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EVALUATION OF EMISSION CONTROL OPTIONS AT LEED ARCHITECTURAL PRODUCTS

CONTROL TECHNOLOGY CENTER

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EVALUATION OF EMISSION CONTROL OPTIONS AT LEED ARCHITECTURAL PRODUCTS

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PREFACE

This emission control evaluation was funded as a project of EPA's Control Technology Center (CTC).

The CTC was established by EPA's Office of Research and Development (ORD) and Office of Air Quality Planning and Standards (OAQPS) to provide technical assistance to State and Local air pollution control agencies. Three levels of assistance can be accessed through the CTC. First, a CTC HOTLINE has been established to provide telephone assistance on matters relating to air pollution control technology. Second, more in-depth engineering assistance can be provided when appropriate. Third, the CTC can provide technical guidance through publication of technical guidance documents, development of personal computer software, and presentation of workshops on control technology matters.

The engineering assistance projects, such as this one, focus on specific topics that are identified by State and Local agencies. This report discusses emission control options for the architectural aluminum coating operation at Leed Architectural Products.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

SECTION 1

INTRODUCTION

The Connecticut Department of Environmental Protection (CTDEP) requested assistance from the U.S. Environmental Protection Agency's (EPA) Control Technology Center in evaluation of feasible alternatives to control emissions of volatile organic compounds (VOCs) from a specialty aluminum coating facility. Leed Architectural Products (Leed) proposed to CTDEP to increase production and requested that their permitted VOC emission level be raised from 40 lbs VOC/booth/day to 150 lbs VOC/booth/day. Leed submitted a BACT evaluation stating that added emission control was not economically feasible. The CTDEP questioned this conclusion and requested an independent evaluation to be performed. Engineering Science (ES) was contracted to assist CTC in performing this evaluation.

CTC identified several broad options for reducing emissions to be investigated, including:

1) Control of existing exhaust streams with conventional VOC control devices;

2) Use of conventional methods to reduce exhaust flow and treatment with conventional VOC control devices; and

3) Use of novel or developmental methods of achieving more cost-effective emission control.

ES, CTC and CTDEP personnel visited the facility on October 29, 1988 to observe the operations and gather data for use in a technical and economic evaluation of control options. Mark Peak represented CTDEP, CTC representatives were David Salman (OAQPS) and Chuck Darvin, (AEERL) and ES was represented by Bill Piske and Jon Bolstad. Howard Goldfarb was the Leed representative.

SECTION 2

PROCESS DESCRIPTION

Leed coats specialty aluminum products used for building construction, mostly monumental (high-rise office) buildings, and low-rise commercial buildings. Typical products include door and window frames, column covers, flat panels for eave and cornice trim, air ventilator covers, light poles and other products. In addition to coating, Leed also fabricates shapes from bar and rod stock. Leed produces anodized parts, powder-coated parts, and Kynar^R-coated parts. Kynar^R is used for monumental (high-rise office-type) buildings The building designer specifies the use of Kynar^R-coated metal. Powder-coating is used, by Leed for storefront and other metal where Kynar^R is not specifically identified or powder coating can be negotiated. Anodization is used when the limited color choices and surface textures possible are acceptable. Neither the anodization nor powder-coating generates VOCs and are not at issue. The basic issue is VOC emissions from the use of Kynar^R.

Kynar^R is a trade name for a solvent-based, high-performance, polyvinylidene fluoride (PVF) resin developed by Pennwalt Corporation and licensed to several producers for manufacture. PPG products, marketed as Duranar, are the coatings used by Leed.

Kynar^R thermoplastic resin is relatively impervious to solvent so a relatively large amount of solvent is required to place the resin in solution. Partially because of the resulting high VOC (volatile organic compound) content, there have been extensive efforts over the last ten years to develop low-VOC alternatives for use on monumental buildings. For example, the triglycidyl isocyanuarte (TGIC) polyester powder coating used almost exclusively for monumental buildings in Europe (where, unlike in this country, there is a specification for acid rain resistance but none for a 5-year Florida exposure test) has recently made some inroads into the United States. The three-year-old 23-story World Bank Building in Oakland, the new Trump Casino in Atlantic City and the proposed MGM studios to be built at Disney World in Orlando are all reportedly TGIC polyester. Liquid

