BLC	WER	BURNER		30	1	080		
WEATHERPROC	)F			130	1	491		
INTAKE SCREE	N			30		469		
V" FILTER SECT	ION			610	2	718		
2" THROWAWAY	FILTERS			35		441		
MOTORIZED INL	ET DAMPER	INDOOR		0		0		
MOTORIZED DIS	CHARGE DA	MPER OUTDOOF	2	190	1	649		
DUCT ADAPTOR	HR-2			0		<b>0</b> .	• .	
DISCHARGE LOU	IVER HORIZ	ONTAL		0		Ο.	•	
FLOOR ISOLATI	ERS	R	UBBER	24		947		
RETURN AIR SE	CTION			0		. 0		
AUX.CONT.PRE-	PURGE & LC	WOUTLET		40		756		
BLOCKED INTAK	E FILTER LIC	GHT/SWITCH		15	:	231		
MS-44 MAXITRO	L				:	278		
T244						178		
HIGH GAS PRES	SURE REGU	LATOR .		10	:	334		
IRI APPROVAL 10	PSIG & UND	DER		0		0		
FM APPROVAL W	ITH FILTER	OR INLET DAMPE	R	120	. 2	480		
INTERNAL ISO,	SPRING			0		0		
MS-14 MAXITRO	WREMOT	E SET POINT	•	0		0		
REMOTE CONTR	ROL F PANEL	INCLUDED		•				
EXTENDED LEG	5 TO 40"				i	B <b>OO</b>		
MSC.								
FRT.RTE.	0	. Wi	EIGHT	5574 #		•		
FRT.CST.	0			· • •	546,2	288 .		
MULTIPLIE	0.4	NET DELIVI	ERED		\$18.5	515		

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MODEL SBD-2	33 HASTIN	IGS DIRECT FIRED	#	\$	
72,500 CFN	ITR	90 7,794 MBH	5380	37213	
MOTOR	60	460/3/60	720	6545	
DISCONNECT	SWITCH		25	399	
VERTICAL UNI	т		500	3330	
ROOF CURB			0	0	
EXTENDED GR	EASE LIN	ES	10	234	
INSULATED BL	OWER	BURNER	40	1400	
WEATHERPRO	OF		150	1649	
INTAKE SCREE	EN		50	651	
V' FILTER SEC	TION		. 760	3784	
2" THROWAWA	Y FILTERS	i	60	608	
MOTORIZED IN	LET DAMP	ER INDOOR	. 0	0	
MOTORIZED DI	SCHARGE	DAMPER OUTDOOR	235	1885	
DUCT ADAPTO	R HR-2		0	0	
DISCHARGE LC	UVER HO	RIZONTAL	0	0	
VIB ISOLATERS	S-SUSPEN	DED-RIINDOOR RU	IBBER 24	947	
80/20 RA/OA MD	XING DAM	PERS/RM SP SW	. 0	0	
AUX.CONT.PRE	-PURGE 8	LOWOUTLET	40	750	
BLOCKED INTA	KE FILTER	RLIGHT/SWITCH	0	231	
MS-44 MAXITRO	JL	· · ·		278	
INTERNAL SPF	ING ISOL	ATION	0	0	
HIGH GAS PRES	SURE RE	GULATOR	10	334	
IRI APPROVAL 1	0 PSIG & U	INDER	0	. 0	
FM APPROVAL	WITH FILT	ER OR INLET DAMPER	R 140	2876	
HIGHER LEGS				950	
MS-14 MAXITRO	DL W/REM	OTE SET POINT ST	TANDARD	0	
REMOTE CONT	ROL F PAN	IEL INCLUDED			
ETL 1 SPEED				0	
UL LABELED RE		И		0	
FRT. RTE	0	WE	IGHT 8144		
FRT.COST	<b>\$</b> 0	LIS	T W/1.05 ESC.	\$64.064	
MULTIPLIE	0.4	NET DELIVE	RED	<u>\$25.626</u>	

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MODEL SBD-115 HASTINGS	#	5
5,250 CFM;TR 90 TSP 1.35 634 MBH	700	10767
MOTOR 5 HP 480/3/60	70	1029
DISCONNECT SWITCH	20	251
VERTICAL UNIT	200	1281
STAND EXTENSION	35	600
INSULATED BURNER	15	258
INSULATED BLOWER SECTION COIL	5	164
WEATHERPROOF	100	830
INTAKE SCREEN	5	164
V" FILTER SECTION	100	1014
2 " TA	10	47
FLAT BANK ON RETURN	0	0
MOTORIZED DISCHARGE DAMPER OUTDOOR	40	1226
DUCT ADAPTOR HR-2	30	0
DISCHARGE LOUVER HORIZONTAL	0	0
VIB. ISOLATERS-SUSPENDED-RI INDOOR RUBBER	16	516
PRE PURGE	0	197
AUX.CONT.PRE-PURGE & LOW OUTLET	40	700
BLOCKED INTAKE FILTER LIGHT/SWITCH	0	231
MS-44 MAXITROL WITH ROOM OVERRIDE		278
SUMMERWINTER SWITCH STANDARD		0
HI GAS PRESSURE	5	77
IRI APPROVAL 10 PSIG & UNDER	40	533
REMOTE PANEL STANDARD	0	o
FM APPROVAL	0	0
MS14 STANDARD ELECTRONIC MODUL, RMT ST PT		117
FRT.RTE 0 FRT.CST \$0.00 WEIGHT	1431	20280
MULT. 0.4		
NET DELIVE	RED	\$9.112

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DATE:	0			
CONTRACTOR:	0		QU	OTE
ATTENTION:	0			
PROJECT:		. <b>_</b>	WEIGHT	LIST
MODEL SBD-21	5 HASTINGS DIRECT FIR	ED	#	\$
8.000 CFM:	TR 90' TR 1.25 TSP	845 MBH	1230	12873
MOTOR 5.0 H	P 208/3/60		70	116
DISCONNECT S	WITCH		20	25
VERTICAL UNIT			250	195
ROOF CURB			0	(
EXTENDED GRE	ASE LINES			23
INSULATED BLO	WER SECTION		20	976
WEATHERPROC	)F		100	86
INTAKE SCREEI	N		15	301
V' FILTER SECT	ON .		115	1424
2" THROWAWAY	FILTERS		15	148
MOTORIZED INL	ET DAMPER INDOOR		0	
MOTORIZED DIS	CHARGE DAMPER OUTDO	DOR	100	1313
DUCT ADAPTOR	HR-2		0	. 0
DISCHARGE LOU	IVER HORIZONTAL		0	c
VIB. ISOLATERS	SUSPENDED-RI INDOOR	RUBBER	12	239
WIS. CODE				761
INTERNAL SPRI	NGISOLATION		0	C
BLOCKED INTAK	E FILTER LIGHT/SWITCH		0	231
MS-44 MAXITRO	L WITH ROOM OVERF	NDE		278
T244				178
HIGH GAS PRES	SURE REGULATOR	1/10 #	10	218
RI APPROVAL 10	PSIG & UNDER		70	1731
FM APPROVAL W	ITH FILTER OR INLET DA	MPER	0	C.
MS-14 MAXITRO	WREMOTE SET POINT	STANDARD		
50" LEGS .				650
FRT.RTE	0	WEIGHT	2027	25799
∞st				
ALT.	0.4	NET DELIVE	ERED	\$10,320