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

RMT INC.

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

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-by-company 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:

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.

"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

Scenario #5 PUNB mold production and storage

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

Mold storage for 12 hours after production

Cost Effectiveness Study:

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.

Summary of Cost-Effectiveness Analysis Results

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 of sand per day			
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 of sand per day			
Mold Production	20.8	825,500 - 1,137,500	43,500 - 59,500
Mold Storage	39.5	1,410,000 - 2,012,500	39,000 - 54,000

*Rounded to nearest $500.00.

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:

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:

- 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:

- 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.

<u>Typical Operation:</u>

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

- 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

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.

2.0 Technical Feasibility Analysis

2.1 Emissions Data:

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.

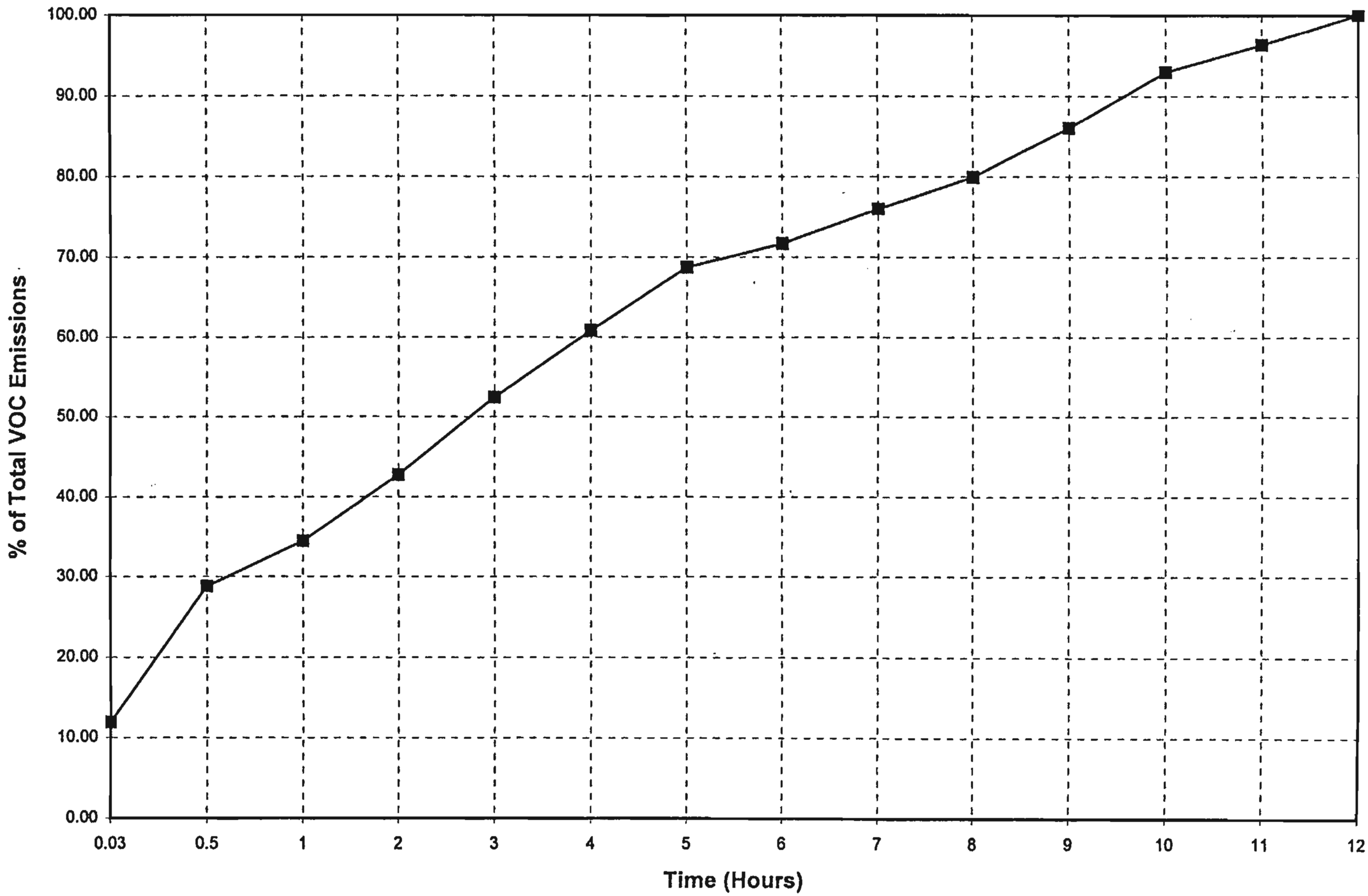
Based on the laboratory testing, the emission factors for VOC emissions for core/mold production and a total period of 12 hours after the resin and sand are mixed were as follows:

- 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.

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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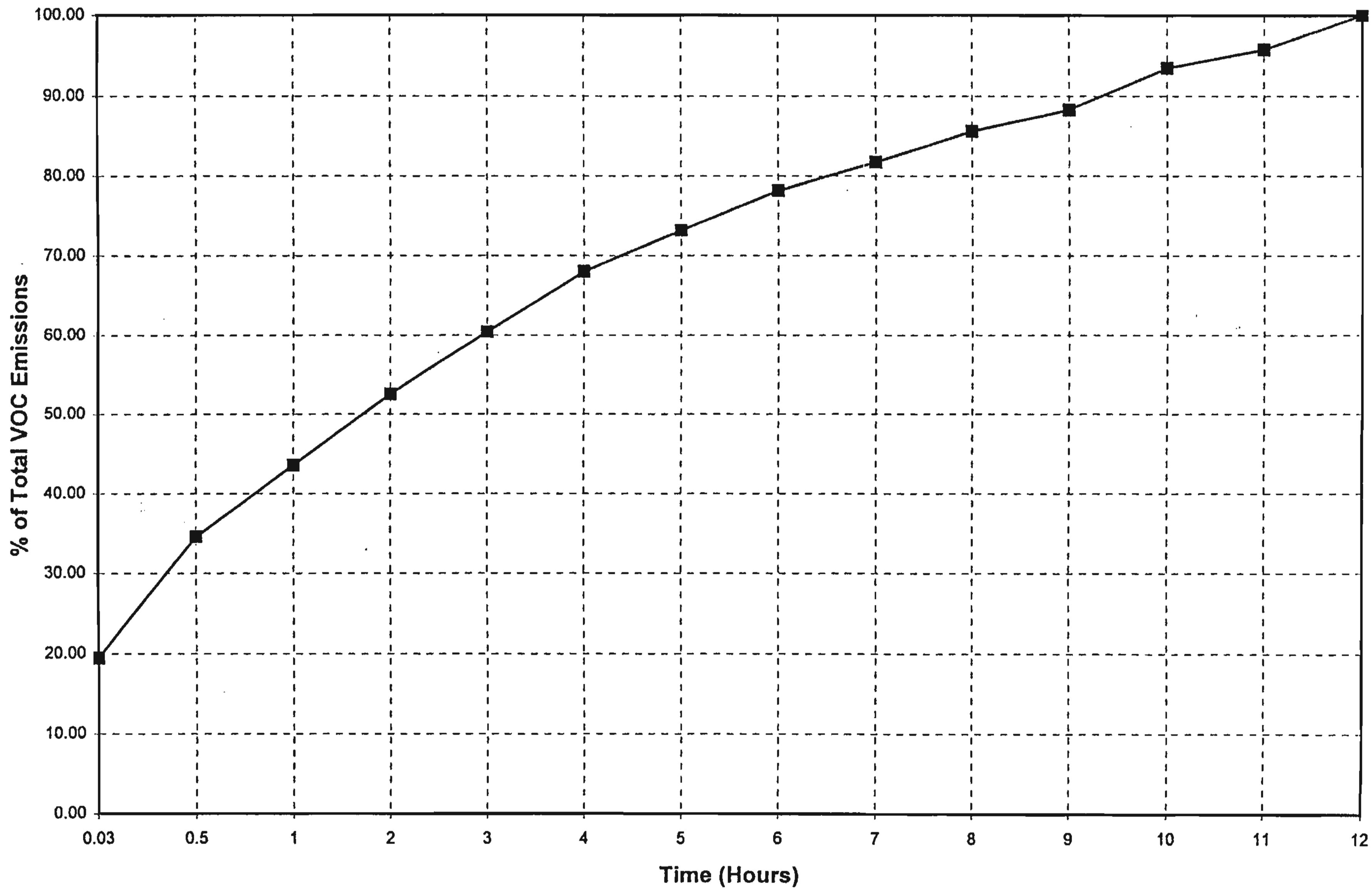
FIGURE 2-2

PUNB (No Bake) Emission Profile (Average)



* Based on average of 9 test results.

** 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:

- PUCB:
  - 28.8% of total VOC emissions* occur during core/mold production
  - 71.2% of total VOC emissions* occur during core/mold storage
- PUNB:
  - 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

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.

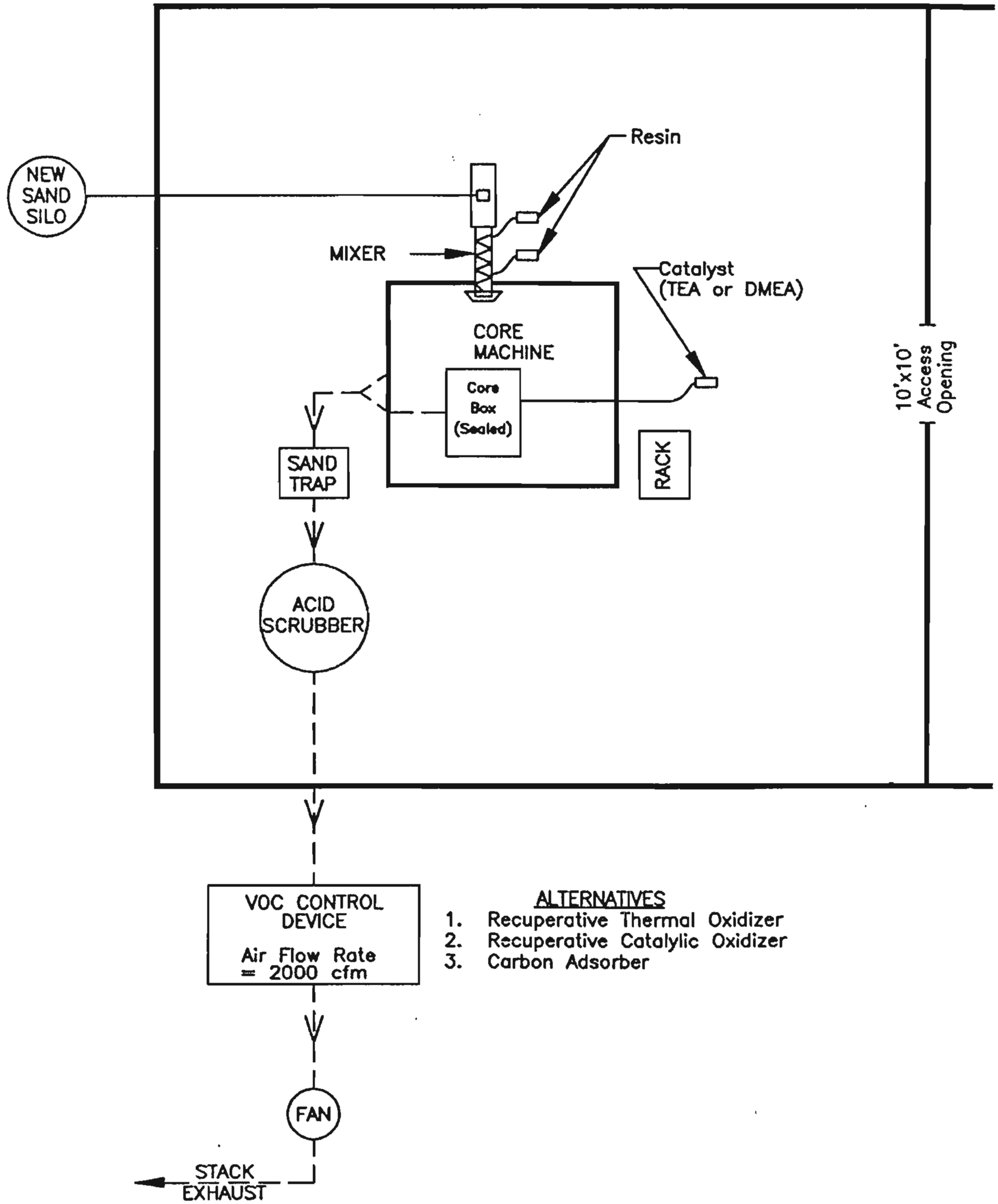
2.2.2 Scenario Overview and Exhaust Ventilation System Analysis

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):

  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



OCMA/VOC STUDY
SCENARIO #1
PUCB CORE PRODUCTION AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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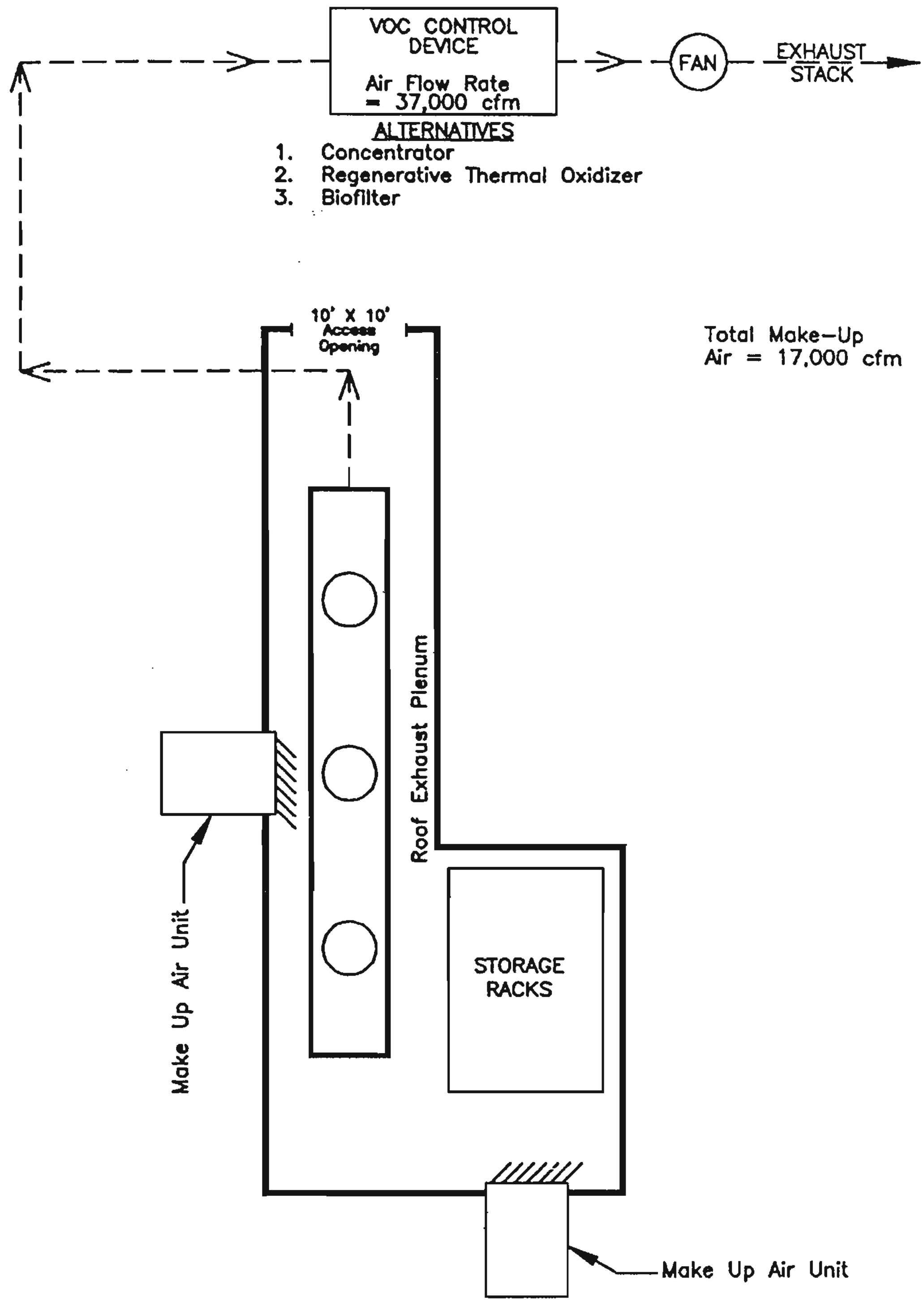
APPROVED BY:	CSS
DATE:	AUG. 1997
PROJ. #	2211.04
FILE #	22110803

NOT TO SCALE

FIGURE 2-3



OCMA/VOC STUDY
SCENARIO #1
PUCB CORE STORAGE AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

RMT INC.

DWN. BY:	MWC
APPROVED BY:	CSS
DATE:	AUG. 1997
PROJ. #	2211.04
FILE #	22110804

NOT TO SCALE

FIGURE 2-4

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^3/minute which was estimated as follows:

a) A minimum of 1000 ft^3/minute of exhaust air per machine is recommended by the acid scrubber vendor[1] 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^3/minute was estimated to be required assuming an air flow rate of 200 cfm/ft^2 of open face area[2]. 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^3/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^3/minute as specified in (a) plus 1000 ft^3/minute as specified in (b), or a total of 2000 ft^3/minute.

- PUCB Core Storage Area (Scenario #1):

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[3].

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[3] 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^3/minute is required for the PTE.

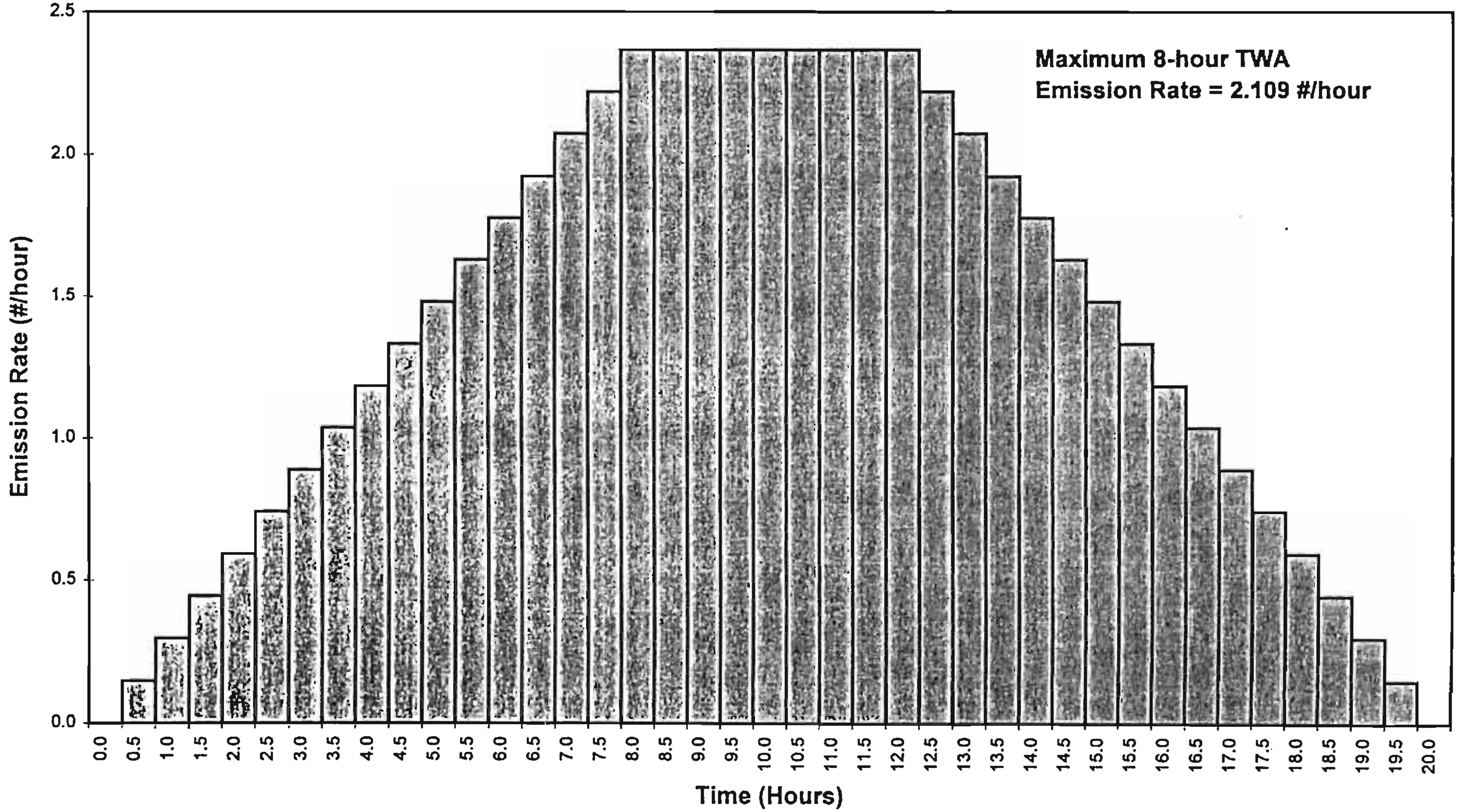
The cores on each rack placed in the PTE emit VOCs for the entire 11 1/2 hour period that they spend in the storage area at a constant rate of 0.148 pounds of VOC per hour (see Appendix D for supporting calculations). As additional racks are placed in the PTE every 30 minutes, the VOC emission rate increases. 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®) of 525 ug/m^3 was selected as the indicator chemical for the purpose of estimating dilution exhaust ventilation rates in the

Figure 2-5

Scenario #1
PUCB (Cold Box) Core Storage Area Emissions



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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® 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® for the indicator chemical. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard[7] 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[2].

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

Scenario #1 PUCB Core Storage Area Air Flows

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

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

2.3.1 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.

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.

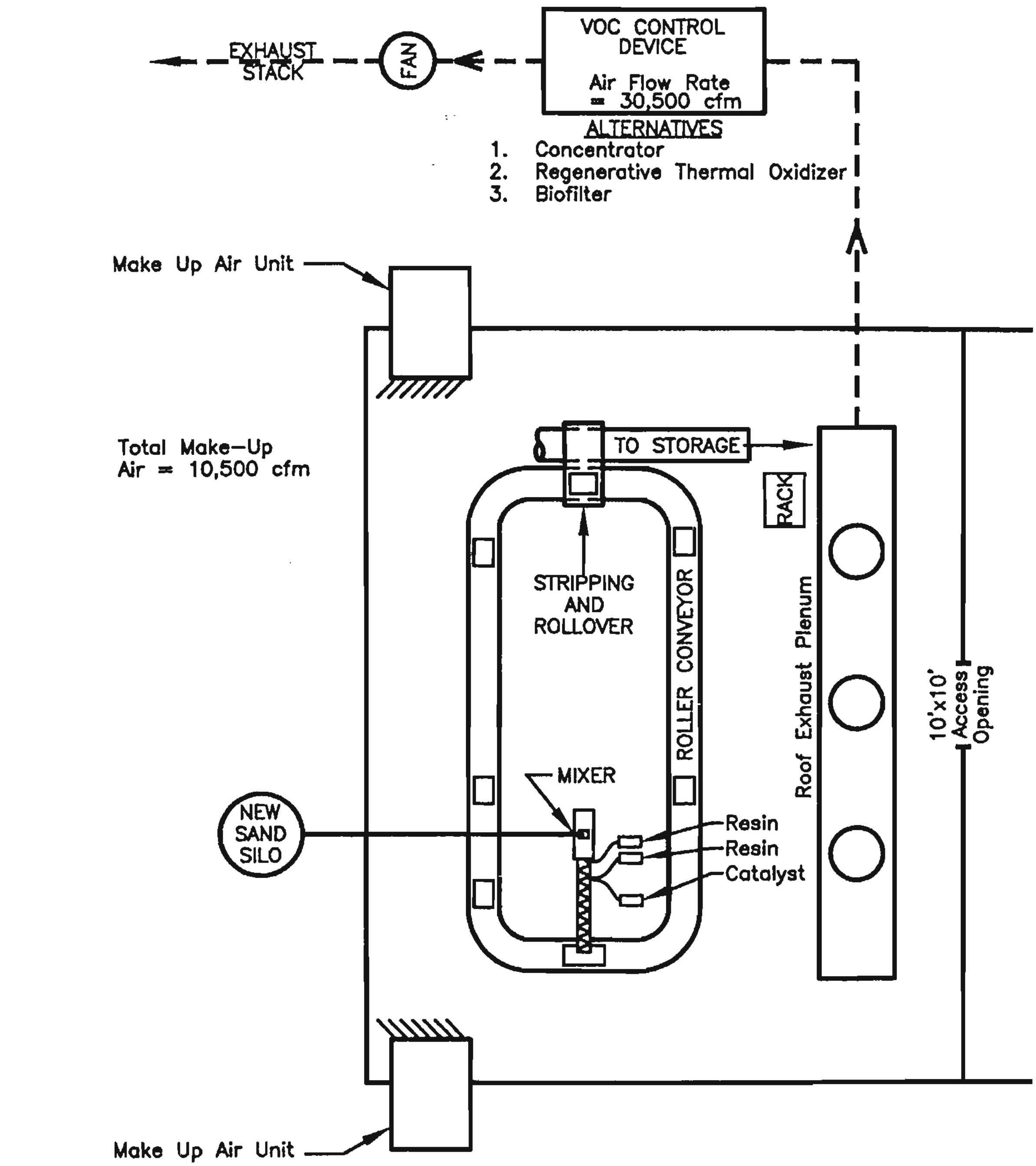
While the PUNB process can be used for production of one of a kind cores and molds, it is typically used for rapid mass production of small to medium-sized cores with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and core boxes.