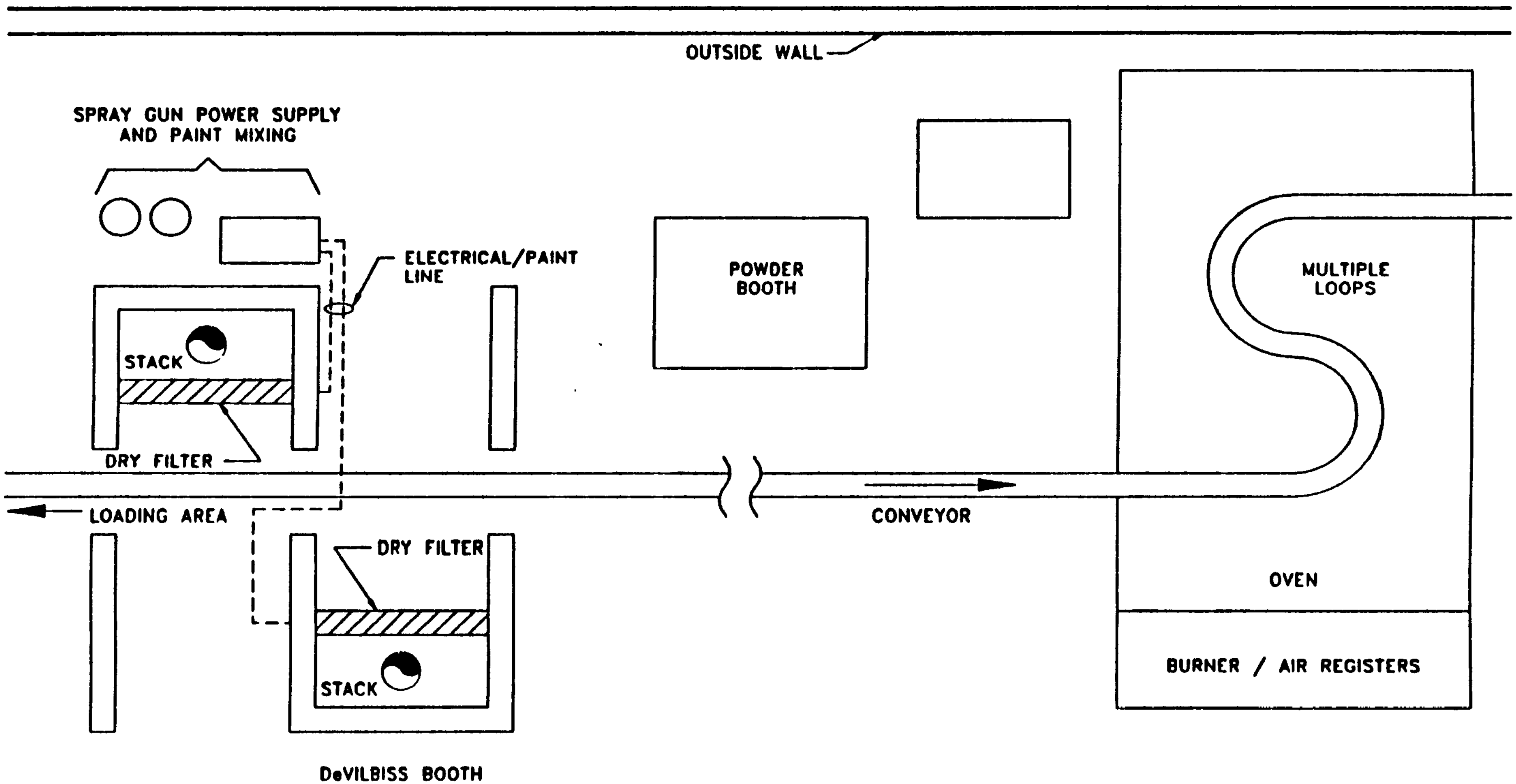
Kynar^R has made little progress in the European market, reportedly because of performance in the acid rain test.