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):

  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



OCMA/VOC STUDY
SCENARIO #2
PUNB CORE PRODUCTION AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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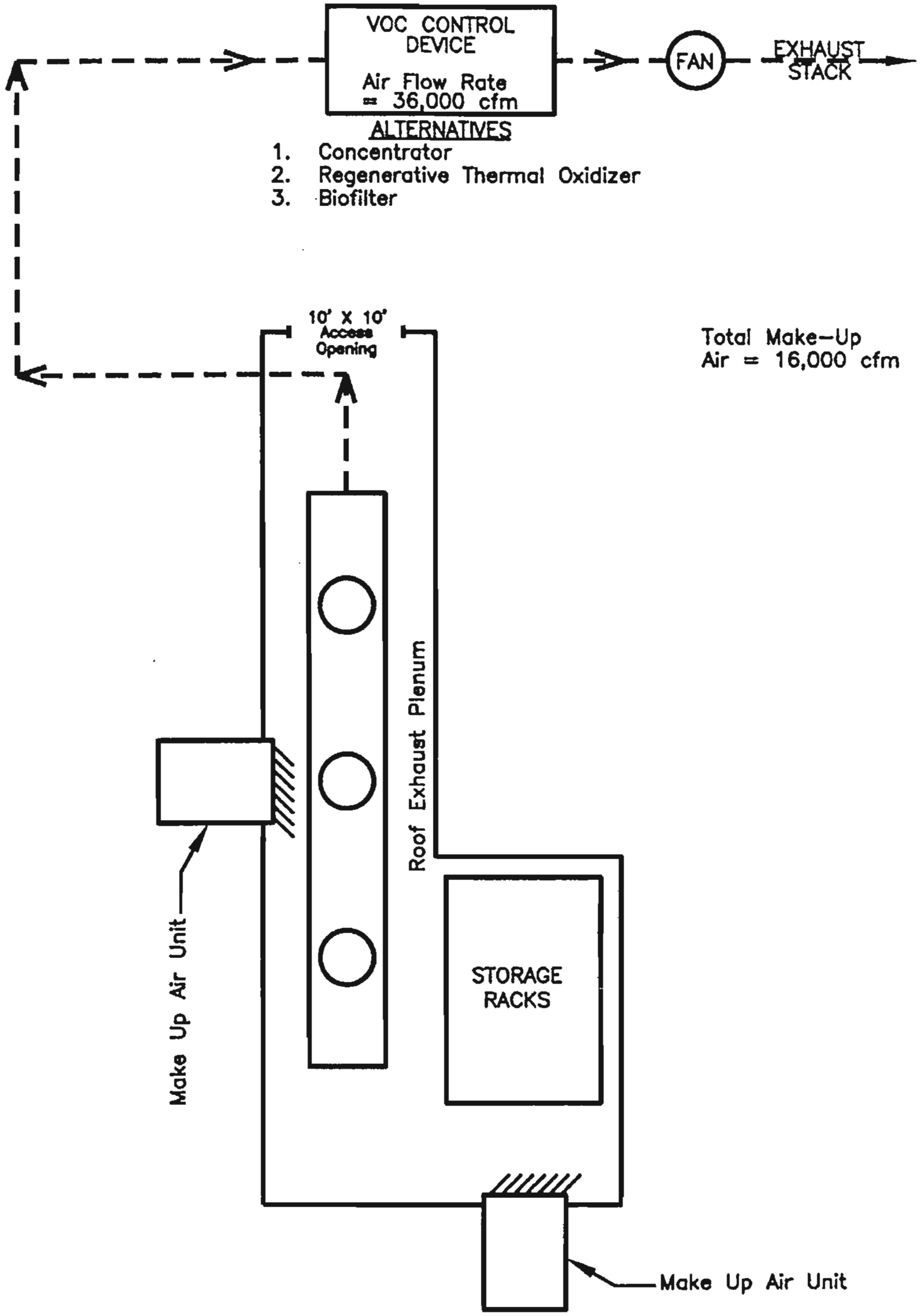
FIGURE 2-6



OCMA/VOC STUDY
SCENARIO #2

PUNB CORE STORAGE AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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APPROVED BY:	CSS
DATE:	AUG. 1997
PROJ. #	2211.04
FILE #	22110807

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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.

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:

- 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[3] 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[3] 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.

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^3 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 production area are exposed should not exceed 10% of the TLV® for the indicator chemical. This assumption is based on criteria generally used by industrial

hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard[7] 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[2].

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

Scenario #2 PUNB Core Production Area Air Flows

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

- PUNB Core Storage Area (Scenario #2):

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[3].

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.
- Per USEPA Method 204[3] 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.

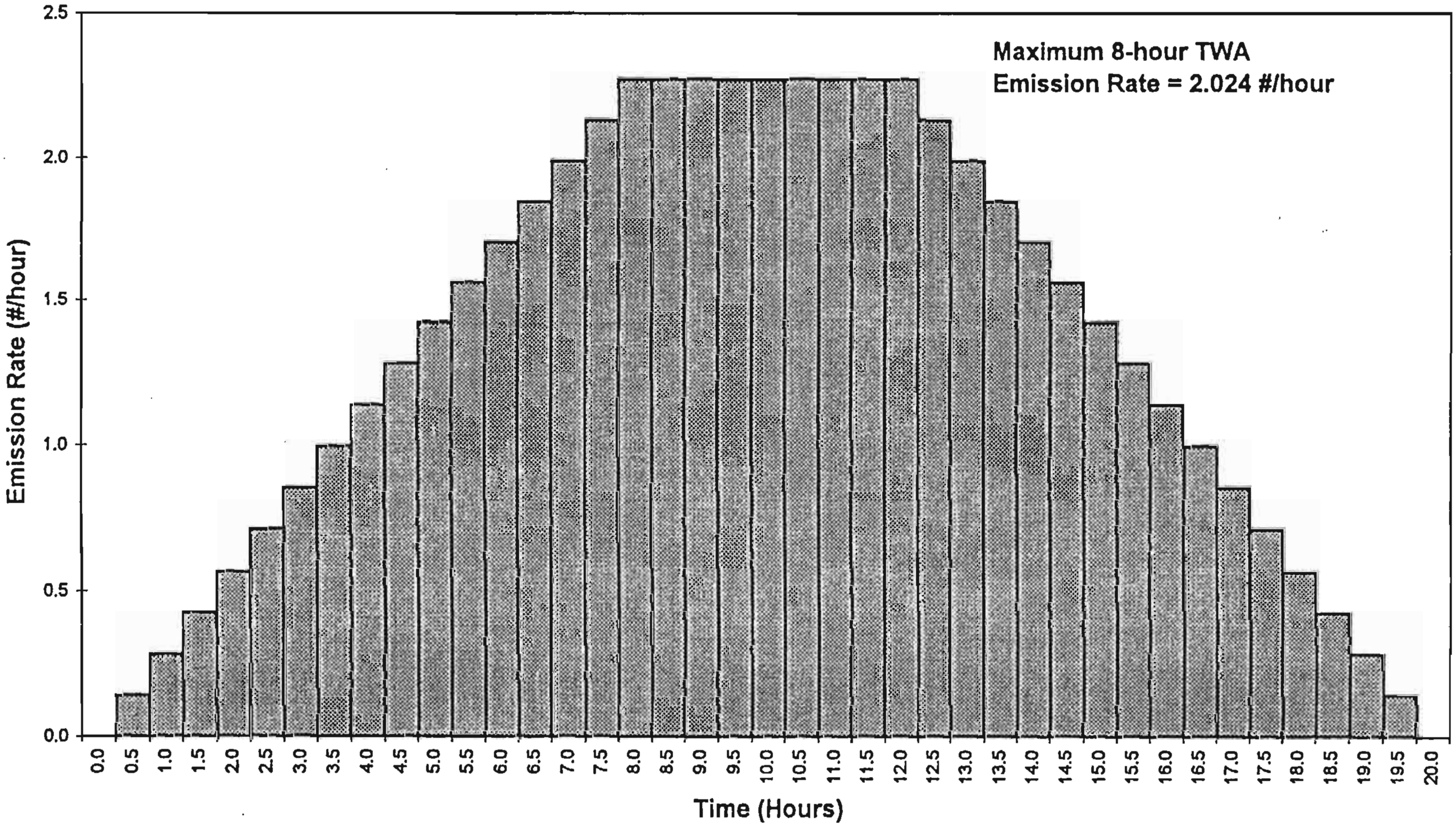
The storage area has an access opening measuring 10 ft wide by 10 ft high to allow forklift trucks to transport core racks in and out of the area on a frequent basis. It is not feasible to install a door or other obstruction in this opening as it would interfere unduly with the required movement of cores 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^3/minute is required for the PTE.

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®) of 525 ug/m^3 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.

FIGURE 2-8
Scenario #2
PUNB (No Bake) Core Storage Area Emissions



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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® for the indicator chemical. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard[7] for industrial process exhaust recirculation systems.
- 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[2].

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

Scenario #2 PUNB Core Storage Area Air Flows

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

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

2.4.1 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.

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.

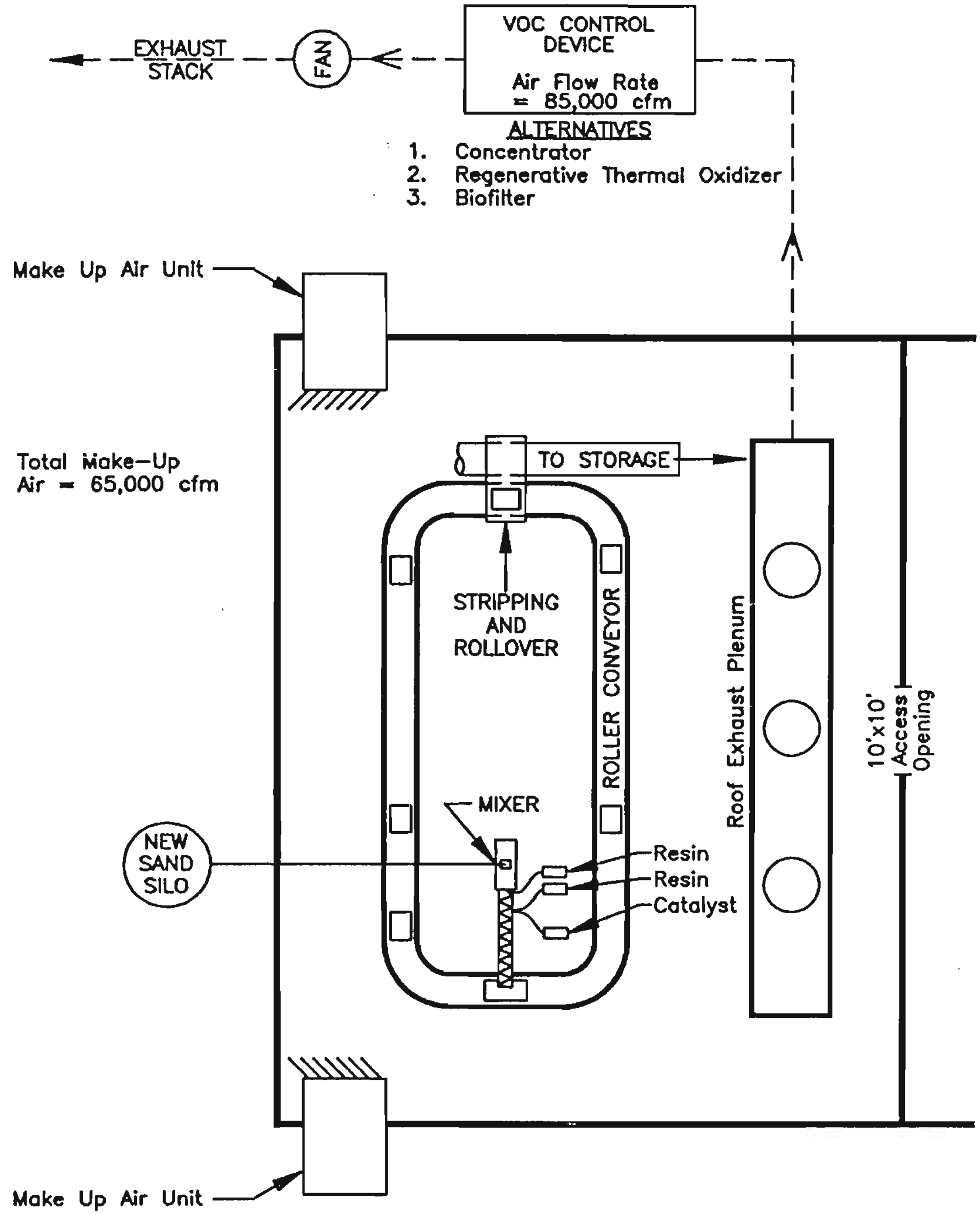
While the PUNB process can be used for production of one of a kind molds, it is typically used for rapid mass production of small to medium-sized molds with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and mold boxes.

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):

  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



OCMA/VOC STUDY
SCENARIO #3
PUNB MOLD PRODUCTION AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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FILE #	22110805

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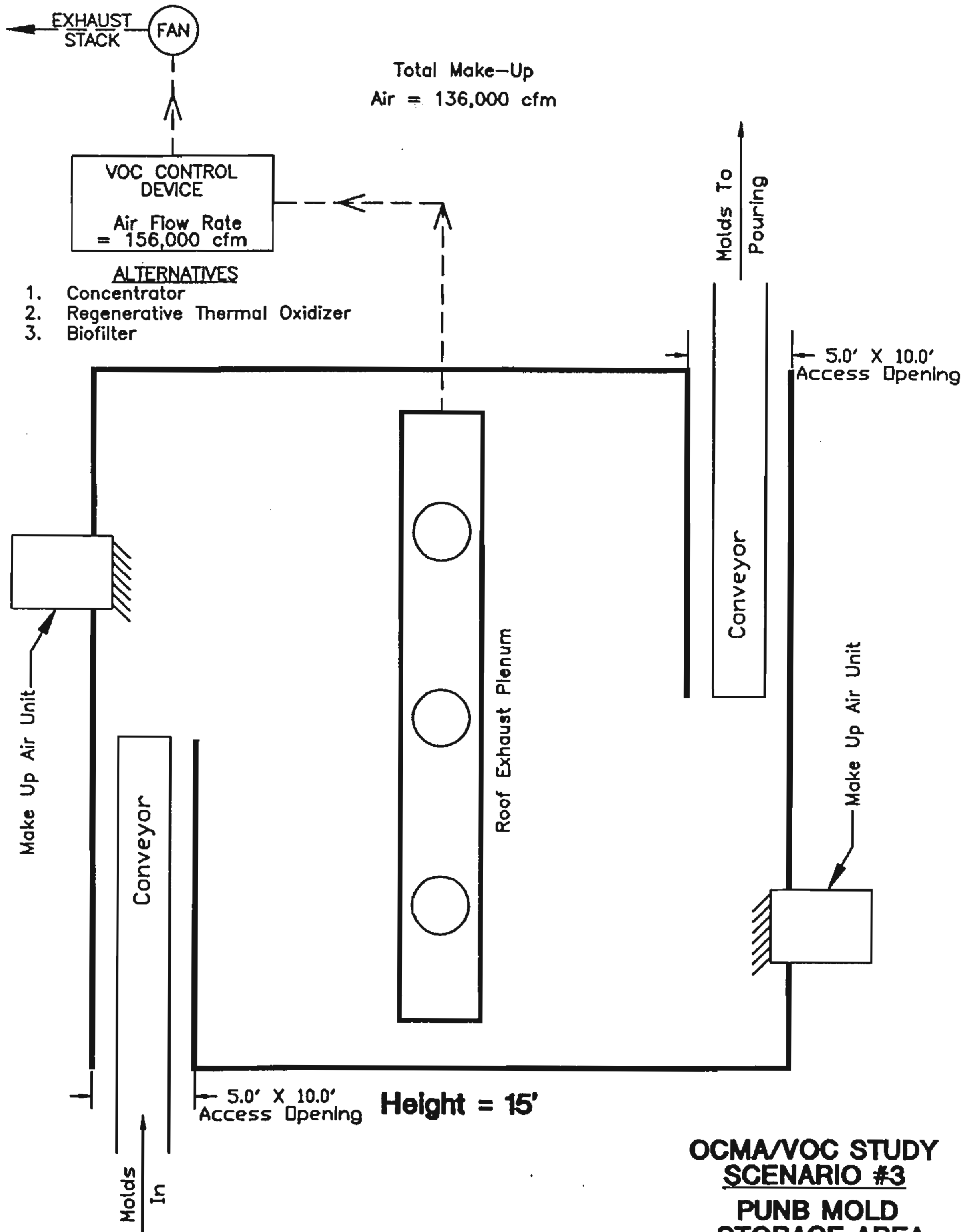
FIGURE 2-9



OCMA/VOC STUDY
SCENARIO #3
PUNB MOLD STORAGE AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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	PROJ. # 2211.04
	FILE # 22110806

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FIGURE 2-10

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;

- 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[3] 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®) of 525 ug/m^3 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® for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard[7] 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[2].

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

Scenario #3 PUNB Mold Production Area Air Flows

	Airflow Rate (ft^3/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):

  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[3].

  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[3] for a PTE, molds must be stored a minimum of 4 equivalent duct diameters from any openings.

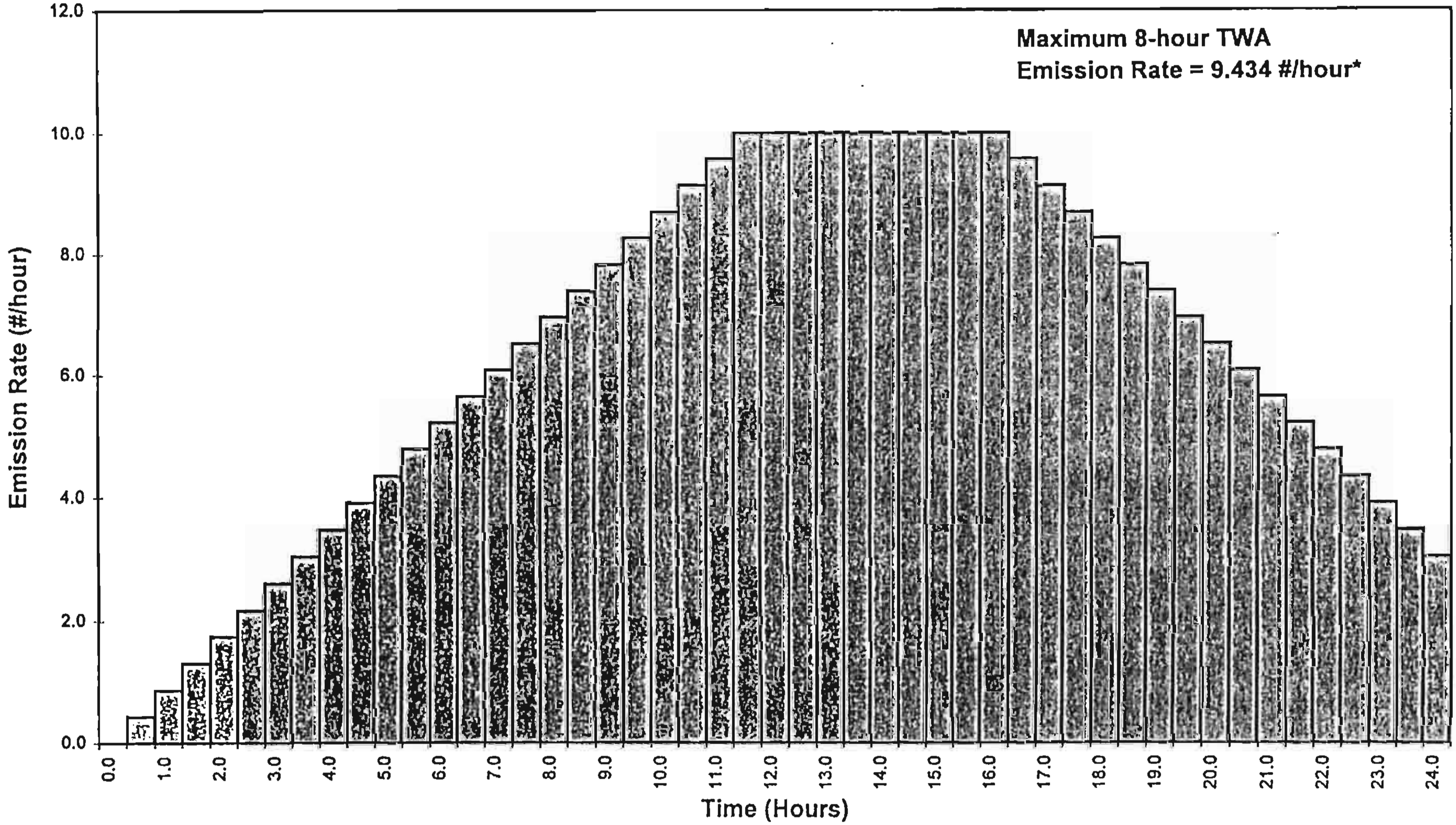
- Molds are stored one high on conveyors. Floor space utilization is forty percent. The building height is 15 feet.

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^3/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:

FIGURE 2-11
Scenario #3
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.

- 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^3 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® for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard[7] 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[2].

Using these criteria, the exhaust and make-up air flow rates were calculated using the dilution ventilation equations in the ACGIH Industrial Ventilation Manual[2] and the AIHA Engineering Field Reference Manual[3] 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^3/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

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.

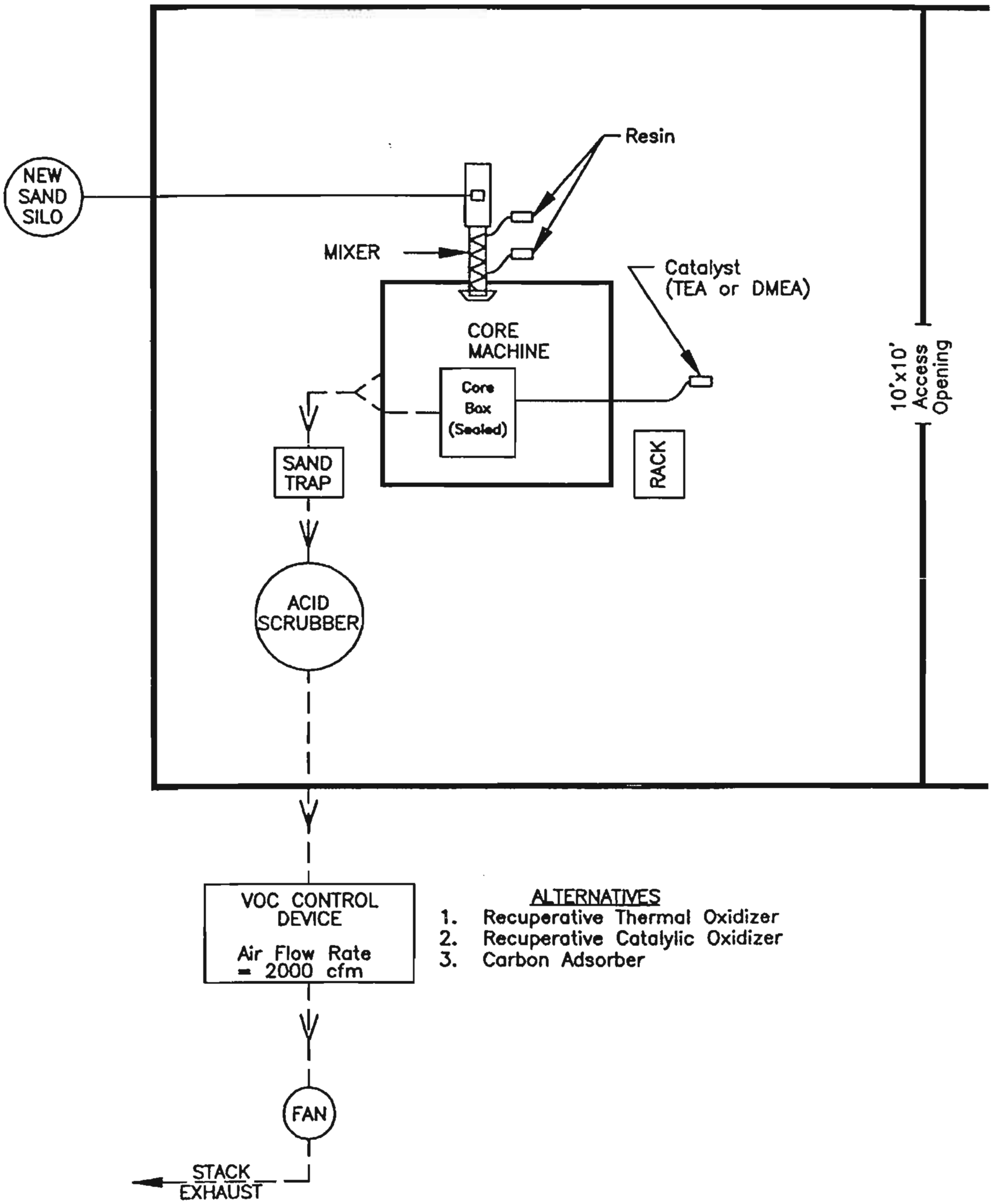
During catalyst gassing and purging cycles, the catalyst, carrier gas and air pass through the core and leave the core box through vents into the exhaust manifold, which conveys the gasses to an acid scrubber which removes the catalyst from the exhaust stream before discharge to atmosphere. The core 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):

  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.



OCMA/VOC STUDY
SCENARIO #4
PUCB CORE PRODUCTION AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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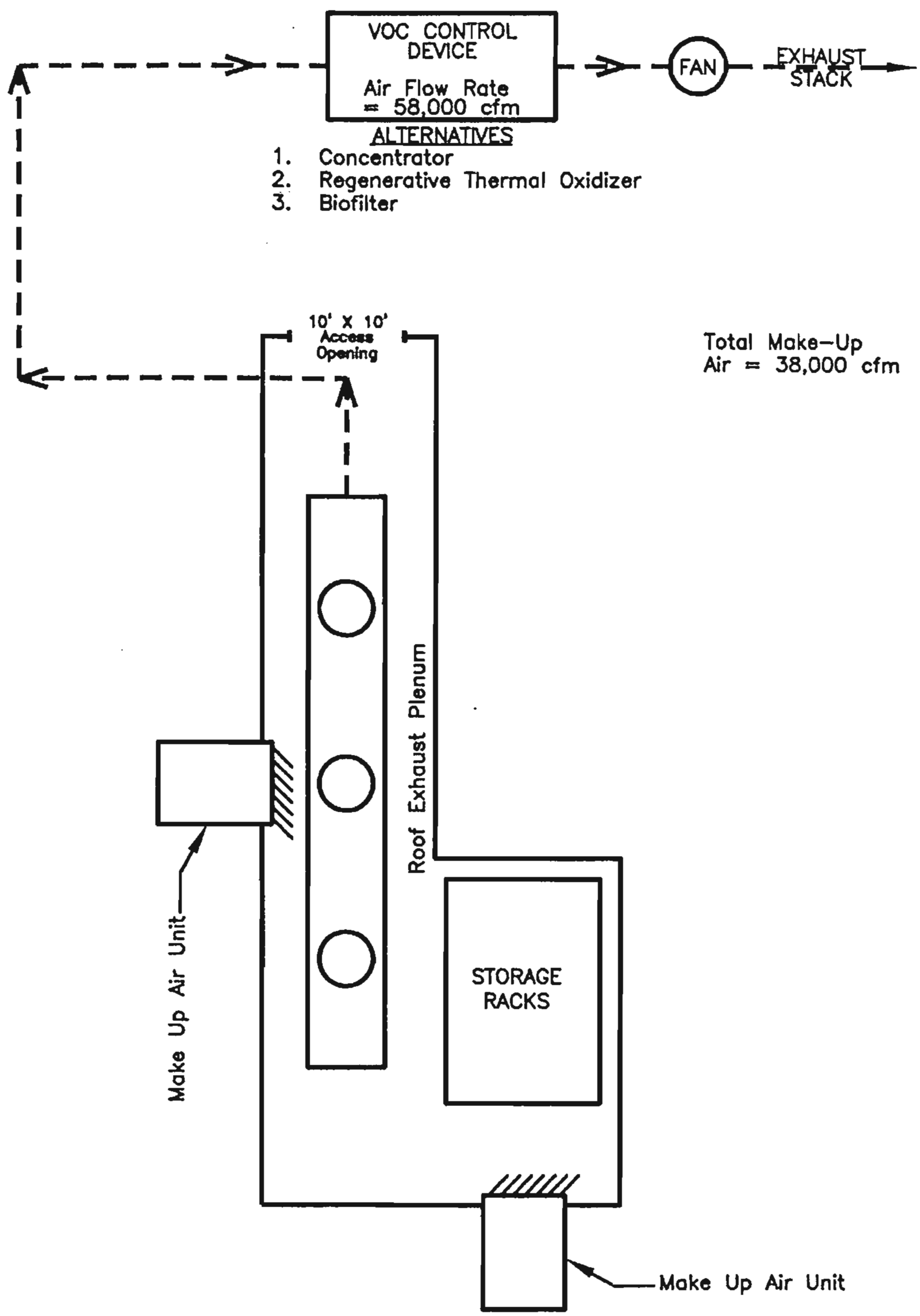
FIGURE 2-12



OCMA/VOC STUDY
SCENARIO #4
PUCB CORE STORAGE AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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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.

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^3/minute which was estimated as follows:

a) A minimum of 1000 ft^3/minute of exhaust air per machine is recommended by the acid scrubber vendor[1] 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^3/minute was estimated to be required assuming an air flow rate of 200 cfm/ft^2 of open face area[2]. 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^3/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^3/minute as specified in (a) plus 1000 ft^3/minute as specified in (b), or a total of 2000 ft^3/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[3].