Powder PVF coatings are now becoming available. A Dutch coatings company, Sigma, has marketed a Kynar^R powder coating in Europe for two years. Information on this coating is presented in Appendix A. In this country, Pennwalt has licensed several major companies to formulate Kynar^R powder coatings. At this time, two years of Florida exposure obtained on one company's product indicate it will equal or surpass the resistance of liquid Kynar^R to ultraviolet. At the 1989 annual meeting of the American Architectural Manufacturer's Association, a representative of a major coating supplier to that market announced development of a proprietary PVF resin powder coating which they anticipate will compete directly with Kynar^R liquid and powder coatings. The formulator reports that, unlike Kynar^R, their powder requires no prime coat thereby eliminating even more VOC emissions. After 18 months of Florida exposure, that company reports superior unltraviolet resistance from this thermosetting PVF powder coating.

The coatings used by Leed are applied manually using Graco electrostatic spray guns in two adjoining, but opposite-facing DeVilbiss booths. An overhead conveyor moves the racked parts through the spray booths. One side of each part is coated in each booth, using spray guns supplied from a common paint tank. Each booth is approximately 7'-2"H x 10'-4"W x 6'-0"D with dry filters across the backs of the booths. Ventilation air is drawn in through the booths, through filters and out the stack by in-duct vane-axial fans. Each booth currently exhausts about 12,500 cubic feet per minute (cfm) of air at approximately 70°F.

The conveyor moves the parts from the loading rack area, through the booth and through about 30 feet of unenclosed flash-off area into the oven. The curing oven operates at 450°F (gas/oil heat) and circulates 12,500 cfm with about 1,500-2,000 cfm exhausted to the atmosphere. A typical Kynar^R topcoat requires about 10 minutes at 450°F to cure; residence time of 14-15 minutes in the oven is obtained by a looping conveyor inside the oven and matching the length of the loop to the conveyor speed. The line speed is usually 4-6 feet per minute for color coats. Figure 1 shows the layout of the system. Between the DeVilbiss booths and oven is an enclosed powder booth mounted on rails. When material is being powder-coated, this booth is moved into the conveyor path; otherwise it remains out of the path.

FIGURE 1
GENERAL LAYOUT



The coating operation is usually a two or three coat operation. The first coat is primer applied to a dry film thickness of 1/4 mil. The second coat is the top (color) coat and is applied to a dry film thickness of about 1.2 mils. The third coat is a clear coat if required. Typically, the painters are able to coat a total of 325 - 375 ft^2 of product per hour. It may be as low as 300 ft^2 per hour when complicated shapes and small pieces are being painted, and as high as 450 ft^2 on large (4'x12') flat panels. Leed estimates that coverage averages 200 ft^2/gal. of topcoat, as applied, ranging from 175 (small piece) to 250 (flat panels). Primer coverage is about 400 ft^2/gal, as applied.

Leed currently operates the Kynar[R] coating operation until they reach their daily VOC limit. The limit (40 lbs per booth per day) is converted to operating practice by assuming that the VOC content of coating as applied is 6.2 lbs/gal, which is equivalent to 12.9 gallons of coating per day. Leed also estimates that this is equivalent to 1,700-1,800 ft^2 coated per day.

Leed had requested that the VOC limit be increased to 300 lbs/day (150 lb/booth/day). According to Mr. Goldfarb, a 300-pound limit would reflect the highest production rate they could achieve in 16 hours and would cover approximately 6,500 ft^2 of product.

SECTION 3

EVALUATION OF CONTROL TECHNOLOGIES

GENERAL

As previously stated, CTC identified broad options and ES investigated several specific possibilities for controlling emission from the booths and the oven. This section discusses the technical feasibility of specific control technologies under each of the options described in Section 1. The economics of technically feasible alternatives are discussed in the next section.

BASIS FOR EVALUATION

Leed submitted an analysis to CTDEP (Ref. 1, "the Radian Report") which addressed the addition of emission controls to the existing facility. An operating schedule of 16 hours/day, 6 days/week was used in that evaluation and this extended schedule was used in our analysis. An uncontrolled emission rate of 300 lbs VOC/day (18.75 lbs/hr) was used, as presented in the Radian Report. No flow rate or VOC concentration measurements have been performed at the facility, so the manufacturers specifications for flow rates were used and spatial distribution of VOCs assumed as follows:

Source	Air Flow scfm	VOCs % of Total
Booth 1	12,500	40
Booth 2	12,500	45
Flash-Off	——	5
Oven	2,000	10

The VOC distributions were estimated from the literature (Refs. 2, 3). The solvent mixture is described in the Radian report as 45 wt.% toluene, 25 wt.% methyl isobutyl ketone (MIBK), 15 wt.% xylene and 15 wt.% butyl carbitol.