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.

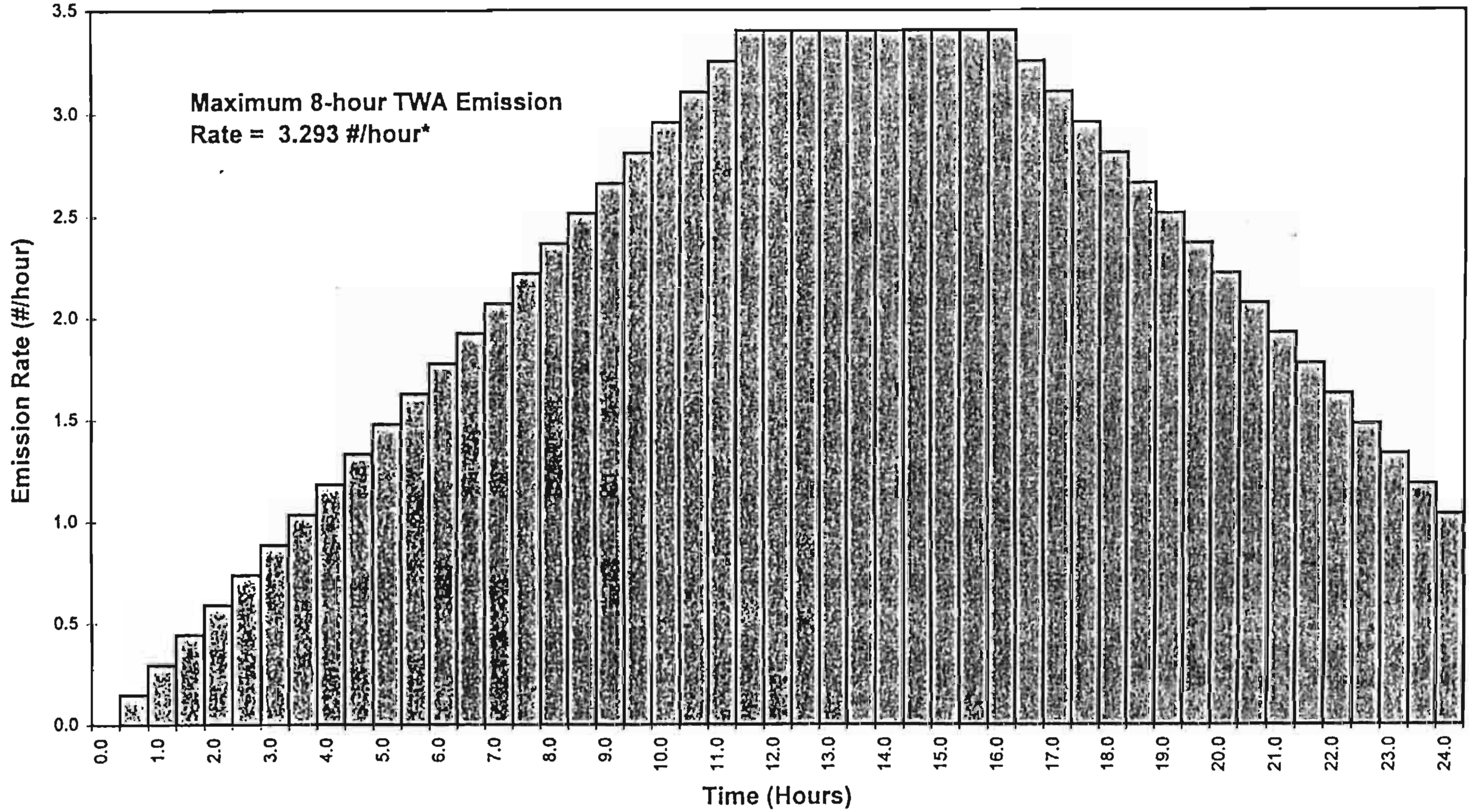
- Core density is equal to 100 pounds per cubic foot.
- Per USEPA Method 204[3] for a PTE, cores must be stored a minimum of 4 equivalent duct diameters from any opening.
- The PTE will be designed to minimize the floor area and a 14-foot horizontal clearance will be required for the forklift.

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^3/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.

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®) of 525 ug/m^3 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 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[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in a proposed ANSI standard[7] 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[2].

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

Scenario #4 PUCB Core Storage Area Air Flows

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

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.

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.

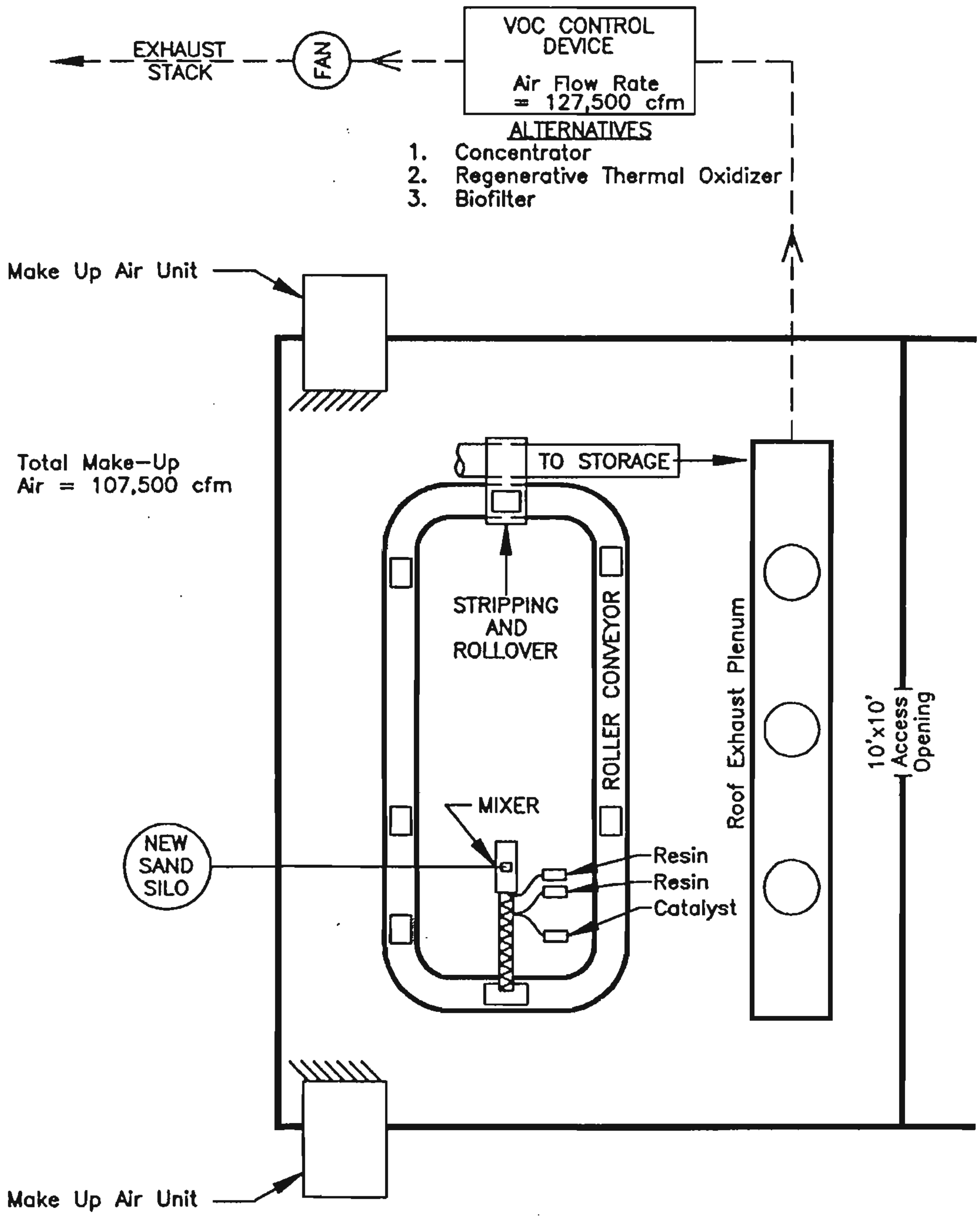
While the PUNB process can be used for production of one of a kind molds, it is typically used for rapid mass production of small to medium-sized molds with turn-tables or conveyorized loop lines which maximize quick recycling of the patterns and mold boxes.

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



OCMA/VOC STUDY
SCENARIO #5
PUNB MOLD PRODUCTION AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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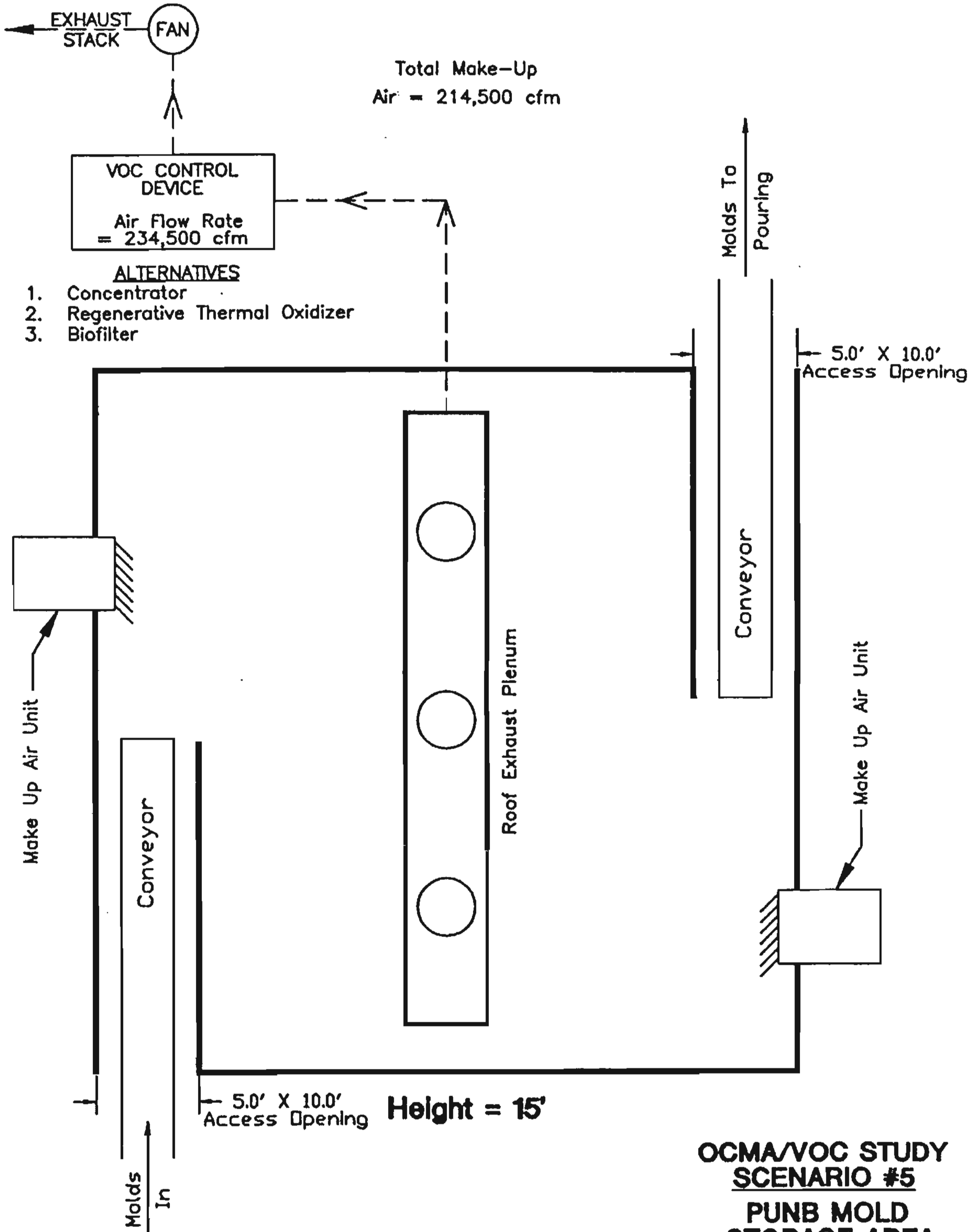
FIGURE 2-15



OCMA/VOC STUDY
SCENARIO #5

PUNB MOLD STORAGE AREA

Note: Actual foundry operations may vary significantly to allow for required operational and maintenance flexability.

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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.

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;
- 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[3] 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®) of 525 ug/m^3 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® for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries.

Also, the 10% criterion is recommended in the proposed ANSI standard[7] 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[2].

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

Scenario #5 PUNB Mold Production Area Air Flows

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

- 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[3].

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[3] 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^3/minute.

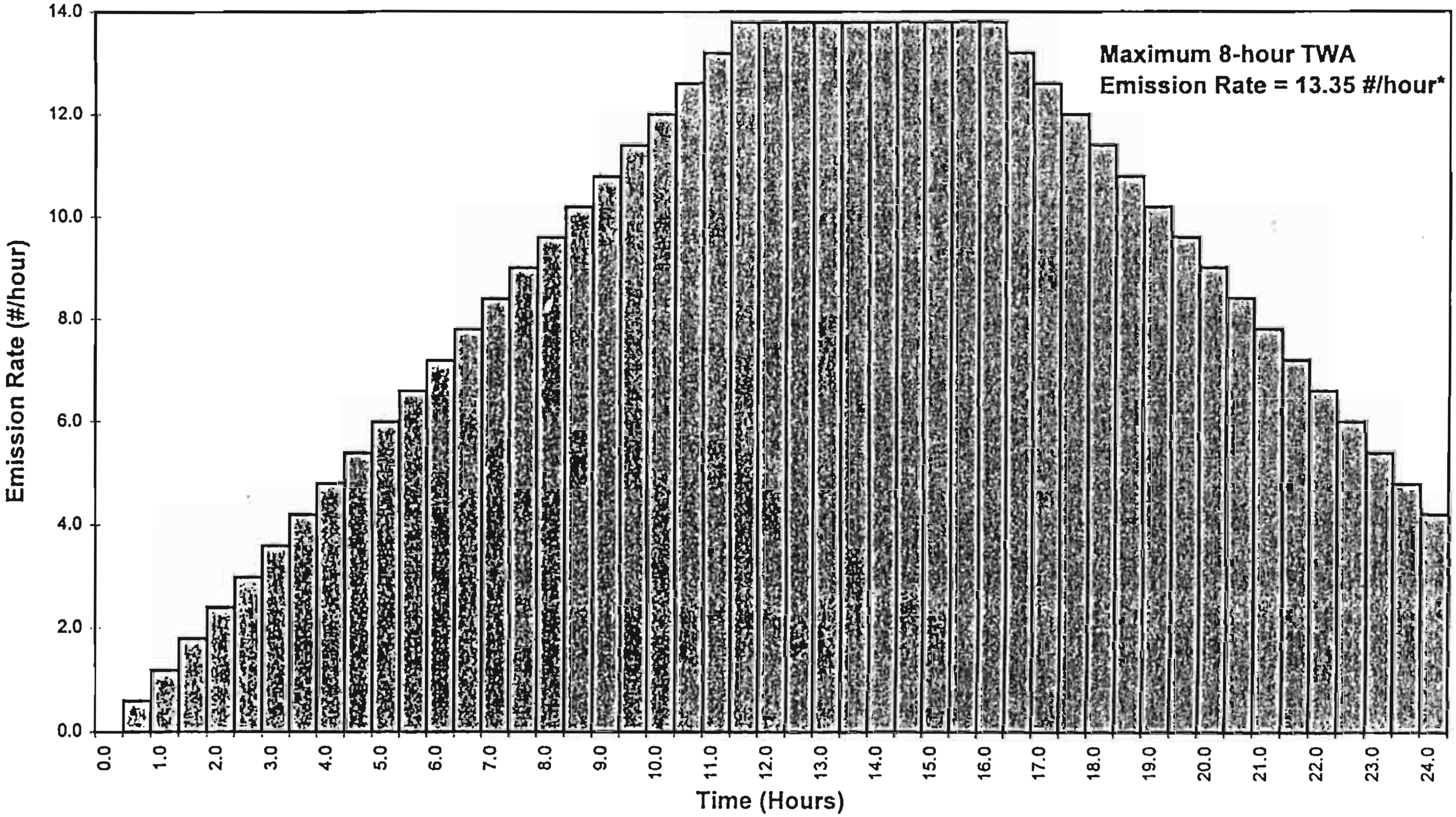
Each batch of molds placed in the PTE emits VOCs for the entire 11 1/2 hours period that it spends in the storage area at a constant rate of 0.60 pounds of VOC per hour (see Appendix D for supporting calculations). As additional batches are placed in the PTE every 30 minutes, the VOC emission rate into 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®) of 525 ug/m^3 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® for the contaminants. This assumption is based on criteria generally used by industrial hygiene professionals[4,5,6] as the basis for designing exhaust air recirculation systems in foundries. Also, the 10% criterion is recommended in the proposed ANSI standard[7] for industrial process exhaust recirculation systems.

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.

- 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[2].

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

Scenario #5 PUNB Mold Storage Area Air Flows

	Airflow Rate (ft^3/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
- 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.

Table 2-1
Summary of Exhaust Rates

SCENARIO	PRODUCTION AREA Exhaust Rate ft³/min			STORAGE AREA Exhaust Rate 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

Note: Airflow rates are rounded to the nearest 500 CFM.
* NDO = Natural Draft Opening
** Airflow Rate for Local Exhaust Ventilation on Core Machine

Table 2-2
Emission Control Technologies Selected for Economic Feasibility Study

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

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.

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 site-specific requirements, especially for retrofitting controls to existing operations.
- 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[3].

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

* Rounded to nearest $500.00.

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

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.

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.

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.

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.

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.

TABLE 3-4A

Scenario #4
Cost Effectiveness Results
PUCB Core Production

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

* Rounded to nearest $500.00.

TABLE 3-4B

Scenario #4
Cost Effectiveness Results
PUCB Core Storage

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.

TABLE 3-5A

Scenario #5
Cost Effectiveness Results
PUNB Mold Production

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.

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:

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

1. Interel Environmental Technologies, Inc.; "Guide to Planning Your Iso-Cure Cold Box Gas Scrubber Installation", December 1992.

2. Industrial Ventilation - A Manual of Recommended Practice; 21st edition, American Conference of Governmental Industrial Hygienists, Cincinnati, Ohio(1992).

3. Criteria For and Verification of A Permanent or Temporary Total Enclosure; US EPA Method 204 (June 1997), Code of Federal Regulations, 40 CFR Part 51, Appendices M.

4. J. T. Radia; "Dust and Fume Control for Cleaning and Finishing Operations in Foundries", Proceedings of AFS-CMI Conference on Cleaning Room Technology - An Update for the 80s; pp 235-298 (1981).

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. Proposed American National Standard for the Recirculation of Air from Industrial Process Exhaust Systems; ANSI/AIHA Standard Z9.7 (1997).

8. Engineering Field Reference Manual; American Industrial Hygiene Association, Akron, Ohio (1982).

Appendix A

Memorandum of Understanding Between Ohio EPA and OCMA

MEMORANDUM OF UNDERSTANDING BETWEEN

OHIO CAST METALS ASSOCIATION
&
THE OHIO ENVIRONMENTAL PROTECTION AGENCY

1. 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.

2. A working group will be formed with representatives from OCMA and Ohio EPA/DAPC 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. 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.

4. 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 foundries when applying for PTI's for "typical" core/mold making operations, as required by OAC rule 3745-31-05; and

   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

DEC 30 1996
Date

Mark E. Armstrong
Mark E. Armstrong
President
Ohio Cast Metals Association

November 5, 1996
Date

OHIO E.P.A.
DEC 30 96
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TIMETABLE FOR DEVE[illegible]PING EMISSION FACTORS FOR TH[illegible] [illegible]ASTING 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.

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 lbs/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):

a. Within one hundred and twenty (120) days of submittal of the revised 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.

c. Should the rule analysis and/or BAT analysis or study indicate that at the 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 submission of the analysis or study, the permittee shall submit an expeditious schedule for implementation of the additional emissions control for the core and/or mold making operations permitted herein. This schedule shall include the following milestone dates, as applicable:

Milestone		Date
i.	Submit, if required, a PTI modification application implementing the revised BAT determination by	________
ii.	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	________
v.	Achieve and demonstrate final compliance with OAC rule 3745-21-07(G) and/or the revised BAT determination by	________

3. Title V Permit Application:

a. Existing Title V facilities

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.

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

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.

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>

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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Milestone		Date
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. Title V Permit Application:

a. Existing Title V facilities

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.

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 estimated OC/VOC emissions from 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 the 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.

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.

Appendix B

Correspondence on "Typical Operations"

OCMA
OHIO CAST METALS ASSOCIATION • 2969 SCIOTO PLACE • COLUMBUS, OHIO 43221 • (614) 876-5100 • FAX (614) 876-3615

February 21, 1997

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

Dear Ms. Hilkens:

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.

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,

Russ Murray

Russ Murray
Executive Director

cc: 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

RMT INC.

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

- 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 lbs/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.

TYPICAL CORE / MOLD MAKING OPERATIONS IN OHIO

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

TYPICAL CORE / MOLD MAKING OPERATIONS IN OHIO

Collector's Name 1	System Number 2	Core or Mold 3	C. Box or No-Bake 4	Average Sand Thruput (lbs/hr) 6	Average Sand Thruput (TPY) 7	Max Sand Thruput (lbs/hr) 8	Max Sand Thruput (TPY) 9	Range of Time Core Stored 12	Configuration 13
JA	2	c	nb	39.71	38.9	8571	37543		7 core mach.
JA	3	c	nb	766.6/900	230/270	13500 / 900	59130 / 3942		Core lg/sm
JA	5	c	nb	192	192	733.33	6716	</= 1 day	3 core mach.
JA	6	c	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 mixer & 1 core mach.
JA	11	c	nb	1800	375.75	1800	1884		1 mixer and 1 core machine
JA	13	c	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	cb	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

TYPICAL CORE / MOLD MAKING OPERATIONS IN OHIO

Collector's Name 1	System Number 2	Core or Mold 3	C. Box or No-Bake 4	Average Sand Thruput (lbs/hr) 6	(TPY) 7	Max Sand Thruput (lbs/hr) 8	(TPY) 9	Range of Time Core Stored 12	Configuration 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		
CS	13	m	nb				10000	(1-3)	10,000 total between 2 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.
JA	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.

OCMA

O CAST METALS ASSOCIATION • 2969 SCIOTO PLACE • COLUMBUS, OHIO 43221 • (614) 876-5100 • FAX (614) 876-3615

March 13, 1997

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

Dear Ms. Hilkens:

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.

Selection 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).

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.

Sincerely,

Russ Murray

Russ Murray
Executive Director

cc: 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

Appendix C
Binder Test Results

Appendix C-1
Test Protocol

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. Record the weight of the bowl plus sand.

3. 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	16.5 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.

6. 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).

Appendix C-2
Supplier Laboratory Results

CONFIDENTIAL

COMPANY: Ashland Chemical - OCMA
ADDRESS: Dublin, Ohio
DATE: 1/8/97
WO#: 10766
Originator: Greg Sturtz
OBJECTIVE: Determine VOC emmisions using "Weight Loss Method" on typical phenolic urethane coldbox and nobake systems from ACME, DELTA and ASHLAND.

SAND: Wedron 540
BALANCE: Mettler PE 16 #E29707

	Mix 1			Mix 2			Mix 3			AVERAGE	
RESIN PT 1	DELTA Techniure A			Borden PUCB I Coldbox			Ashland ISOCURE A			Phenolic Urethane Coldbox	
RESIN PT 2	DELTA Techniure B			Borden PUCB II Coldbox			Ashland ISOCURE B			Binder System	
	Weight	Incremental VOC's	Total VOC's	Weight	Incremental VOC's	Total VOC's	Weight	Incremental VOC's	Total VOC's	Incremental VOC's	Total VOC's
Before 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
At 9 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	0.8
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
At 12 Hour	4177.5	0.0	0.9	4234.0	0.0	0.7	4359.3	0.1	1.2	0.0	0.9

CONFIDENTIAL

COMPANY: Ashland Chemical - OCMA WO#: 10766
ADDRESS: Dublin, Ohio Originator: Greg Sturtz
DATE: 1/8/97
OBJECTIVE: Determine VOC emmisions 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

	Mix 4			Mix 5			Mix 6			AVERAGE	
RESIN PT 1	DELTA Techniset A			Borden PUNB I			Ashland PEP SET A			Phenolic Urethane No-Bake	
RESIN PT 2	DELTA Techniset B			Borden PUNB II			Ashland PEP SET B			Binder System	
	Weight	Incremental VOC's	Total VOC's	Weight	Incremental VOC's	Total VOC's	Weight	Incremental VOC's	Total VOC's	Incremental VOC's	Total VOC's
Before Mix	4298.8	-	-	4347.7	-	-	4346.9	-	-	-	-
After Mix	4298.4	0.4	0.4	4347.1	0.6	0.6	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	0.8	4346.3	0.0	0.6	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
At 3 Hour	4297.9	0.1	0.9	4346.6	0.2	1.1	4346.0	0.1	0.9	0.1	1.0
At 4 Hour	4297.6	0.3	1.2	4346.4	0.2	1.3	4345.8	0.2	1.1	0.2	1.2
At 5 Hour	4297.6	0.0	1.2	4346.4	0.0	1.3	4345.7	0.1	1.2	0.0	1.2
At 6 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	0.1	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	0.1	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
At 12 Hour	4297.1	0.1	1.7	4345.8	0.1	1.9	4345.2	0.0	1.7	0.1	1.8

COMPANY: BORDEN CHEM ICAL, INC.
ADDRESS: FOREST PARK, IL
DATE: 1/27/97
OBJECTIVE: DETERMINE VOC EMISSIONS USING THE OCMA'S SANCTIONED WIEGHT LOSS METHOD ON TYPICAL PHENOLIC URETHANE COLDBOX AND NOBAKE SYSTEMS FROM ASHLAND, BORDEN, AND DELTA

COLD BOX

	Mixture Number 1 Average of Duplicate Runs				Mixture Number 2 Average of Duplicate Runs				Mixture Number 3 Average of Duplicate Runs				AVERAGE	
RESIN PT 1 RESIN PT 2	DELTA TECHNIKURE PT IC DELTA TECHNIKURE PT IID				BORDEN SIGMA CURE 7100 BORDEN SIGMA CURE 7500				ASHLAND ISOCURE IA ASHLAND ISOCURE IIB				Phenolic Urethane Cold Box Binder System	
	Weight	Incremental VOC's	Total VOC's		Weight	Incremental VOC's	Total VOC's		Weight	Incremental VOC's	Total VOC's		Incremental VOC's	Total VOC's
BEFORE MIX	3944.1	-	-		3943.0	-	-		3943.0	-	-		-	-
AFTER 2 MIN MIX	3944.1	0.0	0.0		3942.8	0.0	0.3		3942.8	0.0	0.2		0.0	0.1
30 MIN	3944.0	0.1	0.1		3942.6	0.1	0.4		3942.3	0.5	0.7		0.2	0.4
1 HOUR	3943.9	0.1	0.1		3942.6	0.1	0.4		3942.3	0.0	0.7		0.0	0.4
2 HOUR	3943.7	0.2	0.3		3942.6	0.0	0.4		3942.3	0.0	0.7		0.1	0.5
3 HOUR	3943.6	0.1	0.4		3942.5	0.1	0.6		3942.1	0.2	0.9		0.1	0.6
4 HOUR	3943.5	0.1	0.5		3942.5	0.0	0.6		3942.0	0.1	1.0		0.1	0.7
5 HOUR	3943.5	0.0	0.5		3942.4	0.1	0.6		3941.9	0.1	1.1		0.0	0.7
6 HOUR	3943.5	0.1	0.6		3942.4	0.0	0.6		3941.9	0.0	1.1		0.0	0.8
7 HOUR	3943.5	0.0	0.6		3942.4	0.0	0.6		3941.8	0.1	1.1		0.0	0.8
8 HOUR	3943.4	0.1	0.6		3942.4	0.0	0.6		3941.8	0.0	1.1		0.0	0.8
9 HOUR	3943.4	0.0	0.7		3942.4	0.0	0.6		3941.8	0.1	1.2		0.0	0.8
10 HOUR	3943.3	0.1	0.7		3942.3	0.1	0.7		3941.7	0.1	1.3		0.1	0.9
11 HOUR	3943.3	0.0	0.7		3942.3	0.0	0.7		3941.7	0.0	1.3		0.0	0.9
12 HOUR	3943.3	0.1	0.8		3942.3	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 WIEGHT LOSS METHOD ON TYPICAL PHENOLIC URETHANE COLDBOX AND NOBAKE SYSTEMS FROM ASHLAND, BORDEN, AND DELTA

NO BAKE

	Mixture Number 1 Average of Duplicate Runs				Mixture Number 2 Average of Duplicate Runs				Mixture Number 3 Average of Duplicate Runs			AVERAGE		
:IN PT 1	DELTA TECHNISET PT IA				BORDEN SIGMA SET 6100				ASHLAND PEPSET IA			Phenolic Urethane No Bake Binder System		
RESIN PT 2	DELTA TECHNISET PT IIB				BORDEN SIGMA SET 6500				ASHLAND PEPSET IIB					
	Weight	Incremental VOC's	Total VOC's		Weight	Incremental VOC's	Total VOC's		Weight	Incremental VOC's	Total VOC's		Incremental VOC's	Total 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		3950.2	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[illegible]UR	3949.7	0.1	1.7		3950.0	0.1	1.6		3949.7	0.1	1.5		0.1	1.6

DELTA RESINS & REFRACTORIES

Report Number: (Page 2 of 3) TSR #: 1940-2
Date: 01/05/97
Customer: OCMA

Objective

Assist in establishing a more accurate estimate of the VOC emissions from the mixing, core-making, 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
Sand Type: Wedron 540 I II Sand Temp: 72°F
% Resin: 1.00 Ratio: 55 45

	1	2	3
Part I	SC CB Pt I	TK Pt I C	IC I A
Batch	T-5178	E0210.0	T-5127
Part II	SC CB Pt II	TK Pt II D	IC II B
Batch	T-5179	E0211.0	T-5128

1940-2

Sand Testing Results

	1	2	3
Mixing 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 Wt. Loss	-0.36	-0.46	-0.52
2nd Hr Wt Loss	-0.06	-0.08	-0.09
Cumulative Wt. Loss	-0.42	-0.54	-0.61
3rd Hr Wt Loss	-0.07	-0.08	-0.10
Cumulative 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 Wt Loss	-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
Cumulative Wt. Loss	-0.70	-0.92	-0.97
8th Hr Wt Loss	-0.03	-0.07	-0.05
Cumulative Wt. 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 Wt. 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

DELTA RESINS & REFRACTORIES
TECHNISET - NO BAKE

Report Number: (Page 3 of 3) TSR #: 1940-2
Date: 01/05/97
Customer: OCMA

Objective

Assist in establishing a more accurate estimate of the VOC emissions from the mixing, core-making, 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
Sand Type:	Wedron 540	I / II	Sand Temp:	72°F
% Resin:	1.00	Ratio: 55 / 45	% Cat (BOPt I	3.00

	4	5	6
Part I	TS Pt I A	PS I A	SS NB Pt I
Batch	E0208.0	T-5125	T-5180
Part II	TS Pt II B	PS II B	SS NB Pt II
Batch	E0209.0	T-5126	T-5181
Catalyst	17-737	17-737	17-737
Batch	PT064B	PT064B	PT064B

1940-2 **Sand Testing Results**

	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 Wt. Loss	-0.92	-0.94	-1.12
3rd Hr Wt Loss	-0.14	-0.15	-0.14
Cumulative Wt. Loss	-1.06	-1.09	-1.26
4th Hr Wt Loss	-0.12	-0.15	-0.13
Cumulative Wt. 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 Wt. 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 Wt Loss	-0.08	-0.07	-0.07
Cumulative Wt. Loss	-1.64	-1.72	-1.74
10th Hr Wt Loss	-0.06	-0.06	-0.10
Cumulative Wt. Loss	-1.70	-1.78	-1.84
11th Hr Wt Loss	-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/RLS Originator: Stone

Appendix C-3
Summary of Test Results

PUCB Test Results
% Resin Loss

Time (hou	0.03	0.5	1	2	3	4	5	6	7	8	9	10	11	12
Borden Tests														
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 Tests														
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 Tests														
Borden	0.00	0.00	0.33	0.66	0.66	1.33	1.67	1.00	1.33	1.67	1.67	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

$$\text{VOC Emissions Factor} = \frac{3.26\% \times 30 \text{ g resin} \times 2000\ \#}{100 \times 3000\text{g sand} \times 1 \text{ ton}} = 0.65\ \#\ \text{VOC/ton sand}$$

PUNB (No Bake) Test Results
% Resin Loss

Time (hou	0.03	0.5	1	2	3	4	5	6	7	8	9	10	11	12
Borden Tests														
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 Tests														
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 Tests														
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

$$\text{VOC Emissions Factor} = \frac{5.74\% \times 30.5 \text{ g resin/catalyst} \times 2000 \text{ \#}}{100 \times 3000\text{g sand} \times 1 \text{ ton}} = 1.17 \text{ \# VOC/ton sand}$$

Appendix D
Supporting Calculations

Appendix D-1
Exhaust Ventilation Calculations

PUCB Core Production/Storage (Scenario # 1):

Emission Rate (ER)

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

= 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 $= \frac{40\#VOC}{1 \text{ day}} \times \frac{1 \text{ ton sand}}{0.68 \#VOC}$

= 58.8 ton sand/day

= 7.35 ton sand/hour

Production:

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

= 1.37 #VOC/hour

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

= 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:

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

$$\text{Hourly emission rate per batch} = \frac{58.8 \text{ ton sand}}{1 \text{ day}} \times \frac{1 \text{ day}}{2\text{x}8 \text{ batches}} \times \frac{0.65 \text{ \#VOC}}{1 \text{ ton sand}} \times \frac{71.2}{100} \times \frac{1}{11.5 \text{ hours}}$$

$$= 0.148 \text{ \#VOC per hour per batch}$$

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

$$= \frac{2.11}{60} = 0.035 \text{ \#VOC/minute}$$

Dilution Ventilation (D)

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

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m^3

For C = TLV® x 0.10 = 525 x 0.10 = 52.5 mg/m^3,

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

$$= 1.053 \times 10^6$$

Total airflow rate = $(1.053 \times 10^6) \times (0.035 \text{ \# VOC/minute})$

= 36,855 CFM

Airflow rate through NDO = 10 ft x 10 ft x 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 = $\frac{40\#VOC}{1\ day} \times \frac{1\ ton\ sand}{1.17\ \#VOC}$

= 34.2 ton sand/day

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

= 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)

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m^3

For C = TLV® x 0.10 = 525 x 0.10 = 52.5 mg/m^3,

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

= 1.053×10^6

Total airflow rate = (1.053×10^6) x (0.029 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:

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

Hourly emission rate per batch = $\frac{34.2 \text{ ton sand}}{1 \text{ day}} \times \frac{1 \text{ day}}{2 \text{x} 8 \text{ batches}} \times \frac{1.17 \text{ \#VOC}}{1 \text{ ton sand}} \times \frac{65.5}{100} \times \frac{1}{11.5 \text{ hours}}$

= 0.142 #VOC per hour per batch

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

$= \frac{2.02}{60} =$ 0.034 #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® x 0.10 = 525 x 0.10 = 52.5 mg/m³,

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

$= 1.053 \times 10^6$

Total airflow rate = (1.053×10^6) x (0.034 # VOC/minute)

= 35,802 CFM

Airflow rate through NDO = 10 ft x 10 ft x 200 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 = $\frac{14\#VOC}{1\ hour} \times \frac{1\ ton\ sand}{1.17\ \#VOC}$

= 11.97 tons per hour

= 11.97 x 16 hours/day

= 191.5 tons /day

Production:

VOC Emission Rate = 14 #/hour x $\frac{34.5\%}{100}$ = 4.83 #VOC/hour = 0.081 #VOC/min.

Dilution Ventilation (D)

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

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m³

For C = TLV® x 0.10 = 525 x 0.10 = 52.5 mg/m³,

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

= 1.053×10^6

Total airflow rate = (1.053×10^6) x (0.081# VOC/minute)

= 85,293 CFM

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

= 20,000 CFM

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

Storage:

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

Hourly emission rate per batch = $\frac{192 \text{ ton sand}}{1 \text{ day}} \times \frac{1 \text{ day}}{2\text{x}16 \text{ batches}} \times \frac{1.17 \text{ \#VOC}}{1 \text{ ton sand}} \times \frac{65.5}{100} \times \frac{1}{11.5 \text{ hours}}$

= 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 = $\frac{387 \times 10^6 \times K}{C \times 24.5}$ (AIHA Engineering Field Reference Manual)

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m^3

For C = TLV® x 0.10 = 525 x 0.10 = 52.5 mg/m^3,

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

$= 1.053 \times 10^6$

Total airflow rate = $(1.053 \times 10^6) \times$ (0.148 # VOC/minute)

= 156,204 CFM

Airflow rate through NDO = 10 ft x 10 ft x 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

Emission Rate (ER)

Catalyst emission =

				(100 - 98.5)		
1	ton resin	10	ton catalyst	1.5	2000	lbs
100	ton sand	100	ton resin	100	1	ton

= 0.03 pounds catalyst/ton sand

Overall VOC Emission = 0.65 lbs/ton
+ 0.03 lbs/ton
0.68 lbs VOC/ton sand

=

7.35	ton sand	16	hours
	hours		day

= 117.6 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 (2 x 16)	batches	1	ton sand	100	11.5	hrs

= 0.15 lbs VOC/hr/batch

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

=

3.293	lbs VOC/hr
60	minutes/hr

= 0.055 lbs VOC /minute

Dilution Ventilation (D)

CF air/lbs solvent evaporated = 387 x 10^6 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^3

For C = TLV x 0.10 = 525 x 0.10 = 52.5 mg/m^3

CF air/ lbs solvent evaporated = (387 | 1.E+06 | 3.5) / (52.5 | 24.5)

= 1.053E+06

Total airflow rate = (1.053E+06 | 0.055 lbs VOC) / (minute)

= 57796 CFM

Airflow rate through NDO = (10 feet | 10 feet | 200 feet) / (minute)

= 20000 CFM

Airflow through make-up air distribution system =

57796	CFM
- 20000	CFM
37796	CFM

Scenario 5
PUNB Mold Production/Storage

Production

Sand Throughput = (18 tons sand / 1 hr) × (16 hrs / 1 day)

= 288 tons sand/day

VOC Emission Rate = (18 tons sand / hr) × (1.17 lbs VOC / ton sand) × (34.5 / 100)

= 7.2657 lbs VOC/hr
= 0.121 lbs VOC/min

Dilution Ventilation (D)

CF air/lbs solvent evaporated = $387 \times 10^6 \times K / C \times 24.5$ (AIHA Engineering Field Reference Manual)

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m^3

For C = TLV x 0.10 = 525 x 0.10 = 52.5 mg/m^3

CF air/ lbs
solvent evaporated = (387 / 52.5) × (1.E+06 / 24.5) × 3.5

= 1.053E+06

Total airflow rate 1.053E+06 × (0.121 lbs VOC / minute)

= 127520 CFM

Airflow rate
through NDO (10 feet) × (10 feet) × (200 feet / minute)

= 20000 CFM

Airflow through make-up air distribution system		127520	CFM
	-	20000	CFM
		107520	CFM

Storage

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

Hourly emission rate per batch =

288.0 ton sand	1 day	1.17 lbs VOC	65.5	1
1 day	32 batches (2 x 16)	1 ton sand	100	11.5 hrs

= 0.60 lbs VOC/hr/batch

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

$$= \frac{13.35 \text{ lbs VOC/hr}}{60 \text{ minutes/hr}}$$

= 0.223 lbs VOC /minute

Dilution Ventilation (D)

CF air/lbs solvent evaporated = $387 \times 10^6 \times K / C \times 24.5$ (AIHA Engineering Field Reference Manual)

where K = Mixing Factor (or Safety Factor)
C = Target Workplace Concentration in mg/m^3

For C = TLV x 0.10 = 525 x 0.10 = 52.5 mg/m^3

CF air/ lbs solvent evaporated =

387	1.E+06	3.5
52.5	24.5	

= 1.053E+06

Total airflow rate

1.053E+06	0.223 lbs VOC
	minute

= 234306 CFM

Airflow rate through NDO

10 feet	10 feet	200 feet
		minute

= 20000 CFM

Airflow through make-up air distribution system

	234306	CFM
-	20000	CFM
	214306	CFM

Appendix D-2

Storage Air Emission Calculations

SCENARIO #1
PUCB (Cold Box) Storage Area Emissions

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 #2

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

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 Time (Hours)	Scenario 4 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	2.516
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	3.404
16.5	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

Scenario #5

PUNB Molds Time (Hours)	Scenario 5 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

Appendix E
Supporting Information on Cost Estimates

Appendix E-1
Cost Effectiveness of Scenario Control Alternatives

Recuperative Thermal Oxidizer with 2000 scfm

Annualized Cost Analysis
Scenario 1 - Production Area
Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			110000	Lowest Quote - Vendor F
Auxiliary Equipment/duct to oxidizer			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	6191	
Base Price:			136191	
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
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	
TOTAL 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
OTAL INDIRECT COSTS=			43581	
OTAL CAPITAL COSTS (Direct + Indirect)=			220629	

Annualized Cost Analysis
Scenario 1 - Production Area
Recuperative thermal oxidizer w/2000 scfm ventilation from core machine

Cost Item	Cost($)/unit	Units/year	Cost	Basis of Costs
Direct Operating Costs:				
Operating Labor:				
Operator ($/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			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)
Materials (100% of labor)			5019	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
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 ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	2920	11680	Vendor F Quote (1Mft3/hr x2920hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Vastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			28191	
direct operating (fixed) costs:				
)verhead	80% of O & M(labor)		7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		2206	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		2206	Eng. Guide #46, Table 5-1
dministration	2% of capital costs		4413	Eng. Guide #46, Table 5-1
apital Recovery CRF=	0.156	220629.42	34418	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			50908	
dits				
Product recovery			0	
Heat recovery			0	
TAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			79099	
ontrolled Emissions Rate (tons/year)=			2.3	
Overall (Capture & device eff.)Control				
tem Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.07	
($/ton)=			38212	

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Recuperative Catalytic Oxidizer with 2000 scfm

Annualized Cost Analysis
Scenario 1 - 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:				
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	
Instruments/controls	0.10	1.00	0	Included in quote
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 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 (Direct + Indirect)=			236978	

Annualized Cost Analysis

Scenario 1 - Production Area

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

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 (12ft3 at 650/ft3)=			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	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	20440	1226	Vendor F Quote (7.0 KWH x2920 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	964	3856	Vendor F Quote (0.33Mft3/hr x 2920hrs/yr)
Water			0	
Steam			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			22395	
Indirect operating (fixed) costs:				
Overhead	80% of O & M/labor		7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		2370	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		2370	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		4740	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	236977.51	36968	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			54113	
Credits				
Product recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			76507	
Uncontrolled Emissions Rate (tons/year)=			2.3	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.07	
Cost ($/ton)=			36960	

Carbon Absorption (Disposable/Rechargeable) with 2000 scfm

Annualized Cost Analysis

Scenario 1 - Production Area

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

Cost Item	Average Cost Factor	Adjustment 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 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	0.05	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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Annualized Cost Analysis

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/yr)	$0.06	16555	993	KWH calculated base on Horsepower
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00		0	
Water			0	
Steam			0	
Other			0	
Waste Disposal			136682	No. of carbon changes calculated by using Control Technologies of HAPs handbook
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			152959	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		495	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		495	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		990	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	49508.8	7723	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			17369	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			170328	
Uncontrolled Emissions Rate (tons/year)=			2.3	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.07	
Cost ($/ton)=			82284	

Concentrator/Oxidizer with 37,000 scfm

Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Concentrator/oxidizer w/37,000 scfm ventilation from enclosure around PUCB storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
adsorber/oxidizer, fan controls,stack/duct			650000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure, make-up air and ductwork			147196	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			797196	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	39860	
Freight	0.05	1.00	39860	
Base Price:			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 + 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
Performance Test	0.01	1.00	8769	Estimate for 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	26307	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			271844	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1411834	

Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Concentrator/oxidizer w/37,000 scfm ventilation from enclosure around PUCB storage

Cost Item (\$/unit x units/year) COST				
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):				
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 (\$/10^3ft^{3}x 10^3ft^3/yr)	\$4.00	3559	14236	Vendor C Quote (.5 Mft^3/hr x 7117 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (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)			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.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.50	
Cost (\$/ton)=			98701	

Regenerative Thermal Oxidizer with 37,000 scfm

Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Regenerative Thermal oxidizer w/37,000 scfm ventilation from enclosure for PUCB storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			591782	Lowest Quote - Vendor B
Auxiliary Equipment/enclosure, make-up air and ductwork			147196	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			738978	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	36949	
Freight	0.05	1.00	36949	
Base Price:			812876	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	65030	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	113803	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	32515	Eng Guide #46, Table 4-3
Piping	0.02	1.00	16258	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	8129	Eng Guide #46, Table 4-3
Painting	0.01	1.00	8129	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:			243863	
TOTAL DIRECT COSTS (Base Price + Installation)=			1056739	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	40644	Eng Guide #46, Table 4-3
Construction/field expenses	0.10	1.00	81288	Table 4-3
Construction fee	0.10	1.00	81288	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	16258	Eng Guide #46, Table 4-3
Performance Test	0.012	1.00	9755	Estimate for 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	24386	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			253617	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1310356	

Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Regenerative Thermal oxidizer w/37,000 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	443	11075	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):				
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)			12183	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	861157	51669	vendor(121.0 KWH x7117 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	25621	102484	vendor(3.6Mft3/Hrx7117hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			191255	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		18606	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		13104	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		13104	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		26207	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1310355.79	204416	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			275436	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			466690	
Uncontrolled Emissions Rate (tons/year)=			5	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.50	
Cost ($/ton)=			103709	

Biofilter with 37,000 scfm

Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Biofilter w/37000 scfm for PUCB Core Storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
Biofilter			1496000	Lowest Quote - Vendor E
Auxiliary Equipment/enclosure/make-up air units/ductwork			147196	Eng. Estimate (Appendix E-3)
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 Price + Installation)=			1807516	
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	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
TOTAL INDIRECT COSTS=			280165	
TOTAL CAPITAL COSTS (Direct + Indirect)=			2087681	

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Annualized Cost Analysis
Scenario 1 - Storage Area
Control System: Biofilter w/37000 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 E Estimate
Supervision(15% of labor)			0	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	100	2750	Vendor E Estimate
Materials (100% of labor)			2750	
Replacement parts (as required)			47500	Vendor E Estimate
Labor (100% of parts cost)			47500	
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	244113	14647	vendor (34.3 KWHx7117hrs/yr))
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10^3ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			115147	
Indirect operating (fixed) costs:				
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				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			430499	
Uncontrolled Emissions Rate (tons/year)=			5	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.50	
Cost (\$/ton)=			95666	.

Concentrator/Oxidizer with 30,500 scfm

Annualized Cost Analysis
Scenario 2 - Production
Control System: Concentrator/oxidizer w/30,500 scfm ventilation from enclosure around PUNB core prod.

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			650000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure, make-up air units and ductwork to			246340	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			896340	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	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	0	Eng Guide #46, Table 4-3
Total Installation Costs:			295792	
TOTAL DIRECT COSTS (Base Price + Installation)=			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	

Annualized Cost Analysis
Scenario 2 - Production
Control System: Concentrator/oxidizer w/30,500 scfm ventilation from enclosure around PUNB core prod.

Cost Item	$/unit	units/yr	$/yr	
Direct Operating Costs:				
Operating Labor:				
Operator ($/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			0	
Maintenance (general):				
Labor	27.5	182.5	5019	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 1 shifts/day x 365 days/yr)
Materials (100% of labor)			5019	
Replacement parts (as required)			18000	
Labor (100% of parts cost)			18000	
Utilities:				
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^{3}x 10^3ft^3/yr)	$4.00	1460	5840	Vendor C quote (.5 Mft3/Hr x 2920 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			82353	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		7665	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		15874	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		15874	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		31748	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	1587418.14	247637	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			318799	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			401152	
Uncontrolled Emissions Rate (tons/year)=			2.5	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.25	
Cost ($/ton)=			178290	

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Regenerative Thermal Oxidizer with 30,500 scfm

Annualized Cost Analysis
Scenario 2 - Production
Control System: Regen.Thermal oxidizer w/30,500 scfm ventilation from enclosure for PUNB core prod.

Cost Item	Average Cost Factor	Adjustment 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)
Total Equipment Costs:			818122	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	40906	
Freight	0.05	1.00	40906	
Base Price:			899934	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	71995	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	125991	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	35997	Eng Guide #46, Table 4-3
Piping	0.02	1.00	17999	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	8999	Eng Guide #46, Table 4-3
Painting	0.01	1.00	8999	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:			269980	
TOTAL DIRECT COSTS (Base Price + Installation)=			1169914	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	44997	Eng Guide #46, Table 4-3
Construction/field 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	17999	Eng Guide #46, Table 4-3
Performance Test	0.012	1.00	10799	Estimate for 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	26998	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			280779	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1450694	

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Annualized Cost Analysis

Scenario 2 - Production

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

Cost Item	$/unit	units/yr	cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/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)			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)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	289080	17345	Vendor B (99.0 KWH x2920 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	8468	33872	Vendor B (2.9Mft3/Hrx2920 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			66501	
Indirect operating (fixed) costs:				
Overhead	80% of O & 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	$1,450,694	226308	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			292001	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			358502	
Uncontrolled Emissions Rate (tons/year)=			2.5	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.25	
Cost ($/ton)=			159334	

Biofilter with 30,500 scfm

Anualized Cost Analysis
Scenario 2 - Production
Control System: Biofilter w/30500 scfm for PUNB Core Production

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
Biofilter			1190000	Lowest Quote - Vendor D
Auxiliary Equipment/enclosure/make-up air units/ductwork			246340	Eng. Estimate (Appendix E-3)
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 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 Price + Installation)=			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	
Contingencies	0.03	5.00	236996	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
TOTAL INDIRECT COSTS=			244896	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1824870	

Control System: Biofilter w/30500 scfm for PUNB Core 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):				
Labor	27.5	50	1375	Vendor D Quote
Materials (100% of labor)			1375	
Replacement parts (as required)			39150	Vendor E Estimate of Media Costs
Labor (100% of parts cost)			39150	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	82636	4958	Vendor E Quote (28.3 KWH x 2920 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			86008	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		18249	
Insurance	1% of capital costs		18249	
Administration	2% of capital costs		36497	
Capital Recovery CRF=	0.11	1824869.97	200736	
	(9.0% for 20 years)			vendor eq. life estimate
TOTAL FIXED COSTS (B)=			274830	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			360839	
Uncontrolled Emissions Rate (tons/year)=			2.5	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			2.25	
Cost ($/ton)=			160373	

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Concentration/Oxidizer with 36,000 scfm

Annualized Cost Analysis

Scenario 2 - Storage

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			650000	Lowest Quote - Vendor C
Auxiliary Equipment/enclosure, make-up air units and ductwork to			139201	Eng. Estimate
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:				
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 Price + Installation)=			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 fee	0.10	1.00	86812	Eng Guide #46, Table 4-3
Start-up	0.02	1.00	17362	Eng Guide #46, Table 4-3
Performance Test	0.01	1.00	8681	Estimate for Method 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	26044	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			269118	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1397675	

Annualized Cost Analysis
Scenario 2 - Storage
Control System: Concentrator/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	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2.43 shifts/day x 365 days/yr)
Supervision(15% of labor)			1661	
Operating Materials			0	
Maintenance (general):				
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)			12183	
Replacement parts (as required)			18000	Vendor C quote - annual absorbent cost
Labor (100% of parts cost)			18000	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	1024848	61491	Vendor C quote (144.0 KWH x7117 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	3558	14232	Vendor C quote (0.5Mft3/Hr x7117hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			148824	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		18606	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		13977	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		13977	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		27953	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	$1,397,675	218037	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			292550	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			441374	
Uncontrolled Emissions Rate (tons/year)=			4.8	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.32	
Cost ($/ton)=			102170	

Regenerative Thermal Oxidizer with 36,000 scfm

Annualized Cost Analysis
Scenario 2 - Storage
Control System: Regen.Thermal oxidizer w/36,000 scfm ventilation from enclosure for PUNB core storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan, controls,stack/duc			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	
Installation costs, direct:				
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
Insulation	0.01	1.00	7928	Eng Guide #46, Table 4-3
Painting	0.01	1.00	7928	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:			237825	
TOTAL DIRECT COSTS (Base Price + Installation)=			1030577	
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 (Direct + Indirect)=			1277915	

Annualized Cost Analysis
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	
Maintenance (general):				
Labor	27.5	443	12183	(b) Eng. Guide #46, Table 5-2 (.5 hrs/5 ft x 2.43 shifts/day x 365 days/yr)
Materials (100% of labor)			12183	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	839806	50388	Vendor B (118.0 KWH x7117 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	25621	102484	Vendor B (3.6Mft3/Hrx7117hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			189974	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(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	$1,277,915	199355	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			269077	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			459051	
Uncontrolled Emissions Rate (tons/year)=			4.8	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.32	
Cost ($/ton)=			106262	

Biofilter for 36,000 scfm

Annualized Cost Analysis
Scenario 2 - Storage
Control System: Biofilter for 36,000 scfm/PUNB Core Storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
biofilter			1455000	Lowest Quote - Vendor E
Auxiliary Equipment/enclosure, make up air units & ductwork			139201	Eng. Estimate (Appendix E-3)
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:				
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 Price + Installation)=			1753621	
Installation 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	0.005	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
TOTAL INDIRECT COSTS=			271811	
TOTAL CAPITAL COSTS (Direct + Indirect)=			2025432	

Annualized Cost Analysis
Scenario 2 - Storage
Control System: Biofilter for 36,000 scfm/PUNB Core Storage

Cost Item	$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)	25	0	0	Vendor E estimate
Supervision(15% of labor)			0	
Operating Materials			46200	Vendor E estimate - annual media costs
Maintenance (general):				
Labor	27.5	100	2750	Vendor E quote
Materials (100% of labor)			2750	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	233454	14007	Vendor E quote (32.8 kwh x 7117)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			65707	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		2200	
Property Tax	1% of capital costs		20254	
Insurance	1% of capital costs		20254	
Administration	2% of capital costs		40509	
Capital Recovery CRF=	0.11	$2,025,432	222798	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			306015	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			371722	
Uncontrolled Emissions Rate (tons/year)=			4.8	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.32	
Cost ($/ton)=			86047	

Concentrator/Oxidizer with 85,000 scfm

Annualized Cost Analysis
Scenario 3 - Production
Control System: Concentrator/oxidizer w/85,000 scfm ventilation from enclosure for PUNB mold production

Cost Item	Average Cost Factor	Adjustment 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			468818	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			1768818	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	88441	
Freight	0.05	1.00	88441	
Base Price:			1945700	
Installation costs, direct:				
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 Price + Installation)=			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	