The booth specifications (Ref. 4) call for a face velocity through openings of greater than 125 feet/min. Each booth has about 85 ft^2 of opening which requires 10,625 acfm to maintain the face velocity and the fans are designed to exhaust 12,500 acfm. The face velocity specifications address capturing the solvents and overspray as they are generated.

Another concern is the concentration of solvents in the gas stream. The Occupational Safety and Health Administration (OSHA) has established standards for occupational exposure to solvent-laden air (SLA). Flammability issues are addressed by OSHA and the National Fire Protection Association (NFPA). The exposure standards are 8-hour time-weighted averages (TWAs) and 30-minute short term exposure limits (STELs).

For purposes of both technical and economic feasibility, the control technologies evaluated were sized to treat the emissions from both spray booths and the oven. The unenclosed flash-off area was not included. The following control technologies were evaluated.

1) Emission control of the existing facilities with conventional pollution control devices,

2) Conventional methods of flow rate reduction and treatment with conventional devices, and

3) Novel or developmental methods to reduce flow and/or treat emissions.

TECHNICAL FEASIBILITY OF ALTERNATIVES

Conventional Control of Existing Facilities

A pollution control system for the existing plant would consist of a treatment device and the ductwork to connect it to the booth exhausts and oven exhaust. Conventional devices considered were direct-fired and catalytic incinerators.

Both types of incinerators are technically feasible for use in Leed's situation. The only consideration of potential significance is whether the existing dry filters on the booths remove enough paint solids to avoid poisoning the catalyst in a catalytic system. This could be minimized by adding a second set of filters to the existing system and sizing the required new exhaust fan appropriately. The basic consideration for this treatment option is the relative cost between direct-fired and catalytic incineration, discussed in Section 4.

Conventional Method of Flow Rate Reduction and Treatment with Conventional Devices

Modification of Existing Booths. Reduction of the gas volume to be treated is a common technique for reducing the overall cost of pollution control; many systems for air flow management and pollutant capture can be modified to effect the same or similar results with a more sophisticated (and usually more costly) approach to air management. ES evaluated the technical feasibility of modifying Leed's booths to reduce the exhaust volume. Either reduction in total circulating flow or recirculation of exhaust air, alone or in combination, are the options available. There are some regulatory and engineering limitations which affect how much flow reduction can be effected by one or the other approach.

First, NFPA sets limits with regard to the allowable concentration of potentially flammable vapors in the gas. Second, OSHA has established standards for worker exposure to solvent vapors. In Leed's case, the flammability issues addressed by NFPA standards will not be an issue unless the exhaust flow rate is reduced by a factor of 100, which is very unlikely. Practically, the OSHA standards will be limiting and these relate to booth design and solvent vapor concentration.

Spray booths are designed so that sufficient air is drawn to prevent the vapors and particles from escaping the area and/or exposing workers to SLA. Leed's booths were designed to maintain a face velocity through openings of at least 125 ft/min. The existing system flow rate maintains this velocity.

Leed's painting procedures require a significant amount of operator freedom. The size and shape of the parts requires the painter to move back and forth across the booth and to paint items or portions at elevation from 1' to 6' off the floor. One approach which offers a significant reduction in flow rate is to reduce the face velocity to 60 ft/min. Reflecting the higher transfer efficiency of electrostatic spray guns, OSHA permits a minimum face velocity of 60 ft/min for manual electrostatic spray guns. In Leed's case, the exhaust flow rate could be reduced from the current 25,000 cfm (~135 ft/min) to 11,040 cfm (60 ft/min). In order to ensure that the booths were not used for conventional air- or airless-atomized spray guns, an interlock should be added to the gun power supply to ensure that only electrostatic guns are used. The exhaust fans would be slowed by replacing drive sheaves with an appropriate size. We have assumed a booth flow rate reduction of 50 percent to be conservative and have evaluated the economics of such a system in Section 4. Except for the gas flows, all other elements of system (solvent loss, production, oven exhaust, etc.) remain the same.

Replacement of Existing Booths with Air Recirculation Systems Followed by Conventional Control Devices. ES contacted several manufacturers of paint spray booths to determine the availability (and cost) of "off-the-shelf" recirculating booths. None of the suppliers contacted were willing to propose a recirculation booth for a manual operation the size of Leed's.