Annualized Cost Analysis
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)			40000	Vendor C Quote
Labor (100% of parts cost)			40000	Eng. guide #46
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	1904000	114240	Vendor C Quote (340 KWH x 5600 hrs/yr
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	6720	26880	Vendor C Quote (1.2 Mft3/Hr x 5600hrs/
Water			0	
Steam			0	
Other			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			250433	
Indirect 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	$3,124,794	487468	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			627160	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			877592	
Uncontrolled Emissions Rate (tons/year)=			13.4	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			12.06	
Cost ($/ton)=			72769	

Regenerative Thermal Oxidizer with 85,000 scfm

Annualized Cost Analysis

Scenario 3 - Production

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

Cost Item	Average Cost Factor	Adjustment 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	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	86475	
Freight	0.05	1.00	86475	
Base Price:			1902450	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	152196	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	266343	Eng Guide #46, Table 4-3
Electrical	0.04	1.00	76098	Eng Guide #46, Table 4-3
Piping	0.02	1.00	38049	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	19025	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 Price + 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	

Annualized Cost Analysis

Scenario 3 - Production

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)			10038	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	1540000	92400	vendor(275 KWH x 5600hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	47040	188160	vendor(8.5Mft3/Hrx 5600hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			311129	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		30553	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		30553	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		61107	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	$3,055,335	476632	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			614176	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			925304	
Uncontrolled Emissions Rate (tons/year)=			13.4	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			12.06	
Cost ($/ton)=			76725	

Biofilter with 85,000 scfm

Annualized Cost Analysis
Scenario 3 - Production
Control System: Biofilter for 85,000 scfm/PUNB Mold Production

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
biofilter		-	2350000	Lowest Quote - Vendor D
Auxiliary Equipment/enclosure, make up air units & ductwork			468818	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			2818818	
Instruments/controls	0.10	1.00	0	Include in quote
Taxes	0.05	1.00	140941	
Freight	0.05	1.00	140941	
Base Price:			3100700	
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 Price + Installation)=			3100700	
Installation 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	
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	

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Annualized Cost Analysis
Scenario 3 - Production
Control System: Biofilter for 85,000 scfm/PUNB Mold Production

Cost Item	$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)	25	0	0	
Supervision(15% of labor)			0	
Operating Materials			109100	Vendor E estimate of annual media costs
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	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	430080	25805	Vendor E Estimate (76.8 KWH x 5600 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			137655	
Indirect operating (fixed) costs:				
Overhead	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	$3,573,557	393091	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			537133	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			674788	
Uncontrolled Emissions Rate (tons/year)=			13.4	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			12.06	
Cost ($/ton)=			55953	

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Concentrator/Oxidizer with 156,000 scfm

Annualized Cost Analysis

Scenario 3 - Storage

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
adsorber/oxidizer, fan controls,stack/duct			2115295	Low Quote - Vendor F scaled (0.7 per eng. guide #46, section 3.2) for 156,000 scfm
Auxiliary Equipment/enclosure, make-up air units and ductwork to			386582	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			2501877	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	125094	
Freight	0.05	1.00	125094	
Base Price:			2752065	
Installation costs, direct:				
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
Painting	0.01	1.00	27521	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:			825619	
TOTAL DIRECT COSTS (Base Price + Installation)=			3577684	
Installation costs, indirect:				
Engineering/supervision	0.05	1.00	137603	Eng Guide #46, Table 4-3
Construction/field 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	
Contingencies	0.03	1.00	82562	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			835252	
TOTAL CAPITAL COSTS (Direct + Indirect)=			4412936	

Annualized Cost Analysis

Scenario 3 - Storage

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

Cost Item (\$/unit x units/year) COST				
Direct Operating Costs:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	525	13125	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 350 days/yr)
Supervision(15% of labor)			1969	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	40	1100	Vendor F Quote
Materials (100% of labor)			1100	
Replacement parts (as required)			0	Vendor F Quote
Labor (100% of parts cost)			0	Eng. guide #46
Utilities:				
Electricity (\$/KWHxKWH/yr)	\$0.06	1486800	89208	Vendor F Quote scaled to 156,000 scfm (177KWH x 8400hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10^3ft^3x 10^3ft^3/yr)	\$4.00	53760	215040	Vendor F Quote scaled for 156,000 scfm (6.4Mft^3/hr x 8400 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			321542	
Indirect operating (fixed) costs:				
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
Insurance	1% of capital costs		44129	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		88259	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	\$4,412,936	688418	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			876315	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1197857	
Uncontrolled Emissions Rate (tons/year)=			25.2	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			22.68	
Cost (\$/ton)=			52816	

Regenerative Thermal Oxidizer with 156,000 scfm

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Annualized Cost Analysis

Scenario 3 - Storage

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

Cost Item	Average Cost Factor	Adjustment 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
Auxiliary Equipment/enclosure, make-up air units and ductwork			386582	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			3548015	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	177401	
Freight	0.05	1.00	177401	
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
Total Installation Costs:			1170845	
TOTAL DIRECT COSTS (Base Price + Installation)=			5073661	
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	
TOTAL CAPITAL COSTS (Direct + Indirect)=			6264020	

Annualized Cost Analysis

Scenario 3 - Storage

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)	$0.06	3948840	236930	(407 KWHx 8400hrs/yr) scaled from vendor quote for 156,000 cfm syst
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	26880	107520	(3.2 Mft3/Hrx8400hrs/yr) scaled from vendor quote scaled for 156,000
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			388419	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		22050	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		62640	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		62640	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		125280	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	$6,264,020	977187	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			1249798	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1638217	
Uncontrolled Emissions Rate (tons/year)=			25.2	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			22.68	
Cost ($/ton)=			72232	

Biofilter with 156,000 scfm

Annualized Cost Analysis
Scenario 3 - Storage
Control System: Biofilter for 156,000 scfm/PUNB Mold Storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
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 Costs:			5155117	
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 Price + Installation**)=			5670629	
Installation 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	0.002	1.00	8506	Estimate for 25A inlet/outlet
Model study	0.00	1.00	0	
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	

Annualized Cost Analysis
Scenario 3 - Storage
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	
Operating Materials			212450	Vendor E Quote
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	
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 ($/10^{3}ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (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	$6,529,729	718270	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			980559	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1267286	
Uncontrolled Emissions Rate (tons/year)=			25.2	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			22.68	
Cost ($/ton)=			55877	

Recuperative Thermal Oxidizer with 2000 scfm Ventilation from Core Machine

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment				
oxidizer, fan controls,stack/duct			110000	Lowest Quote - Vendor F
Auxiliary Equipment/duct to oxidizer			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	6191	
Base Price:			136191	
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
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	
Total Installation Costs:			40857	
TOTAL 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	1.00	4500	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
TOTAL INDIRECT COSTS=			38548	
TOTAL CAPITAL COSTS (Direct + Indirect)=			215596	

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

Cost Item	Cost($)/unit	Units/year	Cost	Basis of Costs
Direct Operating Costs:				
Operating Labor:				
Operator ($/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			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	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	40880	2453	Vendor F Quote (7.0 KWH x 5840 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	5840	23360	Vendor F Quote (1Mft3/hr x 5840 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			56382	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		2156	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		2156	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		4312	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	215596.05	33633	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			57587	
Credits				
Product recovery			0	
Heat recovery			0	
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			113968	
Uncontrolled Emissions Rate (tons/year)=			4.7	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.23	
Cost ($/ton)=	.		26943	

Recuperative Catalytic Oxidizer with 2000 scfm

Annualized Cost Analysis
Scenario 4 - Production Area
Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

Cost Item	Average Cost Factor	Adjustment 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	
Instruments/controls	0.10	1.00	0	Included in quote
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	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			44157	
TOTAL DIRECT COSTS (Base 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	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 (Direct + Indirect)=			232646	

Annualized Cost Analysis
Scenario 4 - Production Area
Control System: Recuperative catalytic oxidizer w/2000 scfm ventilation from core machine

Cost Item	Cost ($)/unit	Units/year	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/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 (CCR=0.26) at 9% for 5 years (12ft3 at 650/ft3)=			2028	Vendor F Quote - 5 year catalyst life
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	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/y	$0.06	40880	2453	Vendor F Quote (7.0 KWH x5840 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	1927	7708	Vendor F Quote (0.33Mft3/hr x 5840 hrs/yr)
Water			0	
Steam			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			42758	
Indirect operating (fixed) costs:				
Overhead	80% of O & M/labor		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		2326	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		2326	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		4653	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	232646.05	36293	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			60929	
Credits				
Product recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			103686	
Uncontrolled Emissions Rate (tons/year)=			4.7	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.23	
Cost ($/ton)=			24512	

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

Annualized Cost Analysis
Scenario 4 - Production Area
Control System: Carbon adsorption (disposable/rechargeable) w/2000 scfm ventilation from core machine

Cost Item	Average Cost Factor	Adjustment 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	
Facilities/buildings	0.00	1.00	0	
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 (Direct + Indirect)=			52462	

Annualized Cost Analysis
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/YR)	25	365	9125	Eng. Guide #46, Table 5-2 (.5 hrs/shft x 2 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	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	33110	1987	Pressure drop 12 inches and 7.6 BHP
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00		0	
Water			0	
Steam			0	
Other			0	
Waste Disposal			301764	Vendor quote ($2.92/lb x 103,344 lbs used)
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			334319	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. Guide #46, Table 5-1
Property Tax	1% of capital costs		525	Eng. Guide #46, Table 5-1
Insurance	1% of capital costs		525	Eng. Guide #46, Table 5-1
Administration	2% of capital costs		1049	Eng. Guide #46, Table 5-1
Capital Recovery CRF=	0.156	52461.65	8184	Eng. Guide #46, Table 5-1
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			25612	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			359932	
Uncontrolled Emissions Rate (tons/year)=			4.7	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			4.23	
Cost ($/ton)=			85090	

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

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
adsorber/oxidizer, fan controls,stack/duct			965000	Vendor F Quote
Auxiliary Equipment/enclosure, make-up air and ductwork			164288	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			1129288	
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	24844	Eng Guide #46, Table 4-3
Insulation	0.01	1.00	12422	Eng Guide #46, Table 4-3
Painting	0.01	1.00	12422	Eng Guide #46, Table 4-3
Site preparation	0.00	1.00	0	
Facilities/buildings	0.00	1.00	0	
Total Installation Costs:			372665	
TOTAL DIRECT COSTS (Base Price + 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	1.00	9000	Estimate for 25a inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	1.00	37267	Eng Guide #46, Table 4-3
TOTAL INDIRECT COSTS=			381665	
TOTAL CAPITAL COSTS (Direct + Indirect)=			1996547	

Annualized Cost Analysis
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:				
Operating Labor:				
Operator (\$/HR X HRS/YR)	25	547	13675	Eng. Guide #46, Table 5-2 (.5 hrs/sht x 3 shts/day x 365
Supervision(15% of labor)			2051	
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	
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 ($\$/10^3ft^3 x 10^3ft^3/yr$)	\$4.00	4380	17520	Vendor Quote (.5 Mft^3/hr x 8760 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
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	
Uncontrolled Emissions Rate (tons/year)=			9.9	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			8.91	
Cost (\$/ton)=			57853	

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

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			1145000	Lowest Quote-Vendor B
Auxiliary Equipment/enclosure, make-up air and ductwork			164288	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			1309288	
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:			432065	
TOTAL DIRECT COSTS (Base Price + Installation)=			1872282	
Installation costs, indirect:				
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	
TOTAL CAPITAL COSTS (Direct + Indirect)=			2313347	

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/yr)	\$0.06	1112520	66751	vendor quote (127 KWH x 8760 hrs/yr)
Fuel oil (\$/gal x gal/yr)			0	
Gas (\$/10^3ft^{3}x 10^3/yr)	\$4.00	37668	150672	vendor(4.3 Mft3/Hrx 8760 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			263234	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		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 5-1
Capital Recovery CRF=	0.108	2313346.88	249841	
	(9.0% for 20 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			365349	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			628584	
Uncontrolled Emissions Rate (tons/year)=			9.9	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			98	
Controlled Emissions (tons/year)=			9.70	
Cost (\$/ton)=			64789	

Biofilter with 58,000 scfm for PUCB Core Storage

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
Biofilter			1988240	Interpolation of Vendor D cost per cfm exhaust for 36,000 and 85,000 cfm systems ($34.28/1000 cfm)
Auxiliary Equipment/enclosure/make-up air units/ductwork			164288	Eng. Estimate (Appendix E-3)
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	
Base Price:			2367781	
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 Price + Installation)=			2367781	
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	1.00	9000	Est. for Method 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	5.00	355167	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
TOTAL INDIRECT COSTS=			364167	
TOTAL CAPITAL COSTS (Direct + 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 ($/$10^3$ft^{3}x 10^3/yr)			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	$2,731,948	300514	
	(9.0% for 20 years)			Vendor E estimate of equipment life
TOTAL FIXED COSTS (B)=			410892	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			585794	
Uncontrolled Emissions Rate (tons/year)=			9.9	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			8.91	
Cost ($/ton)=			65746	

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

Annualized Cost Analysis
Scenario 5 - Production
Control System: Concentrator/oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan controls,stack/duct			1530000	Vendor F Quote
Auxiliary Equipment/enclosure, 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 Price + Installation)=			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 + Indirect)=			3568813	

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

Annualized Cost Analysis
Scenario 5 - Production
Control System: Concentrator/oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

Cost Item	$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)	25	365	9125	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/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/shift x 2 shifts/day x 365 days/yr)
Materials (100% of labor)			10038	
Replacement parts (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)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	6424	25696	Vendor Quote (1.1 Mft3/Hr x 5840 hrs/yr)
Water			0	
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	$3,568,813	556735	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			714817	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			825394	
Uncontrolled Emissions Rate (tons/year)=			21.2	
Overall (Capture & device eff.)Control System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			19.08	
Cost ($/ton)=			43260	

Annualized Cost Analysis
Scenario 5- Production
Control System: Regen.Thermal oxidizer w/127,500 scfm ventilation from enclosure for PUNB mold production

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan, controls,stack/duct			2250000	Lowest quote-vendor B
Auxiliary Equipment/enclosure, make-up air units and ductwork			492621	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			2742621	
Instruments/controls	0.10	1.00	0	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 (Direct + Indirect)=			4836013	

Annualized Cost Analysis
Scenario 5- Production
Control System: Regen.Thermal oxidizer w/127,500 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	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365
Supervision(15% of labor)			1369	
			0	
Maintenance (general):				
Labor	27.5	365	10038	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 2 shifts/day x 365
Materials (100% of labor)			10038	
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 ($/$10^3$ft^{3}x 10^3/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 DIRECT OPERATING COSTS (A)=			350601	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		15330	Eng. 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	$4,836,013	522289	
	(9.0% for 20 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			731060	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1081661	
Uncontrolled Emissions Rate (tons/year)=			21.2	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			98	
Controlled Emissions (tons/year)=			20.78	
Cost ($/ton)=			52063	

Biofilter for 127,500 scfm from PUNB
Mold Production

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

Cost Item	Average Cost Factor	Adjustment 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, make up air units & ductwork			492621	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			4129901	
Instruments/controls	0.10	1.00	0	Include in quote
Taxes	0.05	1.00	206495	
Freight	0.05	1.00	206495	
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
Total Installation Costs:			0	
TOTAL DIRECT COSTS (Base Price + Installation)=			4542891	
Installation 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	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 COSTS (Direct + Indirect)=			5233325	

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):				
Labor	27.5	50	1375	Vendor D Quote
Materials (100% of labor)			1375	
Replacement parts (as required)			162560	Vendor E estimate for annual media replacement costs
Labor (100% of parts cost)			162560	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	570568	34234	Scaled from 85000 cfm system (97.7 KWH x 5840 hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			362104	
Indirect operating (fixed) costs:				
Overhead	80% of O & M(labor)		1100	
Property Tax	1% of capital costs		52333	
Insurance	1% of capital costs		52333	
Administration	2% of capital costs		104666	
Capital Recovery CRF=	0.108	$5,233,325	565199	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			775632	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1137736	
Uncontrolled Emissions Rate (tons/year)=			21.2	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			19.08	
Cost ($/ton)=			59630	

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

Annualized Cost Analysis
Scenario 5 - Storage
Control System: Concentrator/oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
adsorber/oxidizer, fan controls,stack/duct			2800000	Vendor F Quote
Auxiliary Equipment/enclosure, 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 (Direct + 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 ($/unit x units/year)	COST			
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)	25	547	13675	Eng. Guide #46, Table 5-2 (.5 hrs/shift x 3 shifts/day x 365 days/
Supervision(15% of labor)			2051	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	40	1100	Vendor Quote
Materials (100% of labor)			1100	
Replacement parts (as required)			0	
Labor (100% of parts cost)			0	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	2479080	148745	Vendor Quote (283KWH x 8760hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3ft^3/yr)	$4.00	17520	70080	Vendor Quote (2.0 Mft3/hr x 8760 hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			236751	
Indirect operating (fixed) costs:				
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	$5,926,701	924565	
	(9.0% for 10 years)			Eng. guide #46, Table 5-3
TOTAL FIXED COSTS (B)=			1173453	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1410204	
Uncontrolled Emissions Rate (tons/year)=			40.3	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			36.27	
Cost ($/ton)=			38881	

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

Annualized Cost Analysis
Scenario 5 - Storage
Control System: Regen.Thermal oxidizer w/234,500 scfm ventilation from enclosure for PUNB mold storage

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
oxidizer, fan, controls,stack/duct			3500000	Lowest Quote vender B
Auxiliary Equipment/enclosure, make-up air units and ductwork			562330	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			4062330	
Instruments/controls	0.10	1.00	0	Included in quote
Taxes	0.05	1.00	203117	
Freight	0.05	1.00	203117	
Base Price:			4468563	
Installation costs, direct:				
Foundations/Supports	0.08	1.00	357485	Eng Guide #46, Table 4-3
Erection/handling	0.14	1.00	625599	Eng Guide #46, Table 4-3
Electrical	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	
Total Installation Costs:			1340569	
TOTAL DIRECT COSTS (Base Price + Installation)=			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	0	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
TOTAL INDIRECT COSTS=			1349569	
TOTAL CAPITAL COSTS (Direct + Indirect)=			7158701	

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):				
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/yr)	$0.06	4520160	271210	vendor (516 KWHx 8760hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)	$4.00	153300	613200	vendor (17.5 Mft3/Hr x 8760hrs/yr)
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (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	$7,158,701	773140	
	(9.0% for 20 years)			
TOTAL FIXED COSTS (B)=			1082462	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			2012683	
Uncontrolled Emissions Rate (tons/year)=			40.3	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			98	
Controlled Emissions (tons/year)=			39.49	
Cost ($/ton)=			50962	

Biofilter for 234,500 scfm
from PUNB Mold Storage

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

Cost Item	Average Cost Factor	Adjustment Factor	Cost ($s)	Basis of Costs
Direct Costs:				
Basic Equipment:				
'biofilter			6136937	Scaled from Vendor D quote for 165,000 cfm system
Auxiliary Equipment/enclosure, make up air units & ductwork			562330	Eng. Estimate (Appendix E-3)
Total Equipment Costs:			6699267	
Instruments/controls	0.10	1.00	0	Include in quote
Taxes	0.05	1.00	334963	
Freight	0.05	1.00	334963	
Base Price:			7369194	
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 Price + Installation)=			7369194	
Installation 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	0.000	1.00	9000	Estimate for 25A inlet/outlet
Model study	0.00	1.00	0	
Contingencies	0.03	5.00	1105379	Eng Guide #46, Table 4-4, new application of control technology and guaranteed performance
TOTAL INDIRECT COSTS=			1114379	
TOTAL CAPITAL COSTS (Direct + Indirect)=			8483573	

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

Cost Item	$/unit	units/yr	Cost	
Direct Operating Costs:				
Operating Labor:				
Operator ($/HR X HRS/YR)	25	0	0	Vendor D Quote
Supervision(15% of labor)			0	
Operating Materials			0	
Maintenance (general):				
Labor	27.5	50	1375	Vendor D Quote
Materials (100% of labor)			1375	
Replacement parts (as required)			300160	Vendor E Quote for annual media costs ($1.28/cfm)
Labor (100% of parts cost)			300160	
Utilities:				
Electricity ($/KWHxKWH/yr)	$0.06	1594320	95659	165000 cfm system (182.0 kwh x 8760 Hrs/yr)
Fuel oil ($/gal x gal/yr)			0	
Gas ($/$10^3$ft^{3}x 10^3/yr)			0	
Water			0	
Steam			0	
Other			0	
			0	
Waste Disposal				
Wastewater Treatment			0	
TOTAL DIRECT OPERATING COSTS (A)=			698729	
Indirect operating (fixed) costs:				
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	$8,483,573	916226	
	(9.0% for 20 years)			equipment vendor estimate
TOTAL FIXED COSTS (B)=			1256669	
Credits				
Product recovery				
Heat recovery				
TOTAL CREDITS (C)=			0	
TOTAL ANNUALIZED COSTS (A +B minus C)=			1955398	
Uncontrolled Emissions Rate (tons/year)=			40.3	
Overall (Capture & device eff.)Control				
System Efficiency (%)=			90	
Controlled Emissions (tons/year)=			36.27	
Cost ($/ton)=			53912	

Appendix E-2
Vendor Quotes

facsimile

TRANSMITTAL

[redacted]

VENDOR A

Pages: (8) Including this cover sheet

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,

Scenario 1
Phenolic Urethane Cold Box (PUCB) Core Production

Ventilation rate= 2000 scfm   Temperature= ambient
Daily 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# 68477-31-6/64742-95-6 (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))

Control equipment type #1:

Recuperative thermal oxidizer (w/ 50% recovery)

Equipment Costs: Oxidizer = $210,000
Supporting Controls = Included above
Fan = 21,000
ductwork ($/ft) = 55
Total =

Operating info. hourly gas usage (ft3) = 1900 (All scenarios based on 950 BTU/SCFM)
electrical use (Kwh) =25 kw x 8 x 365 = 73,000 kwh (Annual)

Control equipment type #2:

Recuperative Catalytic oxidizer

Equipment Costs: Oxidizer = $170,000
Supporting Controls =Included above
Fan = 17,000
ductwork ($/ft) = 55
Total =

Operating info. hourly gas usage (ft3) =990
electrical use (Kwh) =25 kw x 8x 365 = 73,000 kwh (Annual)
expected catalyst life =

Control Equipment #3 – By Others

Carbon adsorption with off-site disposal:

Equipment costs: carbon adsorber =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
annual carbon usage (lbs) =

Scenario 2 1
Phenolic Urethane Cold Box (PUCB) Core Storage

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
Max. hourly 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# 68477-31-6/64742-95-6 (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))

Control equipment 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 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) = 210
Total =

Operating info. hourly gas usage (ft3) = 990
electrical use (Kwh) = 130 kw x 19.5 x 365 = 925,275 kwh (Annual)
expected catalyst life = 3-5 years

Control Equipment #3 – By Others
Biofiltration:
Equipment Costs Biofilter/structure =
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) =

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

Ventilation rate= 30,500 scfm Temperature= ambient
Daily operating schedule= ~~19.5~~ 8.0 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

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 (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: - 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 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: 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) =

Scenario 4
Phenolic Urethane No Bake (PUNB) Core Storage

Ventilation rate= 36,000 scfm Temperature= ambient
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, 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: – 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 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) = 205
Total =

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 (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =
Operating info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario ~~5~~ 3
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

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 (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: – 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 equipment type #2:
Regenerative Catalytic oxidizer (w/min. 98% 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 (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =
Operating Info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario ~~6~~ 3
Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 165,500 scfm Temperature= ambient
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# 68477-31-6/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumene and trimethylbenzene);
Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
-potential constituents (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: --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 equipment type #2:
Regenerative Catalytic oxidizer (w/min. 98% heat recovery)
Equipment Costs: Oxidizer = $3,075,000
Supporting Controls = Included above
Fan = 220,000
ductwork ($/ft) = 650
Total =

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 =
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) =

VENDOR A
(REVISED)

TRANSMITTAL

[redacted]

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,

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=3.4 lbs/hour (control inlet approx. 5.0 ppmv)
Annual VOC/OC emissions=~~9.5~~ 9.9 tons/year

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 (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	=	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	=	1,000,000
Supporting Controls	=	Included
Fan	=	100,000
Ductwork ($/ft)	=	325
Total	=	

Operating Info. Hourly Gas Usage (ft3)	=	2,560
electrical us (Kwh)	=	350 kw x 24 x 365 = 3,066,000 kwh (annual)
expected catalyst life	=	N.A.

Equipment Supplier Name SMITH ENVIRONMENTAL CORPORATION B01-97-127

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~~ 365 days/year
Max. hourly VOC/OC emissions rate-7.3 lbs/hour (control inlet approx. 5.0 ppmv)
Annual VOC/OC emissions= ~~20.3~~ 21.2 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 (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:

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 ($/ft) =	600
	Total =	

Operating Info.		
	Hourly Gas Usage (ft3) =	5,260
	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

Scenario ~~6~~ 5
Phenolic Urethane No Bake
(PUNB) Mold Storage

Ventilation rate=234,500 scfm Temperature=ambient
Daily operating schedule=24.0 hours/day and ~~350~~ 365 days/year
Max. hourly VOC/OC emissions rate=13.8 lbs/hour (control inlet approx. 5.0 ppmv)
Annual VOC/OC emissions=~~38.6~~ 40.3 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 (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:

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 = 2,600,000
Supporting Controls = Included
Fan = 300,000
Ductwork ($/ft) = 840
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

VENDOR B

Facsimile Transmission

Date: August 4, 1997

Reference Number: Budgetary Scenarios

Number of pages (including cover sheet): 7

Copy to:

Subject: Phenolic Urethane Core Budgetary Analysis

Thank you for your interest in and it's products. I am pleased to provide you with the budgetary numbers that you inquired about. Please do not hesitate to call if there is any additional information or cutsheets that I can supply for your report. I look forward to hearing about any progress that may transpire from the data.

Sincerely,

Scenario 1
Phenolic Urethane Cold Box (PUCB) Core Production

Ventilation rate= 2000 scfm Temperature= ambient
Daily 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# 68477-31-6/64742-95-6 (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))

Control equipment type #1:

✓ Recuperative thermal oxidizer (w/ 50% recovery)

Equipment Costs:	Oxidizer	=	132,000
	Supporting Controls	=	15,000
	Fan	=	3,000
	ductwork ($/ft)	=	----
	Total	=	150,000
Operating info.	hourly gas usage (ft3)	=	1.35 mmbtu
	electrical use (Kwh)	=	5.34

Control equipment type #2:

Recuperative Catalytic oxidizer

Equipment Costs:	Oxidizer	=	160,000
	Supporting Controls	=	15,000
	Fan	=	3,000
	ductwork ($/ft)	=	
	Total	=	178,000
Operating info.	hourly gas usage (ft3)	=	
	electrical use (Kwh)	=	
	expected catalyst life	=	

Control Equipment #3

Carbon adsorption with off-site disposal:

Equipment costs:	carbon adsorber	=	
	Supporting Controls	=	
	Fan	=	
	ductwork ($/ft)	=	
	Total	=	
Operating info.	hourly gas usage (ft3)	=	
	electrical use (Kwh)	=	
	annual carbon usage (lbs)	=	

Scenario ~~2~~ 1
Phenolic Urethane Cold Box (PUCB) Core Storage

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

Max. hourly 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# 68477-31-6/64742-85-6 (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))

Control equipment type #1:

Concentrator

Equipment Costs:	adsorber/Oxidizer =	752,716
	Supporting Controls =	18,982
	Fan =	10,000
	ductwork ($/ft) =	-----
	Total =	781,698

Operating info.	hourly gas usage (ft3) =	1.9 mmbtu
	electrical use (Kwh) =	68
	annual adsorbent cost ($) =	One-time inclusive cost (self-regenerative
	annual maintenance (man-hours)=	60

Control equipment type #2: Thermal

Regenerative ~~Catalytic~~ oxidizer (w/min. 98% heat recovery)

Equipment Costs:	Oxidizer =	560,000
	Supporting Controls =	18,982
	Fan =	12,800
	ductwork ($/ft) =	---
	Total =	591,782

Operating info.	hourly gas usage (ft3) =	3.67 mmbtu
	electrical use (Kwh) =	121
	expected ~~catalyst~~ /media life =	7 yrs

Control Equipment #3

Biofiltration:

Equipment Costs	Biofilter/structure =	
	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) =	

Scenario ~~3~~ 2
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

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 (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	= 727,325
	Supporting Controls	= 18,982
	Fan	= 9,000
	ductwork ($/ft)	=
	Total	= 755,307

Operating info.	hourly gas usage (ft3)	= 1.4 mmbtu
	electrical use (Kwh)	= 57
	annual adsorbent cost ($)	= 0.00
	annual maintenance (man-hours)	= 60

Control equipment type #2:

Regenerative ~~Catalytic~~ thermal 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 (ft3)	= 2.92 mmbtu
	electrical use (Kwh)	= 99
	expected ~~catalyst~~ Media 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)	=

Scenario ~~1~~ 2
Phenolic Urethane No Bake (PUNB) Core Storage

Ventilation rate= 36,000 scfm Temperature= ambient
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, 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 = 738,372
Supporting Controls = 18,982
Fan = 9,800
ductwork ($/ft) = ____________
Total = 767,154

Operating info. hourly gas usage (ft3) = 1.8 mmbtu
electrical use (Kwh) = 64
annual adsorbent cost ($) = 0.00
annual maintenance (man-hours)= 60

Control equipment type #2:

Regenerative ~~Catalytic~~ thermal oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer = 551,000
Supporting Controls = 18,982
Fan = 11,500
ductwork ($/ft) = ____________
Total = 581,482

Operating info. hourly gas usage (ft3) = 3.63 mmbtu
electrical use (Kwh) = 118
expected ~~catalyst~~ media 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) =

Scenario ~~5~~ 3
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 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 (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

Equipmentl Costs:	adsorber/Oxidizer	=	1,300,000
	Supporting Controls	=	18,982
	Fan	=	32,000
	ductwork ($/ft)	=	
	Total	=	1,350,982

Operating info.	hourly gas usage (ft3)	=	4.28	mmbtu
	electrical use (Kwh)	=	161	
	annual adsorbent cost ($)	=	0.00	
	annual maintenance (man-hours)	=	80	

Control equipment type #2:

Regenerative ~~Catalytic~~ thermal oxidizer (w/min. 98% heat recovery)

Equipment Costs:	Oxidizer	=	1,200,000
	Supporting Controls	=	18,982
	Fan	=	41,700
	ductwork ($/ft)	=	
	Total	=	1,260,682

Operating info.	hourly gas usage (ft3)	=	8.48 mmbtu
	electrical use (Kwh)	=	275
	expected ~~catalyst~~ /media 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)	=

Scenario 6

Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 165.500 scfm Temperature= ambient
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# 68477-31-6/64742-95-8 (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 referance test methods (40 CFR Part 60))

Control equipment type #1:

Concentrator

Equipment Costs: adsorber/Oxidizer	=	2,400,000
Supporting Controls	=	32,000
Fan	=	56,000
		2,488,000

Hourly Fuel = 8.67 mmbtu
Hourly Electric 317 kw

Vendor B

FAXED

Fax

Inc.

Facsimile Transmission

Date:	March 11, 1998	Reference Number:	
To:	Dave Newsad	From:	
Company:	Residuals Management Tech., Inc.	Department:	
Phone:	614-793-0026	Phone:	
Fax:	614-793-0151	Fax:	
Number of pages (Including cover sheet):	4	Copy to:	
Subject:	Budgetary analysis for additional scenario's		

Dear Mr. Newsad,

The attached are the budgetary quotes for the additional scenarios that you had forwarded to Karl. As with all abatement equipment, all devices are contingent of final analysis of the process stream being treated.

If you have any questions regarding the control devices or numbers presented, please give me a call.

Best regards,

Marketing Coordinator

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-3.4 lbs/hour (control inlet approx. 5.0 ppmv)
Annual VOC/OC emissions=9.9 tons/year

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 (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/OXIDIZER
Equipment Costs: Adsorber/Oxidizer = 1,150,000
Supporting Controls = INCL.
Fan = INCL.
Ductwork ($/ft) = —
Total = 1,150,000

Operating Info. Hourly Gas Usage ([redacted]) =0.4 mmBTU/HR
electrical us (Kwh) =56 kwh
annual adsorbent cost ($) = 0.00
annual maintenance (man-hours) = 70 HRS

Control Equipment Type #2:
Regenerative Thermal Oxidizer (w/min. 98% ~~heat recovery~~ DESTRUCTION EFFIC.)
Equipment Costs: Oxidizer = 1,145,00
Supporting Controls = INCL.
Fan = INCL
Ductwork ($/ft) = —
Total = 1,145,000

Operating Info. Hourly Gas Usage ([redacted]) =4.3 mmBTU/HR
electrical us (Kwh) =127 kwh
~~expected catalyst life~~ = N/A

Equipment Supplier Name ____________________

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 inlet approx. 5.0 ppmv)
Annual VOC/OC emissions=20.3 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 (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:
Concentrator

Equipment Costs:		
Adsorber/Oxidizer	=	2,400,000
Supporting Controls	=	INCL.
Fan	=	INCL.
Ductwork ($/ft)	=	—
Total	=	2,400,000

Operating Info.		
Hourly Gas Usage (~~CF~~)	=	0.9 mmBTU/HR
electrical us (Kwh)	=	122 kwh
annual adsorbent cost ($)	=	0.00
annual maintenance (man-hours)	=	140 HRS.

Control Equipment Type #2:
Regenerative Thermal Oxidizer (w/min. 98% heat recovery)

Equipment Costs:		
Oxidizer	=	2,250,000
Supporting Controls	=	INCL.
Fan	=	INCL.
Ductwork ($/ft)	=	—
Total	=	2,250,000

Operating Info.		
Hourly Gas Usage (~~CF~~)	=	9.5 mm BTU/HR
electrical us (Kwh)	=	280 kwh
~~expected catalyst life~~	=	N/A

Equipment Supplier Name ______________________

Scenario 5
Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate=234,500 scfm 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 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 (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:

Concentrator

Equipment Costs: Adsorber/Oxidizer = 3,500,000
Supporting Controls = INCL.
Fan = INCL.
Ductwork ($/ft) = —
Total = INCL.

Operating Info. Hourly Gas Usage (~~$~~) = 1.6 mm BTU/HR
electrical us (Kwh) = 225 kwh
annual adsorbent cost ($) = 0.00
annual maintenance (man-hours) = 250 HRS.

Control Equipment Type #2:

Regenerative Thermal Oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer = 3,450,000
Supporting Controls = INCL.
Fan = INCL.
Ductwork ($/ft) = —
Total = 3,450,000

Operating Info. Hourly Gas Usage (~~$~~) = 17.5 mmBTU/HR
electrical us (Kwh) = 516 kwh
~~expected catalyst life~~ = NA

Equipment Supplier Name ____________

Vendor C

FACSIMILE COVERSHEET

DATE: 8/8/97 OUR REFERENCE NUMBER: ____________

TO: ____________

COMPANY: ____________

FAX NO: ____________

FROM: ____________

RE: UOC/OC EQUIPMENT COST ESTIMATE REQUEST

NUMBER OF PAGES, INCLUDING COVERSHEET: 7

NOTE: ____________

PLEASE NOTE: If you have any problems with the transmission, please call us immediately at

M-P Files/faxcvr.fax

Scenario 1
Phenolic Urethane Cold Box (PUCB) Core Production

Ventilation rate= 2000 scfm Temperature= ambient
Daily 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# 68477-31-6/64742-95-6 (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))

Control equipment type #1:

Recuperative thermal oxidizer (w/ 50% recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
} 120,000
ductwork ($/ft) =
Total =

Operating Info. hourly gas usage (ft3) = 1,500,000
electrical use (Kwh) = ?

Control equipment type #2:

Recuperative Catalytic oxidizer

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
} 120,000
ductwork ($/ft) =
Total =

Operating Info. hourly gas usage (ft3) = 300,000
electrical use (Kwh) = 7
expected catalyst life = 6 yrs

Control Equipment #3

Carbon adsorption with off-site disposal: DO NOT BUILD

Equipment costs: carbon adsorber =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

Operating Info. hourly gas usage (ft3) =
electrical use (Kwh) =

Scenario 2
Phenolic Urethane Cold Box (PUCB) Core Storage

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
Max. hourly 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# 68477-31-6/64742-95-6 (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))

Control equipment type #1:

Concentrator

Equipment Costs: adsorber/Oxidizer = } $650,000
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating Info. hourly gas usage (ft3) = 100,000 BTU/HR
electrical use (Kwh) = 144
annual adsorbent cost ($) = 78,000
annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration:

Equipment Costs Biofilter/structure =
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) =

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

Ventilation rate= 30,500 scfm | Temperature= ambient

Daily operating schedule= ~~19.5~~ 8 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

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 (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 =
Supporting Controls = } $650,000
Fan =
ductwork ($/ft) = ___________
Total =

Operating info. hourly gas usage (ft3) = 500,000 BTU/hr
electrical use (Kwh) = 177
annual adsorbent cost ($) = $8,000
annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ___________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

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) =

Scenario 4

Phenolic Urethane No Bake (PUNB) Core Storage

Ventilation rate= 38,000 scfm Temperature= ambient
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, 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 = } $ 650,000
Supporting Controls =
Fan =
ductwork ($/ft) = ________
Total =

Operating Info. hourly gas usage (ft3) = 500,000 BTU/HR
electrical use (Kwh) = 144
annual adsorbent cost ($) = 98,000
annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery) DO NOT BUILD

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration: DO NOT BUILD

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) =

Scenario ~~5~~ 3
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 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 (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 = } 1,300,000
Supporting Controls = }
Fan = }
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) = 1,200,000
electrical use (Kwh) = 340
annual adsorbent cost ($) = 40,500
annual maintenance (man-hours) =

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

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) =

Scenario 3

Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 165,500 scfm Temperature= ambient
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# 68477-31-6/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumene and trimethylbenzene);
Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
-potential constituents (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 = } $2,400,000
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) = 2,400,000
electrical use (Kwh) = 640
annual adsorbent cost ($) = 50,000
annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

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) =

VENDOR D

August 4, 1997

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	$\$1.5 \times 10^{-6}$
Scenario 3	30,500 ACFM	$\$1.19 \times 10^{-6}$
Scenario 4	36,000 ACFM	$\$1.47 \times 10^{-6}$
Scenario 5	85,000 ACFM	$\$2.35 \times 10^{-6}$
Scenario 6	165,000 ACFM	$\$4.97 \times 10^{-6}$

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

Very truly yours,

GM:ew

VENDOR E

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,

Scenario ~~2~~ 1
Phenolic Urethane Cold Box (PUCB) Core Storage

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
Max. hourly 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# 68477-31-6/64742-95-6 (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))

<u>Control equipment type #1:</u>
<u>Concentrator</u>
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)=

<u>Control equipment type #2:</u>
<u>Regenerative Catalytic oxidizer (w/min. 98% heat recovery)</u>
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

<u>Control Equipment #3</u>
<u>Biofiltration:</u>
Equipment Costs Biofilter/structure = $1,496,000.00
Installation Costs (turnkey) = INC
Supporting Controls = INC
Fan = INC
ductwork ($/ft) = N/A
Total = 1,496,000.00
Operating info. electrical use (Kwh) = 343
annual media costs ($) = $47,500.00
annual maintenance (man-hrs) = 100
estimated size (length x width) = 60' x 114'

Scenario ~~3~~ 2
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

OC/VOC composition ranges=Petroleum Distillates CAS# 68477-31-6/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumane 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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3
Biofiltration:
Equipment Costs: Biofilter/supports = $1,370,000.00
Installation Costs (turnkey) = INC
Supporting Controls = INC
Fan = INC
ductwork ($/ft) = N/A
Total = $1,370,000.00
Operating info. electrical use (Kwh) = 26.3
annual media costs ($) = $39,150.00
annual maintenance (man-hrs) = 100
estimated size (length x width) = 60' x 94'

Scenario ~~4~~ 3
Phenolic Urethane No Bake (PUNB) Core Storage

Ventilation rate= 36,000 scfm Temperature= ambient
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, 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))

<u>Control equipment type #1:</u>

<u>Concentrator</u>

Equipmentl 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)=

<u>Control equipment type #2:</u>

<u>Regenerative Catalytic oxidizer (w/min. 98% heat recovery)</u>

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

<u>Control Equipment #3</u>

<u>Biofiltration:</u>

Equipment Costs Biofilter/supports = $1,455,000.00
Installation Costs (turnkey) = INC
Supporting Controls = INC
Fan = INC
ductwork ($/ft) = N/A
Total = $1,455,000.00

Operating Info. electrical use (Kwh) = 32.8
annual media costs ($) = 46,200
annual maintenance (man-hrs) = 100
estimated size (length x width) = 60' x 111'

Scenario ~~5~~ 3
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 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 (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

Equipmentl 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 equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration:

Equipment Costs: Biofilter/supports = $2,946,000
Installation Costs (turnkey) = Inc
Supporting Controls = Inc
Fan = Inc.
ductwork ($/ft) = N/A
Total = $2,946,000.00

Operating info. electrical use (Kwh) = 768
annual media costs ($) = $107,100.00
annual maintenance (man-hrs) = 200
estimated size (length x width) = 120' x 131'

Scenario ~~8~~ 3
Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 165,500 scfm Temperature= ambient
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# 68477-31-6/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumene and trimethylbenzene);
Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
-potential constituents (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 = } $2,400,000
Supporting Controls = }
Fan = }
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) = 2,400,000
electrical use (Kwh) = 640
annual adsorbent cost ($) = 50,000
annual maintenance (man-hours)=

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) = ____________
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

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) =

VENDOR F

FAX TRANSMISSION

To:	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.

Scenario 1
Phenolic Urethane Cold Box (PUCB) Core Production

Ventilation rate= 2000 scfm Temperature= ambient
Daily 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# 68477-31-6/64742-95-6 (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))

Control equipment type #1: 65%

Recuperative thermal oxidizer (w/ ~~50%~~ recovery)
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $110,000

Operating info. hourly gas usage (ft3) = 1000
electrical use (Kwh) = 17

Control equipment type #2:

Recuperative Catalytic oxidizer
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $120,000

Operating info. hourly gas usage (ft3) = 330
electrical use (Kwh) = 7
expected catalyst life = 5 yr.

Control Equipment #3

Carbon adsorption with off-site disposal: N/A
Equipment costs: carbon adsorber =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
annual carbon usage (lbs) =

Scenario ~~2~~ 1

Phenolic Urethane Cold Box (PUCB) Core Storage

Ventilation rate= 37,000 acfm Temperature= ambient
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

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))

Control equipment type #1:

Concentrator

Equipment Costs: adsorber/Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $1,050,000

Operating info. hourly gas usage (ft3) = 1,490
electrical use (Kwh) = 143
annual adsorbent cost ($) = 0
annual maintenance (man-hours)= 40

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration:

Equipment Costs Biofilter/structure =
Installation Costs (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario ~~1~~ 2
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

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 (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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $785,000

Operating info. hourly gas usage (ft3) = 1,220
electrical use (Kwh) = 36
annual adsorbent cost ($) = 0
annual maintenance (man-hours)= 40

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration:

Equipment Costs: Biofilter/supports =
Installation Costs (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario ~~4~~ 2
Phenolic Urethane No Bake (PUNB) Core Storage

Ventilation rate= 36,000 acfm — Temperature= ambient
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# 68477-31-8/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumene and trimethylbenzene);
Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
-potential constituents (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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $1,050,000

Operating info. hourly gas usage (ft3) = 1,490
electrical use (Kwh) = 43
annual adsorbent cost ($) = 0
annual maintenance (man-hours)= 40

Control equipment type #2:
Regenerative Catalytic oxidizer (w/min. 98% heat recovery)
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3
Biofiltration:
Equipment Costs Biofilter/supports =
Installation Costs (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario ~~5~~ 3
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 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 (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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $1,400,000

Operating info. hourly gas usage (ft3) = 3,400
electrical use (Kwh) = 96
annual adsorbent cost ($) = 0
annual maintenance (man-hours)= 40

Control equipment type #2:
Regenerative Catalytic oxidizer (w/min. 98% heat recovery)
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3
Biofiltration:
Equipment Costs: Biofilter/supports =
Installation Costs (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

Scenario 3

Phenolic Urethane No Bake (PUNB) Mold Storage

Ventilation rate= 185,500 scfm Temperature= ambient
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# 68477-31-6/64742-95-6 (approx. 50% by weight)
-potential constituents (xylene, cumene and trimethylbenzene);
Petroleum Distillates CAS# 647-742-94-5 (approx. 50% by weight)
-potential constituents (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 =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total = $ 2,200,000

Operating Info. hourly gas usage (ft3) = 6,700
electrical use (Kwh) = 184
annual adsorbent cost ($) = 0
annual maintenance (man-hours)= 40

Control equipment type #2:

Regenerative Catalytic oxidizer (w/min. 95% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating Info. hourly gas usage (ft3) =
electrical use (Kwh) =
expected catalyst life =

Control Equipment #3

Biofiltration:

Equipment Costs: Biofilter/supports =
Installation Costs (turnkey) =
Supporting Controls =
Fan =
ductwork ($/ft) =
Total =

N/A

Operating Info. electrical use (Kwh) =
annual media costs ($) =
annual maintenance (man-hrs) =
estimated size (length x width) =

VENDOR (REVISED)

Date: February 20, 1998

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

From:

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   Temperature=ambient
Daily operating schedule=24.0 hours/day and 365 days/year
Max. hourly VOC/OC emissions rate-3.4 lbs/hour (control inlet approx. 5.0 ppmv)
Annual VOC/OC emissions=~~9.5~~ 9.9 tons/year

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 (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 = $965,000

Operating Info. Hourly Gas Usage (ft3) = 504
electrical us (Kwh) = 72
annual adsorbent cost ($) = 0
annual maintenance (man-hours) = 40

Control Equipment Type #2:
Regenerative Thermal Oxidizer (w/min. 98% heat recovery)
Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
Ductwork ($/ft) =
Total =

N/A

Operating Info. Hourly Gas Usage (ft3) =
electrical us (Kwh) =
expected catalyst life =

Equipment Supplier Name CSM ENVIRONMENTAL SYSTEMS

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~~ 365 days/year

Max. hourly VOC/OC emissions rate-7.3 lbs/hour (control inlet approx. 5.0 ppmv)

Annual VOC/OC emissions=~~20.3~~ 21.2 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 (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:

Concentrator

Equipment Costs: Adsorber/Oxidizer =
Supporting Controls =
Fan =
Ductwork ($/ft) =
Total = $1,530,000

Operating Info. Hourly Gas Usage (ft3) = 1111
electrical us (Kwh) = 155
annual adsorbent cost ($) = 0
annual maintenance (man-hours) = 40

Control Equipment Type #2:

Regenerative Thermal Oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer =
Supporting Controls =
Fan =
Ductwork ($/ft) =
Total =

N/A

Operating Info. Hourly Gas Usage (ft3) =
electrical us (Kwh) =
expected catalyst life =

Equipment Supplier Name CSM ENVIRONMENTAL SYSTEMS

Scenario 5
Phenolic Urethane No Bake
(PUNB) Mold Storage

Ventilation rate=234,500 scfm 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~~ 40.3 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 (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:

Concentrator

Equipment Costs: Adsorber/Oxidizer	=	
Supporting Controls	=	
Fan	=	
Ductwork ($/ft)	=	
Total	=	$2,800,000
Operating Info. Hourly Gas Usage (ft3)	=	2039
electrical us (Kwh)	=	283
annual adsorbent cost ($)	=	0
annual maintenance (man-hours)	=	40

Control Equipment Type #2:

Regenerative Thermal Oxidizer (w/min. 98% heat recovery)

Equipment Costs: Oxidizer	=	N/A.
Supporting Controls	=	
Fan	=	
Ductwork ($/ft)	=	
Total	=	
Operating Info. Hourly Gas Usage (ft3)	=	
electrical us (Kwh)	=	
expected catalyst life	=	

Equipment Supplier Name CSM ENVIRONMENTAL SYSTEMS

010225

VENDOR G

FACSIMILE MESSAGE

TO: FROM:

DATE: August 11, 1997 TIME: 4:30 pm

FAX #: (614) 793-0151 PAGE: 1 of 3

SUBJECT: <u>ACTIVATED CARBON UNIT</u>

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 2 units

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,

Attn:

Customer:
Address:
Address:
Subject:
Attn:
FAX: 614-793-0151
Date: 8-13-97

ON—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 supersacks or tote bins.)

Recharging the vessels is accomplished via supersacks and crane on the carbon service truck, or via emptying drums or smaller bags.

On-site carbon 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 must 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-RCRA) OR $1,000.00 if RCRA Hazardous (RCRA).

The following information is required to estimate the costs for conducting on-site carbon exchange service:

1. SITE LOCATION — Columbus, Ohio 43210
2. TYPE OF CARBON REQUIRED — ☐ Liquid ☒ Vapor — ☒ Virgin ☐ Reactivated
3. NUMBER OF VESSELS — 1
   POUNDS OF CARBON PER VESSEL — 2000 lbs
   LOCATION OF VESSELS — ☐ Inside ☒ Outside
   VESSEL ACCESSIBLE — ☒ Yes ☐ No (Provide sketch of vessel layout.)
4. SPENT CARBON TO BE — ☒ Non-Hazardous ☐ RCRA Hazardous

Please provide the above information to your Calgon Carbon Representative to obtain a quotation for providing On-Site Carbon Exchange Services.

QUOTE: Price: $3.05/lb on 2,000 lbs Does Not Include Any Applicable Sales Tax.

INCLUDES:
- ☒ The price for Service Only.
- ☒ The price of Fresh Carbon and the freight charges.
- ☒ The price of the Containers used to Return the Spent Carbon. 10 metal drums
- ☒ The Carbon Acceptance Fee. one time fee - $400.00 Non-RCRA
- ☒ The price of the Freight Charges to ship the Spent Carbon to one of the Reactivation Centers — ☒ Non-Hazardous ☐ RCRA Hazardous

note → ☐ Fork Lift ☐ Included in the price. ☒ Provided by Customer

TERMS ARE NET 30 DAYS.

Note: After the first changeout, the price would be $2.92/lb (this does not include the Carbon Acceptance Fee).

(sign and date)

Appendix E-3

Enclosure, Ductwork and Make-Up Air Cost Estimates

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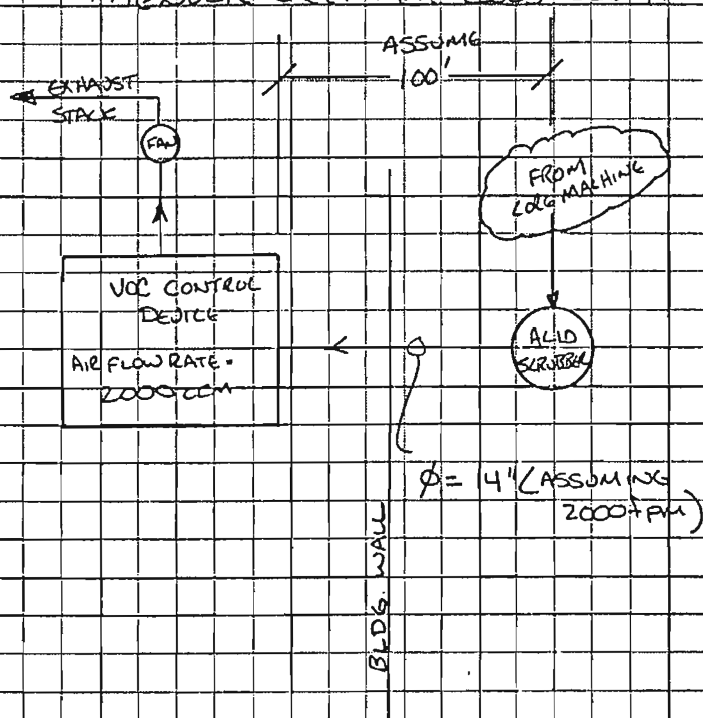
COMPUTATION SHEET

PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	By: LEO	Date: 8/6/97	By: SEO	Date: 8/8	00-02211.04

(CSS)

SCENARIO #1 (Scenario #1 - Production)

PHENOLIC URETHANE COLD BOX (PUCB) CORE PRODUCTION



∴ 100' @ 14" ϕ = 366.52 FT² ✓ OF GALVANIZED STEEL (ASSUMED)

→ FROM SMACNA, ASSUMING CLASS 4 STEEL DUCTWORK BECAUSE OF POTENTIAL FOR SOME SAND CARRYOVER, USE 14 ga. @ 2.5#/FT³ ✓

∴ 366.52 FT² @ 14 ga (3.2825#/FT²) = 1,203#

FROM MEANS 1997 MECHANICAL COST DATA, COST OF GALVANIZED STEEL DUCTWORK IS

\$4.34/Lb. (INCLUDING MATERIAL, LABOR, OVERHEAD, & PROFIT)

+ 15% FOR ELEVATION 20' TO 25' HIGH

+ 15% FOR DESIGN & DETAILING

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COMPUTATION SHEET

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OCMA - OC/UOC STUDY	LEO	8/6/97	SCD	8/8	00-02211.04

(CSS)

∴ ESTIMATED COSTS FOR SCENARIO #1 (Scenario #1 - Production)

• DUCTWORK

= (1,203#) ($4.34/#) (1.15) (1.15) = $6,905 ✓

• EQUIPMENT ENCLOSURE

SOME ADDITIONAL COSTS WOULD BE INCURRED TO BETTER ENCLOSE THE MIXING & HOPPER AREAS OF THE CORE MACHINE TO IMPROVE CAPTURE. THESE COST ARE ASSUMED TO BE APPROXIMATELY EQUAL TO THE DUCTWORK

∴ TOTAL COST ≅ $6,905 x 2 = $13,810 ✓

(CSS)

∴ TOTAL OPTION #1 (Scenario #1 - Production)

≅ $13,810 ✓

COMPUTATION SHEET

RMT

SHEET 3 OF 17

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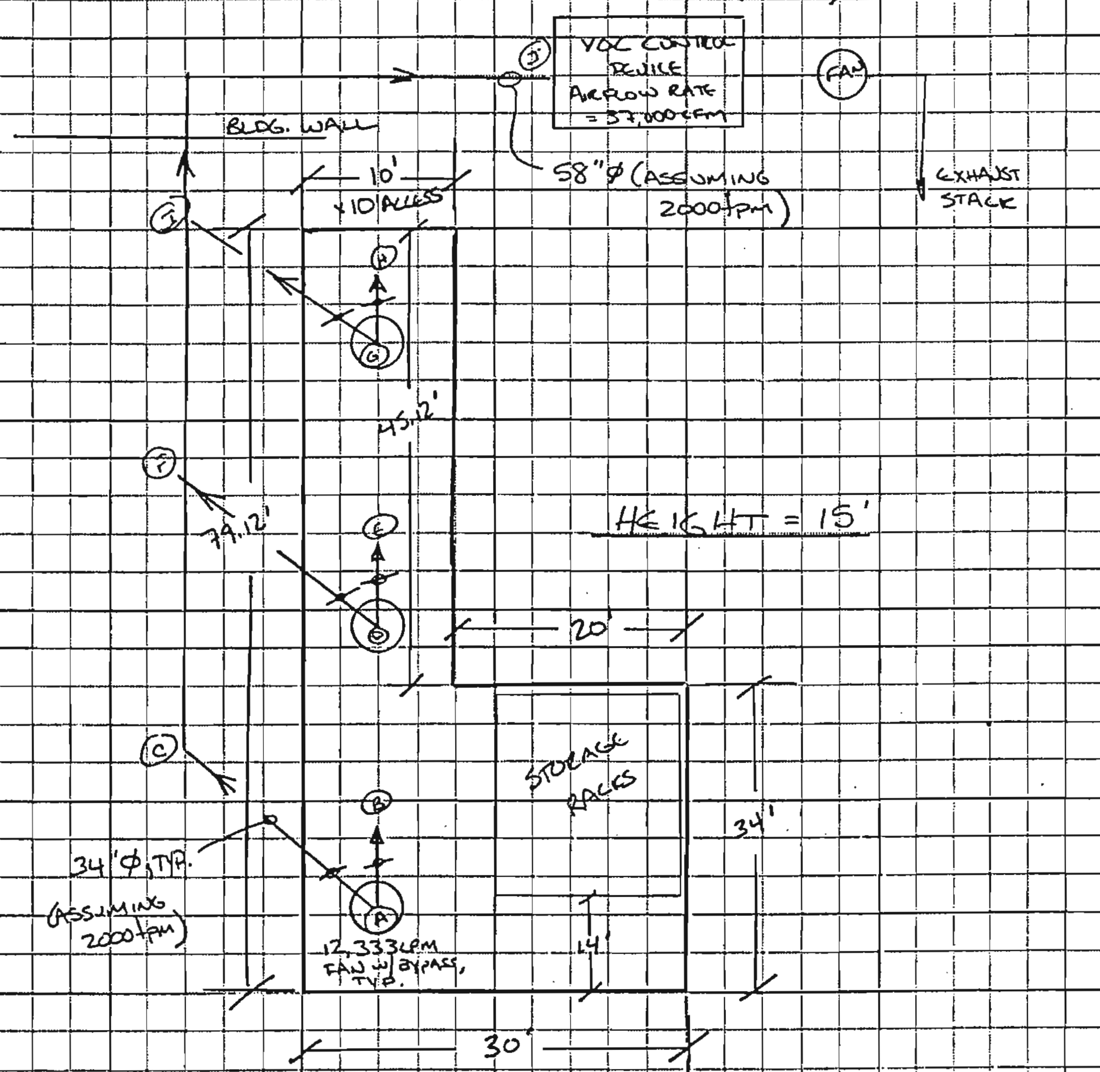
PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	By: LEO	Date: 8/6/97	By: SCD	Date: 8/8	00-02211.04

SCENARIO #2 (Scenario #1 - Storage) (CSS)

PHENOLIC URETHANE COLD BOX (PUCB) CORE STORAGE



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OCMA - OC/VOC STUDY	By: LGO	Date: 8/6/97	By: SGP	Date: 8/8	00-0221.04

CSS

ESTIMATED COSTS FOR SCENARIO #2 (Scenario #1 - Storage)

- DUCTWORK

SEGMENT	Ø	GAUGE	LENGTH	AREA	WEIGHT
A-B	34"	14	10'	89 FT² ✓	292 LBS
A-C	34"	14	25'	223 FT²	732 LBS.
D-E	34"	14	10	89 "	292 "
D-F	34"	14	25'	223 "	732 "
G-H	34"	14	10	89 "	292 "
G-I	34"	14	25	223 "	732 "
C-J	58"	14	100'	1518 "	4981 "
					8053 LBS ✓

(8053 LBS) ($4.34/LB) (1.15)(1.15) = $46,221 ✓

- EQUIPMENT ENCLOSURE

 - FROM SKETCH ON PREVIOUS PAGE, AREA OF EQUIPMENT ENCLOSURE:

 (30' x 79.12') - (20' x 45.12') = 1471.2 FT² ✓

 VOLUME W/ 15' HEIGHT = 22,068 FT³ ✓

FROM MEANS 1997 MECHANICAL COST DATA, COSTS FOR METAL WAREHOUSES & STORAGE BUILDINGS RANGE FROM $1.24 TO $3.35/FT³, MEDIAN IS $1.98/FT³. ASSUMING THE MEDIAN, COSTS TO ENCLOSE THE PUCB AREA ARE ESTIMATED TO BE:

(22,068 FT³) ($1.98/FT³) = $43,695

ASSUMING COSTS FOR ROOF OFFSET COSTS FOR DESIGN & DETAILING

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COMPUTATION SHEET

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OCMA - OC/UOC STUDY	LEO	8/1/97	SAD	8/8	00-02211.04

- MAKEUP AIR SYSTEMS (MUAs)

  - THE PUCB CORE STORAGE AREA WILL REQUIRE THE INSTALLATION OF (2) SIDEWALL ENTRY MUAs TOTALLING 17,000 CFM. PER THE ATTACHED QUOTATION, CAPITAL & INSTALLATION COSTS FOR THESE SYSTEMS ARE:

[$20,640 (EQUIPMENT) + $1,400 (FREIGHT)] x 2 (INSTALLATION)

≅ $44,080 ✓

- EXHAUST FANS & DAMPERS

  - FROM DAYTON, ESTIMATED COSTS FOR (3) ROOF VENTILATORS SUPPLING APPROX 12,333 CFM, EACH WOULD BE:

$2200, INCLUDING FAN, MOTOR, & DAMPERS

→ DOUBLING FOR INSTALLATION = (3)($4400) = $13,200 ✓

∴ TOTAL OPTION #2 (Scenario #1 - Storage) (SAD)

≅ ($46,221 + $43,695 + $44,080 + $13,200)

≅ $147,196 ✓

RMT

COMPUTATION SHEET

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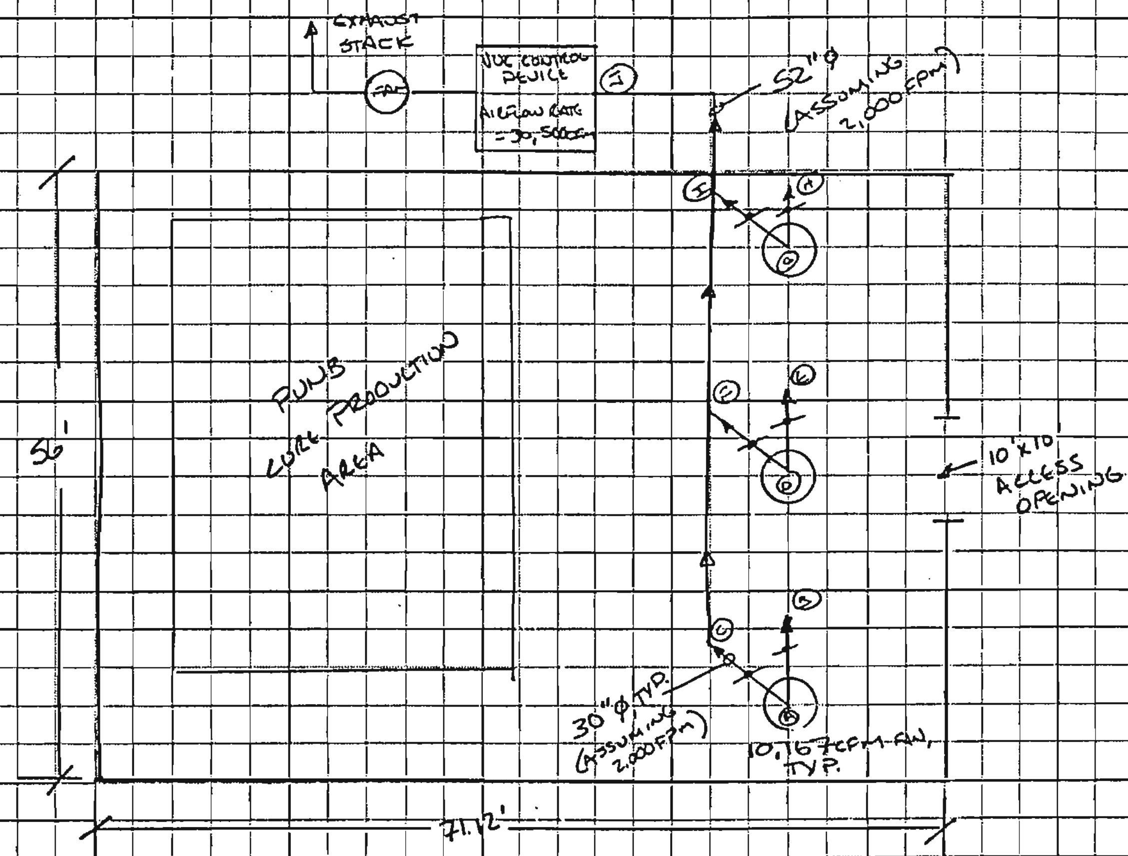
OCMA - OC/VOC STUDY	LCO	8/1/92	SO	8/8	00-02211.04

SCENARIO #3 (Scenario #2 - Production)

PHENOLIC URETHANE NO BAKE (PUNB) CORE PRODUCTION



HEIGHT = 20'

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OCMA - OC/VOC STUDY	LEO	8/6/97	SED	8/8	00-02211.04

ESTIMATED COSTS FOR SCENARIO # 3 (Scenario 2 + Production)

• DUCTWORK

SEGMENT	Ø	GAUGE	LENGTH	AREA	WEIGHT
A-B	30"	14	10'	79 FT^2 ✓	259 LBS ✓
A-C	30"	14	25'	196 "	643 "
D-E	30"	14	10'	79 "	259 "
D-F	30"	14	25'	196 "	643 "
G-H	30"	14	10'	79 "	259 "
G-I	30"	14	25'	196 "	643 "
C-J	52"	14	100'	1361 "	4466 "
					7172 LBS ✓

(7172 LBS)($4.34/LB)(1.15)(1.15) = $41,165 ✓

• EQUIPMENT ENCLOSURE

- FROM SKETCH ON PREVIOUS PAGE, AREA OF EQUIPMENT ENCLOSURE:

(56' x 71.12') = 3983 FT^2

W/ 20' HEIGHT, VOLUME = 79,660 FT^3

∴ ESTIMATED COSTS = (79,660 FT^3)($1.98/$FT^3$)

= $157,727 ✓

COMPUTATION SHEET

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PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	By: LGO	Date: 8/6/97	By: SOD	Date: 8/8	00-0221.04

- MAKEUP AIR SYSTEMS (MUAs)

  - THE PUNB CORE PRODUCTION AREA WILL REQUIRE THE INSTALLATION OF (2) SIDEWALL ENTRY MUAs TOTALLING 10,500 CFM. PER THE ATTACHED QUOTATION, CAPITAL & INSTALLATION COSTS FOR THESE SYSTEMS ARE:

[$16,224 (EQUIPMENT) + $800 (FREIGHT)] x 2 (INSTALLATION)

= $36,048 ✓

- EXHAUST FANS & DAMPERS

  - FROM DAYTON, ESTIMATED COSTS FOR (3) ROOF VENTILATORS SUPPLYING APPROX. 10,167 CFM, EACH WOULD BE:

$1900, INCLUDING FAN, MOTOR, & DAMPERS

→ DOUBLING FOR INSTALLATION = (3)($3800) = $11,400 ✓

∴ TOTAL OPTION #3 (Scenario #2 - Production) (CSS)

≅ ($41,165 + $157,727 + $36,048 + $11,400)

≅ $246,340 ✓

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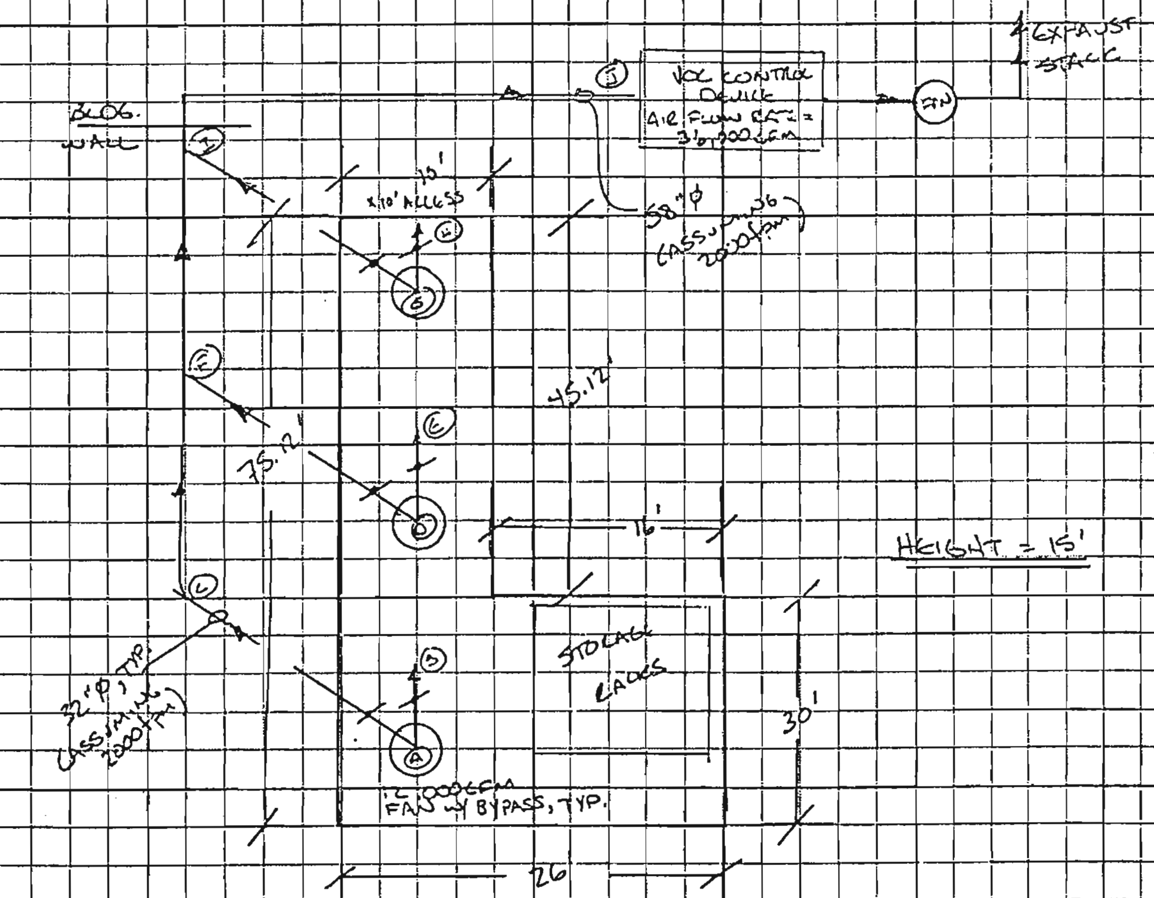
COMPUTATION SHEET

PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	By: LEO	Date: 8/6/97	By: [illegible]	Date: 8/8	00.02211.04

SCENARIO #4 (Scenario #2 - Storage)

PHENOLIC URETHANE NO BAKE (PUNB) CORE STORAGE



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PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA - OC/JOC STUDY	By: LEO	Date: 8/6/97	By: SCD	Date: 8/8	00-0221.04

ESTIMATED COSTS FOR SCENARIO #4 (Scenario #2 - Storage)

- DUCTWORK

SEGMENT	⌀	GAUGE	LENGTH	AREA	WEIGHT
A-B	32"	14	10'	84 FT² ✓	276 LBS ✓
A-C	32"	14	25'	209 "	686 LBS
D-E	32"	14	10'	84 "	276 "
D-F	32"	14	25'	209 "	686 "
G-H	32"	14	10'	84 "	276 "
G-I	32"	14	25'	209 "	686 "
C-J	58"	4	100'	1518 "	4981 "
					7867 LBS. ✓

(7867 LBS)($4.34/LB)(1.15)(1.15) = $45,154 ✓

- EQUIPMENT ENCLOSURE

  - FROM SKETCH ON PREVIOUS PAGE, AREA OF EQUIPMENT ENCLOSURE:

(26' x 75.12') − (16 x 45.12') = 1231.2 FT² ✓

VOLUME W/ 15' HEIGHT = 18,468 FT³ ✓

∴ ESTIMATED COSTS = (18,468 FT3)($1.98/FT³) = $31,567 ✓

COMPUTATION SHEET

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PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	LEO	7/1/92	SCD	8/8	00-02211.04

- MAKEUP AIR SYSTEMS (MUAS)

THE PUNB CORE STORAGE AREA WILL REQUIRE THE INSTALLATION OF (2) SIDEWALL ENTRY MUAS TOTALLING 16,000 CFM. PER THE ATTACHED QUOTATION, CAPITAL & INSTALLATION COSTS FOR THESE SYSTEMS ARE:

[[$20,640 (EQUIPMENT) + $1800 (FREIGHT)] x 2 (INSTALLATION)

= $44,880 ✓

- EXHAUST FANS & DAMPERS

- FROM DAYTON, ESTIMATED COSTS FOR (3) ROOF VENTILATORS SUPPLYING APPROX. 12,000 CFM, EACH WOULD BE:

$2,100, INCLUDING FAN, MOTOR, & DAMPERS

→ DOUBLING FOR INSTALLATION = (3)($4,200) = $12,600 ✓

∴ TOTAL OPTION #4 (Scenario #2 - Storage) (CSS)

≅ ($45,154 + $36,567 + $44,880 + $12,600)

≅ $139,201 ✓

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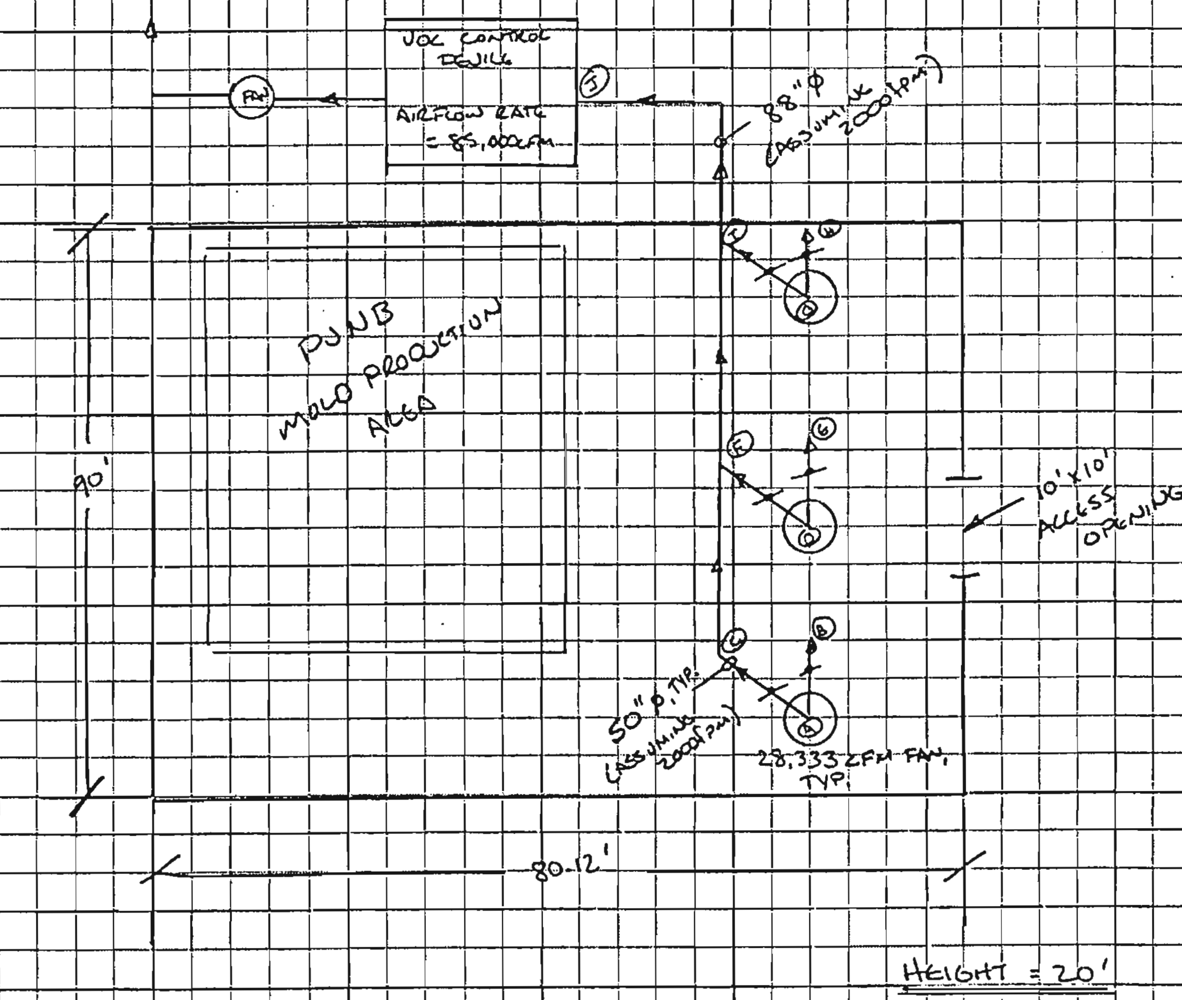
OCMA - OC / VOC STUDY	LEO	8/1/97	SCO	8/8	00-07211.04

SCENARIO #5 (Scenario #3 - Production)

PHENOLIC URETHANE NO BAKE (PUNB) MOLD MAKING



COMPUTATION SHEET

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PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	LEO	8/6/97	SCP	8/8	00-02211.04

ESTIMATED COSTS FOR SCENARIO #5 (Scenario #3 - Production)

- DUCTWORK

SEGMENT	Ø	GAUGE	LENGTH	AREA	WEIGHT
A-B	50"	14	10'	131 FT^2 ✓	430 LBS ✓
A-C	50"	14	25'	327 "	1073 LBS
D-E	50"	14	10'	131 "	430 "
D-F	50"	14	25'	327 "	1073 "
G-H	50"	14	10'	131 "	430 "
G-I	50"	14	25'	327 "	1073 "
C-J	88"	12 (4.5313 #/FT²)	100'	2304 " ✓	10,440 " ✓
					14,949 LBS ✓

(14,949 LBS)($4.34/LB)(1.15)(1.15) = $85,802 ✓

- EQUIPMENT ENCLOSURE

- FROM THE SKETCH ON THE PREVIOUS PAGE, AREA OF EQUIPMENT ENCLOSURE:

(90' x 80.12') = 7,211 FT^3 ✓

w/ 20' HEIGHT, VOLUME = 144,220 FT^3 ✓

∴ ESTIMATED COSTS = (144,220 FT^3)($1.98/$FT^3$)

= $285,556 ✓

COMPUTATION SHEET

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PROJECT / PROPOSAL NAME	PREPARED By	Date	CHECKED By	Date	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	LEO	8/6/97	SOD	8/8	00-02211.04

- MAKEUP AIR SYSTEMS (MUAs)
  - THE PUMB MOLD PRODUCTION AREA WILL REQUIRE THE INSTALLATION OF (2) SIDEWALL ENTRY MUAS TOTALLING 65,500 CFM. PER THE ATTACHED QUOTATION, CAPITAL & INSTALLATION COSTS FOR THESE SYSTEMS ARE:

    [$37,030 (EQUIPMENT) + $2,700 (FREIGHT)] x 2 (INSTALLATION)

    = $79,460 ✓

- EXHAUST FANS & DAMPERS
  - FROM DAYTON, ESTIMATED COSTS FOR (3) ROOF VENTILATORS SUPPLYING APPROX. 28,333 CFM, EACH WOULD BE:

    $3,000, INCLUDING FAN, MOTOR, & DAMPERS

    → DOUBLING FOR INSTALLATION = (3)($6,000) = $18,000

1. TOTAL OPTION #5 (Scenario #3 - Production) (CSS)

   ≅ ($85,802 + $285,556 + $79,460 + $18,000)

   ≅ $468,818 ✓

COMPUTATION SHEET

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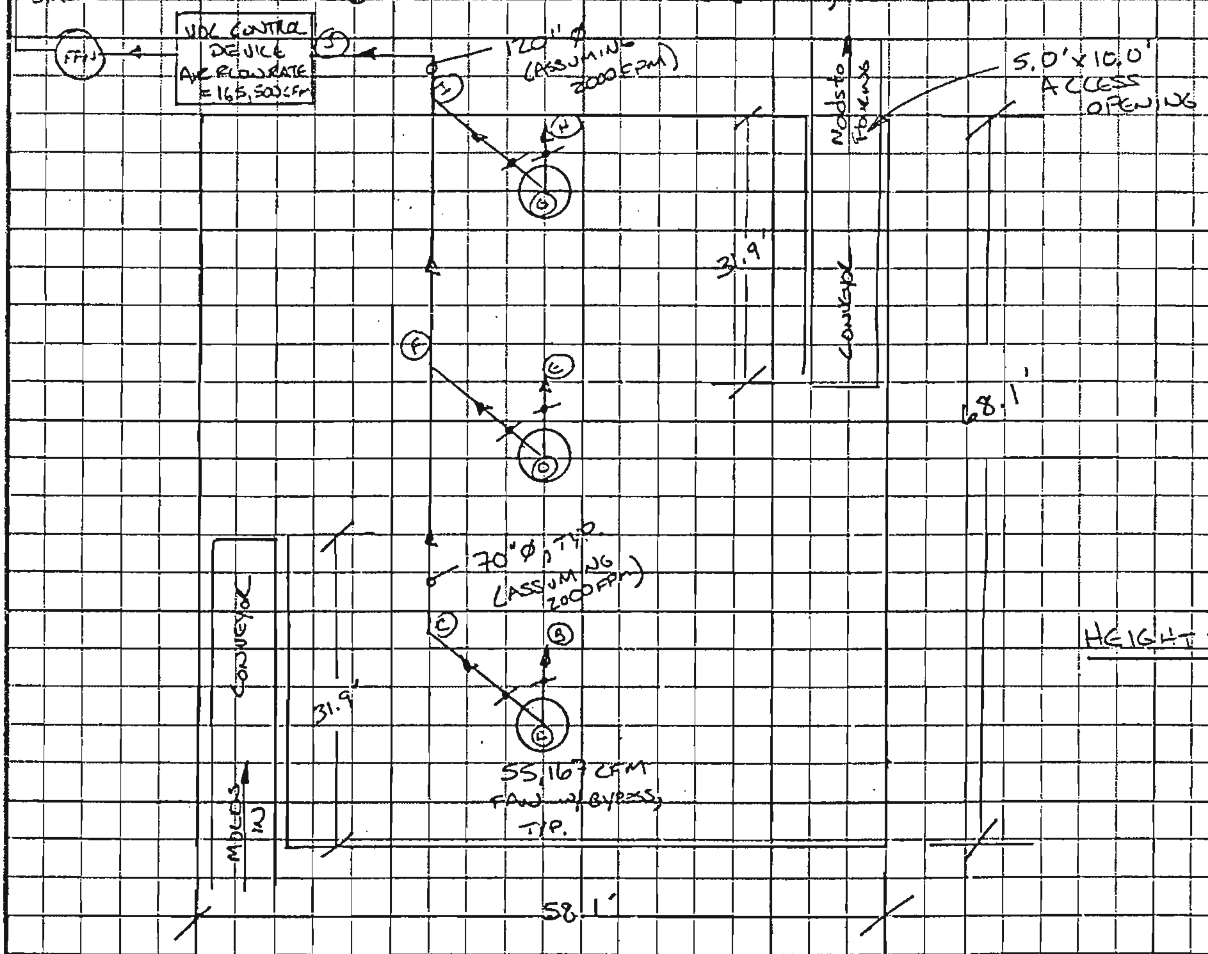
PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	LEO	2/6/92	SCD	3/8	00-02211.04

SCENARIO #6 (Scenario #3 - Storage)

PHENOLIC URETHANE NO BAKE (PUNB) MOLD STORAGE



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PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/UOC STUDY	LEO	8/6/97	SCO	8/8	00-02211.04

(CSS)

ESTIMATED COSTS FOR SCENARIO #6 (Scenario #3 - Storage)

• DUCTWORK

SEGMENT	Ø	GAUGE	LENGTH	AREA	WEIGHT
A-B	70"	12	10'	183 FT² ✓	829 LBS. ✓
A-C	70"	12	25'	458 "	2075 "
D-E	70"	12	10'	183 "	829 "
D-F	70"	12	25'	458 "	2075 "
G-H	70"	12	10'	183 "	829 "
G-I	70"	12	25'	458 "	2075 "
C-J	120"	12	100'	3142 "	14237 "
					22949 LBS. ✓

(22949 LBS)($4.34)(1.15)(1.15) = $131,719 ✓

• EQUIPMENT ENCLOSURE

- FROM THE SKETCH ON THE PREVIOUS PAGE, AREA OF THE EQUIPMENT ENCLOSURE:

(58.1' × 68.1') = 3,957 FT³ ✓

w/ 15' HEIGHT, VOLUME = 59,355 FT3 ✓

∴ ESTIMATED COSTS = (59,355 FT3)($1.98/FT3)

= $117,523 ✓

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COMPUTATION SHEET

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	CSS	4/15/98	plb	4/15/98	2211.05

- MAKE UP AIR SYSTEMS (MUA)
  - THE MUA REQ'TS OF THIS Scenario WAS decreased from 145,500 cfm to 136,000 cfm during final preparation of this report.
  - (2) sidewall entry MUA UNITS totalling 136,000 cfm will be installed, costs were interpolated from existing quotes.

CFM	$
32,750	18,515
68,000	X
72,750	25,625

SOLVING X = $24,781 ; ASSUMING $2700 freight

[49,561 (EQUIP) + $2700 (FREIGHT)] X 2 (INSTALLATION)

= $104,523

- EXHAUST FANS + DAMPERS
  - THE EXHAUST REQ'TS OF THIS SCENARIO WAS DECREASED FROM 165,000 cfm to 156,000 cfm during final preparation of this report.
  - From EXISTING QUOTES, ESTIMATED COST FOR (3) ROOF VENTILATORS SUPPLYING APPROX 52,000 CFM EACH WOULD BE:

CFM	$
28,333	3,000
52,000	X
55,167	5800

- solving X = $5,470 including fan, motor + dampers
→ doubling for installation = (3)(10,939) = $32,817

∴ Total (Scenario 3 - Storage)

≈ ($131,719 + $117,523 + $104,523 + $32,817)

≈ $386,582

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PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	CSS	4/13/98	[illegible]	4/15/98	2211.05

Scenario 4 - Production

- Total Scenario 4 - Production ductwork and enclosure costs is equal to Scenario 1 - Production or $13,810 ✓ (Auxiliary equipment)

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OCMA - OC/VOC STUDY	CSS	4/13/98	pls	4/15/98	2211.05

Scenario 4 - Storage

- Ductwork and Enclosure costs are equal to Scenario 1 - Storage = $89,916 ✓

- M/U Air UNITS

From Existing Quotes

CFM	$
5,250	8,112
8,000	10,320
8,500	10,320
32,750	18,515
72,750	25,625

NEED 2 - 19,000 cfm units

8500	10,320
19000	X
32 750	18,515

SOLVING X = $13,868

- assume $1800 Freight

[13,868 (2) (EQUIPMENT) + $1800] × 2 (INSTALLATION)

= $59,072 ✓

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COMPUTATION SHEET

SHEET 3 OF 9

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA - OC/VOC STUDY	CSS	4/13/98	pls	4/15/98	2211.05

• EXHAUST FANS & Dampers

From Existing Quotes:

cfm	$
10,167	1900
12,000	2100
12,333	2200
28,333	3000
55,167	5800

- NEED (3) ROOF VENTILATORS SUPPLYING APPROX 19,333 cfm ea

12,333	2200
19,333	X
28,333	3000

solving x = $2,550

$2550 including fan, motor, & dampers

– doubling for installation = (3)(5100) = 15,300

Total Scenario #4 - Storage

≈ 89,916 + 59,072 + 15,300 = $164,288

COMPUTATION SHEET

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OCMA - OC/VOC STUDY	CSS	4/13/98	plb	4/15/98	2211.05

Scenario 5 - PRODUCTION

- Ductwork and Enclosure

  Costs equal Scenario 3 - Production = $371,358 ✓

- M/U AIR UNITS

  From Existing Quotes

CFM	$
5,250	8,112
8,000	10,320
8,500	10,320
32,750	18,515
72,750	25,625

NEED 2 - 53,750 cfm units

32,750	18,515
53,750	X
72,750	25,625

SOLVING X = $22,248 ; assume $2700 freight
[(44,496 (equip) + 2700 (freight)] x 2 (INSTALL) = $94,392

- EXHAUST FANS AND DAMPERS
  - FROM EXISTING QUOTES
  - NEED (3) ROOF VENTILATORS SUPPLYING APPROX 42,500 cfm

28,333	3,000
42,500	X
55,167	5,800

SOLVING X = $4,478 including fan, motor + dampers

- doubling for installation = (3) (8,957) = $26,871

Total Scenario #5 - PRODUCTION
≈ $371,358 + $94,392 + $26,871 = $492,621 ✓

COMPUTATION SHEET

SHEET 5 OF 9

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PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA PUCB/PUNB VOC/OC Study	By: CSS	Date: 4/13/98	By: plb	Date: 4/15/98	2211.05

Scenario #5 - Storage

Calculate Scenario 5 - Storage AREA

- Assume
  - Mold Size 4' x 5' x 2'
  - density of IRON = 489.7 lbs/ft^3
  - density of sand = 100.0 lbs/ft^3
  - sand to metal ratio = 1.7 to 1
  - floor space utilization = 40%

4' x 5' x 2' = 40 ft^3 per mold

$$\frac{35.7\ ft^3 \times 100}{4.3\ ft^3 \times 489.7} = \frac{3,570}{2,106} = 1.7 ✓$$

Hourly PROD RATE = 18 TON OF SAND

EACH Mold has 3570 lbs of sand OR 1.78 TONS OF SAND

∴ @ 18 TPH = 10 molds/hr

For 12 hours of Storage = 120 molds

120 x 4' x 5' = 2400 ft^2

at 40% utilization need = 6000 ft^2

Add 2 - 5' x 10' openings + 31.9' for conveyor entrance

(10' x 31.9) x 2 = 638 ft^2

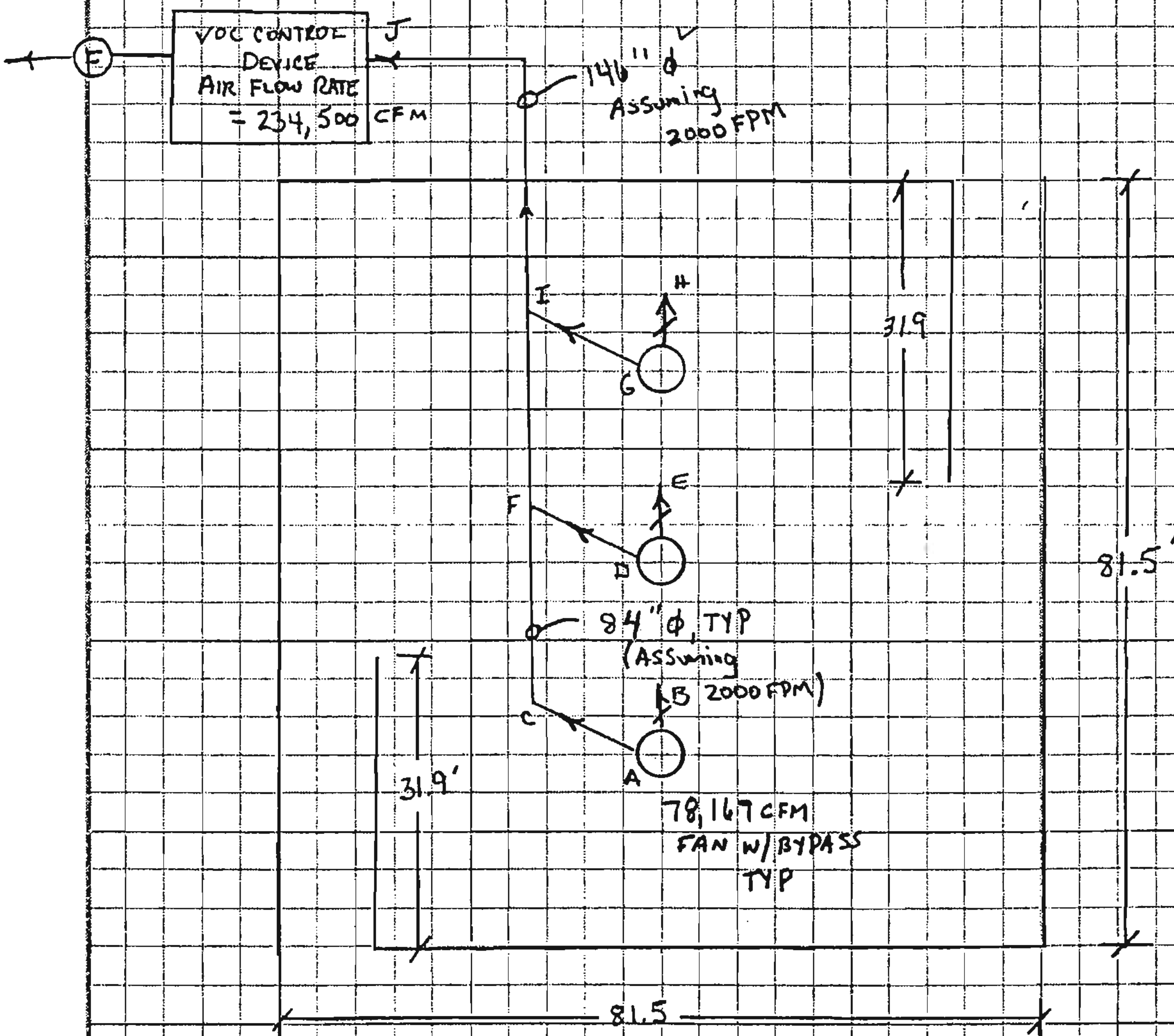
6,000' + 638' = 6,638 sq ft

COMPUTATION SHEET

SHEET 6 OF 9

5890 Sawmill Road Suite 100 Dublin, OH 43017-1591 (614) 793-0026 FAX: (614) 793-0151

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA PUCB/PUNB VOC/OC STUDY	CSS	4/13/98	[illegible]	4/15/98	2211.05



RMT
5890 Sawmill Road Suite 100 Dublin, OH 43017-1591 (614) 793-0026 FAX: (614) 793-0151

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA PUCB/PUNB VOC/OC STUDY	CSS	4/13/98	[illegible]	4/15/98	2211.05

Estimated Costs for Scenario #5 - Storage

• Ductwork

SEGMENT	φ	GAUGE	LENGTH	AREA	WEIGHT
A-B	84"	12	10'	220	997 lbs
A-C	84"	12	25'	550	2,492 "
D-E	84"	12	10'	220	997 "
D-F	84"	12	25'	550	2,492 "
G-H	84"	12	10'	220	997 "
G-I	84"	12	25'	550	2,492 "
C-J	146"	12	120'	4587	20,779 "
					31,246 "

(31,246 lb) ($4.34) (1.15) (1.15)
= $179,341

• Equipment Enclosure

- FROM THE SKETCH ON THE PREVIOUS PAGE, AREA OF THE EQUIPMENT ENCLOSURE is 6,638 ft^2

w/ 15' HEIGHT, VOLUME = 99,570 ft^3

∴ ESTIMATED COSTS = (99,570 ft^3) ($1.981 ft^3)
= $197,248

COMPUTATION SHEET

RMT
5890 Sawmill Road Suite 100 Dublin, OH 43017-1591 (614) 793-0026 FAX: (614) 793-0151

PROJECT / PROPOSAL NAME	PREPARED		CHECKED		PROJECT / PROPOSAL NO.
OCMA PUCB/PUNB VOC/OC STUDY	By: CSS	Date: 4/13/98	By: plh	Date: 4/15/98	2211.05

- MAKEUP AIR UNITS

  - THE PUNB MOLD STORAGE AREA WILL REQUIRE THE INSTALLATION OF (2) SIDEWALL ENTRY MUA totaling 214,500 cfm. CAP + INSTALL COSTS:

  - FROM Existing Quotes

CFM	$
5,250	8,112
8,000	10,320
8,500	10,320
32,750	18,515
72,750	25,625

  - NEED 2 - 107,250 cfm MUA UNITS

32,750	18,515
72,750	25,625
107,250	X

SOLVING X = $31,757

  - ASSUME $2,700 FREIGHT

(63,515 + 2700) × 2
= $132,430

COMPUTATION SHEET

RMT. 5890 Sawmill Road Suite 100 Dublin, OH 43017-1591 (614) 793-0026 FAX: (614) 793-0151

PROJECT / PROPOSAL NAME	PREPARED By:	Date:	CHECKED By:	Date:	PROJECT / PROPOSAL NO.
OCMA PUCB/PUNB VOC/OC STUDY	CSS	9/13/98	plb	9/15/98	2211.05

• Exhaust Fans & Dampers

From Existing Quotes:

cfm	$
10,167	1900
12,000	2100
12,333	2200
28,333	3000
55,167	5800

Need (3) ROOF VENTILATORS SUPPLYING APPROX 78,167 cfm each

28,333	2200
55,167	5800
78,167	x

solving x = $8,885 including fan, motor & damper

→ doubling for installation = (3)(17,770) = $53,311

Total Scenario #5 - Storage

= 179,341 + 197,248 + 132,430 + 53,311

= $562,330

Date: 8-7-97
To: RHT
Attn.:
Subject: LEO TRAMM
OHIO PROJECT

PLEASE FIND PRICES FOR A-B & C AS YOU 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
B. ADD " $1,800.00
C. ADD " $2,700.00

WE WOULD BID THIS JOB AT A BETTER PRICE WHEN WE KNEW WHAT COMBINATIONS YOU MIGHT USE.

Total Pages Being Transmitted Including The Cover Sheet 8.
Please Respond By: ________.

QUOTATION (A) 17,000 CFM

(2) SBD-215 HASTINGS
8,500 CFM EA

Date: 8-7-97
To: RMT
Attn.: LEO TRAMM
Project: OHIO DEPT. ENV.

Quote:

(2) HASTINGS MODEL NO. SBD-218 . CFM 8,500 . TSP 1.35 .
TEMP RISE 90 MBH 898 . DIRECT FIRED GAS
OPTIONS::

- ☐ ROOF CURB ☑ REMOTE PANEL ☑ CONTROL TRANSFORMER
- ☐ SERVICE PLATFORM NAT. GAS @ 1-5 POUNDS ____ INCHES
- ☑ EXTENDED GREASE LINES ☐ 80/20 MIX RETURN AIR/O.A. W/ROOM SENSOR
- ☐ VARIABLE VOLUME WITH: ☐ MOD. DISCHARGE DAMPER ☐ FREQ. DRIVE
- ☑ INSULATED BLOWER ☑ BURNER ☑ FILTER SECTION
- ☐ HORIZONTAL UNIT ☑ VERTICAL UNIT ON STAND
- ☑ WEATHERPROOF ☐ INTAKE HOOD & SCREEN ☑ VUR-2 SCREEN
- ☑ "V" BANK FILTER SECTION ☑ 2" TA ☐ PERMANENT ☐ EXTENDED SURFACE
- ☐ MOTORIZED INLET DAMPER ☑ DISCHARGE DAMPER ☐ DOWN DISCHARGE
- ☐ DISCHARGE LOUVERS: ☐ HORIZONTAL ☐ DOUBLE DEFLECTION
- ☑ VIBRATION ISOLATERS ☐ INTERNAL FAN ISOLATION ☑ PRE-PURGE
- ☑ AUX. STARTER CONTACT ☐ CIRCUIT ANALYZER ☑ LOW OUTLET TEMP. CUT-OFF
- ☑ CLOGGED FILTER LIGHT ☐ ULTRA-VIOLET FLAME SENSOR ☐ DAY-NITE
- ☐ MOTOR HP. 5 VOLTAGE 460-3-60 ☐ ODP ☑ TEFC ☐ HI-EFF.
- ☑ VARIABLE PITCH SHEAVE ☑ DISCONNECT SWITCH ☑ HI 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. ☐ WIS. CODE

ADDITIONAL OPTIONS:

@ $10,320.00 Each

NET PRICE FREIGHT INCLUDED---------------- $20,640.00

FACTORY START UP ADD ________

QUOTATION

Date: 8-7-97
To: DMT
Attn.: Leo Tramm
Project:

(B)
(2) 8,000 CFM = 16,000 CFM
(2) 5,250 CFM = 10,500.

Quote:
(2) Hastings No. SBD-215 CFM 8,000 TSP. 1.35
(2) HASTINGS MODEL NO. SBD-115 . CFM 5250 . TSP 1.35 .
TEMP RISE 90 MBH 845 / 634 . DIRECT FIRED GAS
OPTIONS::

- ☐ ROOF CURB ☑ REMOTE PANEL ☑ CONTROL TRANSFORMER
- ☐ SERVICE PLATFORM NAT. GAS @ 1-5 POUNDS ____ INCHES
- ☐ EXTENDED GREASE LINES ☐ 80/20 MIX RETURN AIR/O.A. W/ROOM SENSOR
- ☐ VARIABLE VOLUME WITH: ☐ MOD.DISCHARGE DAMPER ☐ FREQ. DRIVE
- ☑ INSULATED BLOWER ☑ BURNER ☑ FILTER SECTION
- ☐ HORIZONTAL UNIT ☑ VERTICAL UNIT ON STAND
- ☑ WEATHERPROOF ☐ INTAKE HOOD & SCREEN ☑ VUR-2 SCREEN
- ☑ "V" BANK FILTER SECTION ☑ 2" TA ☐ PERMANENT ☐ EXTENDED SURFACE
- ☐ MOTORIZED INLET DAMPER ☑ DISCHARGE DAMPER ☐ DOWN DISCHARGE
- ☐ DISCHARGE LOUVERS: ☐ HORIZONTAL ☐ DOUBLE DEFLECTION
- ☑ VIBRATION ISOLATERS ☐ INTERNAL FAN ISOLATION ☑ PRE-PURGE
- ☑ AUX. STARTER CONTACT ☐ CIRCUIT ANALYZER ☑ LOW OUTLET TEMP. CUT-OFF
- ☑ CLOGGED FILTER LIGHT ☐ ULTRA-VIOLET FLAME SENSOR ☐ DAY-NITE
- ☐ MOTOR HP. 5 VOLTAGE 460-3-60 ☐ ODP ☑ TEFC ☐ HI-EFF.
- ☐ VARIABLE PITCH SHEAVE ☑ DISCONNECT SWITCH ☑ HI 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. ☐ WIS. CODE

ADDITIONAL OPTIONS:

4 UNITS.

NET PRICE FREIGHT INCLUDED------ $36,864.00

FACTORY START UP ADD ______

QUOTATION (C)

Date: 145,000 CFM (2) SBD-233 @ 72,500 Ea.
To: 65,500 CFM (2) SBD-227 @ 32,750 Ea.
Attn.:
Project:

Quote: (2) HASTINGS NO. SBD-233 CFM 72,500 Ea.
(2) HASTINGS MODEL NO. SBD-227. CFM________. TSP 1.35.
TEMP RISE 90 MBH 10265 / 3,000. DIRECT FIRED GAS
OPTIONS::

- ☐ ROOF CURB ☐ REMOTE PANEL ☐ CONTROL TRANSFORMER
- ☐ SERVICE PLATFORM NAT. GAS @________ POUNDS _____ INCHES
- ☐ EXTENDED GREASE LINES ☐ 80/20 MIX RETURN AIR/O.A. W/ROOM SENSOR
- ☐ VARIABLE VOLUME WITH: ☐ MOD.DISCHARGE DAMPER ☐ FREQ. DRIVE
- ☐ INSULATED BLOWER ☐ BURNER ☐ FILTER SECTION
- ☐ HORIZONTAL UNIT ☐ VERTICAL UNIT ON STAND
- ☐ WEATHERPROOF ☐ INTAKE HOOD & SCREEN ☐ VUR-2 SCREEN
- ☐ "V" BANK FILTER SECTION ☐ 2"TA ☐ PERMANENT ☐ EXTENDED SURFACE
- ☐ MOTORIZED INLET DAMPER ☐ DISCHARGE DAMPER ☐ DOWN DISCHARGE
- ☐ DISCHARGE LOUVERS: ☐ HORIZONTAL ☐ DOUBLE DEFLECTION
- ☐ VIBRATION ISOLATERS ☐ INTERNAL FAN ISOLATION ☐ PRE-PURGE
- ☐ AUX. STARTER CONTACT ☐ CIRCUIT ANALYZER ☐ LOW OUTLET TEMP. CUT-OFF
- ☐ CLOGGED FILTER LIGHT ☐ ULTRA-VIOLET FLAME SENSOR ☐ DAY-NITE
- ☐ MOTOR HP.______ VOLTAGE__________ ☐ ODP ☐ TEFC ☐ HI-EFF.
- ☐ VARIABLE PITCH SHEAVE ☐ DISCONNECT SWITCH ☐ HI 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. ☐ WIS. CODE

ADDITIONAL OPTIONS:

Same Accessories

NET PRICE FREIGHT INCLUDED------------------ $ 88,282.00

FACTORY START UP ADD________

DATE: 0 ......

CONTRACTOR: 0

QUOTE

ATTENTION: 0

PROJECT: 0			WEIGHT	LIST	
MODEL SBD-227 HASTINGS DIRECT FIRED			#	$	
32 750 CFM:TR		90 3.498 MBH	3685	24837	1.05
MOTOR	25	460/3/60	230	2340	
DISCONNECT SWITCH			25	399	
VUR-2 VERTICAL UNIT			400	4626	
ROOF CURB			0	0	
EXTENDED GREASE LINES				234	
INSULATED BLOWER		BURNER	30	1080	
WEATHERPROOF			130	1491	
INTAKE SCREEN			30	469	
V" FILTER SECTION			610	2718	
2" THROWAWAY FILTERS			35	441	
MOTORIZED INLET DAMPER INDOOR			0	0	
MOTORIZED DISCHARGE DAMPER OUTDOOR			190	1649	
DUCT ADAPTOR HR-2			0	0	
DISCHARGE LOUVER HORIZONTAL			0	0	
FLOOR ISOLATERS		RUBBER	24	947	
RETURN AIR SECTION			0	0	
AUX.CONT.PRE-PURGE & LOW OUTLET			40	756	
BLOCKED INTAKE FILTER LIGHT/SWITCH			15	231	
MS-44 MAXITROL				278	
T244				178	
HIGH GAS PRESSURE REGULATOR			10	334	
IRI APPROVAL 10 PSIG & UNDER			0	0	
FM APPROVAL WITH FILTER OR INLET DAMPER			120	2480	
INTERNAL ISO. SPRING			0	0	
MS-14 MAXITROL W/REMOTE SET POINT			0	0	
REMOTE CONTROL F PANEL INCLUDED					
EXTENDED LEGS TO 40"				800	
MSC.					
FRT.RTE.	0	WEIGHT	5574 #		
FRT.CST.	0			$46.288	
MULTIPLIE	0.4	NET DELIVERED		$18.515	

DATE: •••••••

CONTRACTOR:

QUOTE

ATTENTION:

PROJECT:

	WEIGHT	LIST
MODEL SBD-233 HASTINGS DIRECT FIRED	#	$
72,500 CFM;TR 90 7,794 MBH	5380	37213
MOTOR 60 460/3/60	720	6545
DISCONNECT SWITCH	25	399
VERTICAL UNIT	500	3330
ROOF CURB	0	0
EXTENDED GREASE LINES	10	234
INSULATED BLOWER BURNER	40	1400
WEATHERPROOF	150	1649
INTAKE SCREEN	50	651
V" FILTER SECTION	760	3784
2" THROWAWAY FILTERS	60	608
MOTORIZED INLET DAMPER INDOOR	0	0
MOTORIZED DISCHARGE DAMPER OUTDOOR	235	1885
DUCT ADAPTOR HR-2	0	0
DISCHARGE LOUVER HORIZONTAL	0	0
VIB ISOLATERS-SUSPENDED-RI INDOOR RUBBER	24	947
80/20 RA/OA MIXING DAMPERS/RM SP SW	0	0
AUX.CONT.PRE-PURGE & LOW OUTLET	40	750
BLOCKED INTAKE FILTER LIGHT/SWITCH	0	231
MS-44 MAXITROL		278
INTERNAL SPRING ISOLATION	0	0
HIGH GAS PRESSURE REGULATOR	10	334
IRI APPROVAL 10 PSIG & UNDER	0	0
FM APPROVAL WITH FILTER OR INLET DAMPER	140	2876
HIGHER LEGS		950
MS-14 MAXITROL W/REMOTE SET POINT STANDARD		0
REMOTE CONTROL F PANEL INCLUDED		
ETL 1 SPEED		0
UL LABELED REMOTE/MAIN		0

FRT. RTE	0	WEIGHT	8144	
FRT.COST	$0	LIST W/1.05 ESC.		$64,064
MULTIPLIE	0.4	NET DELIVERED		$25,626

1.05esc

DATE: 8/6/97

CONTRACTOR: 0

ATTENTION: 0

PROJECT: 0

QUOTE

					WEIGHT	LIST
MODEL SBD-115 HASTINGS					#	$
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
:NTAKE 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
SUMMER/WINTER SWITCH STANDARD						0
HI GAS PRESSURE					5	77
IRI APPROVAL 10 PSIG & UNDER					40	533
REMOTE PANEL	STANDARD				0	0
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 DELIVERED		$8,112

DATE: 0

CONTRACTOR: 0 *

QUOTE

ATTENTION: 0

PROJECT:

		WEIGHT	LIST
MODEL SBD-215 HASTINGS DIRECT FIRED		#	$
8,000 CFM:TR 90' TR 1.25 TSP	845 MBH	1230	12873
MOTOR 5.0 HP 208/3/60		70	1167
DISCONNECT SWITCH		20	251
VERTICAL UNIT		250	1958
ROOF CURB		0	0
EXTENDED GREASE LINES			234
INSULATED BLOWER SECTION		20	976
WEATHERPROOF		100	861
INTAKE SCREEN		15	308
V" FILTER SECTION		115	1424
2" THROWAWAY FILTERS		15	148
MOTORIZED INLET DAMPER INDOOR		0	0
MOTORIZED DISCHARGE DAMPER OUTDOOR		100	1313
DUCT ADAPTOR HR-2		0	0
DISCHARGE LOUVER HORIZONTAL		0	0
VIB. ISOLATERS-SUSPENDED-RI INDOOR	RUBBER	12	239
W.S. CODE			761
INTERNAL SPRING ISOLATION		0	0
BLOCKED INTAKE FILTER LIGHT/SWITCH		0	231
MS-44 MAXITROL WITH ROOM OVERRIDE			278
T244			178
HIGH GAS PRESSURE REGULATOR	1/10 #	10	218
IRI APPROVAL 10 PSIG & UNDER		70	1731
FM APPROVAL WITH FILTER OR INLET DAMPER		0	0
MS-14 MAXITROL W/REMOTE SET POINT	STANDARD		
50" LEGS			650

FRT.RTE	0	WEIGHT	2027	25799
COST				
MULT.	0.4	NET DELIVERED		$10,320