These manufacturers (Ref. 5) gave several reasons for not recommending or proposing recirculating booths for Leed's situation. Generally, the booths they design are for automated assembly-line operations where there is little or no operator exposure and solvent content of the air is limited by NFPA, or they are built for painting large pieces (like tractors) and involve closed booths with supplied-air suits for the painters. Neither of these is Leed's case and the manufacturers were not interested in the engineering costs for such a small one-time system. Further they indicated that for such a small system the cost of the necessary recirculation hardware and safety features would negate the saving in control costs.

NOVEL OR DEVELOPMENTAL TECHNIQUES

EFS AutoRoll Booth. Initial information was that this system was an air recirculation booth system for automated painting that might be adaptable to manual operation. In fact, it is not normally supplied as a recirculating booth. The significant characteristic of this system is an automatic advance of continuous filter mat for overspray solids removal from the exhaust air stream. The filter media are said to provide better particle removal than either typical dry filter pads (like those at Leed) or water wash booths and to reduce maintenance compared to the conventional wet or dry filtration schemes. The physical layout of the booth is very similar to Leed's booth (back draw, open front, side conveyor opening) and would be subject to the same constraint on breathing zone exposure, painter mobility, and face velocity as the existing units. Thus, the system offers little benefit in Leed's situation.

Nobel Chematur Polyad System. The Radian analysis documented that conventional carbon adsorption was expensive and not cost effective compared to other alternatives. However, one system, the Polyad System by Nobel Chematur, was investigated as an alternative to conventional carbon adsorption.

This system uses a fluidized bed of polymeric beads as surface adsorbers. The bed is stripped and solvent recovered in a manner akin to fixed-bed carbon adsorption. According to the manufacturer, its advantages over carbon accrue with high solvent loadings and humid gas streams, neither of which are present at Leeds. The limited information available suggests that performance (removal efficiency) declines rapidly as inlet concentrations go below about 30 ppm. Like carbon systems, the economic advantages over thermal treatment derive from solvent recovery. This Swedish process may have application to systems such as Leed's, even without solvent recovery, but significant additional investigation would be necessary to determine feasibility and performance, as well as cost.

Mobile Zone System. The Mobile Zone System is a method of recirculating a portion of the solvent-laden air, but supplying only fresh air to the work area by enclosing the painter in a mobile cab. Fresh air is admitted to the cab and recirculated air is delivered to the interior of the booth. Therefore, only the quantity of fresh air admitted through the cab opening is exhausted from the system. The designer's description of this system is included as Appendix B. The designer of this system estimated that the total exhaust flow from the two booths and the oven could be reduced from 27,000 cfm to between 5,800 and 9,300 cfm (Ref. 6). They also stated, however, that application to a system as small as Leed's was marginal. The estimated flow reductions are dependent on work practices, piece sizes, and painting rates. As yet, no commercial Mobile Zone System has been installed, so the technology is still unproven in commercial applications.

SUMMARY OF TECHNICALLY FEASIBLE OPTIONS

Table 1 summarizes the characteristics of feasible systems for Leed. The feasible options for emission control at this facility appear to be:

1) Addition of conventional devices to the existing system and treat ~27,000 cfm.

2) Reduction of the flow rate to achieve an exhaust rate equivalent to 60 ft/min face velocity and using conventional devices to treat ~14,000 scfm.

3) Addition of some form of recirculation air system, like the Mobile Zone, and treating 5800 to 9300 scfm with conventional devices.

Option one is provided for comparison with data presented in the Radian report. Option two is a minimum-cost scheme to achieve some flow reduction. Option three has not been commercially demonstrated but has sufficient promise to warrant consideration. It also provides a basis to compare capital and operating costs if other means of flow reduction/recirculation could be developed. A fourth option, which treats only the reduced-flow emissions from one booth and the oven using the flow reduction offered by the Mobile Zone System use also considered. This option would have lower capital costs and achieve less emission reduction than option three.

TABLE 1

CHARACTERISTICS OF SYSTEMS EVALUATED

Type	Ventilation System Flow Rate, scfm	Ventilation System Temp, °F	Incinerator Type	Comb. Temp, °F	Burner Size MM Btu/hr	Capture %	Removal %	Overall Control %
1-Current*	27,000	85°F	Direct Fire	1500	12.5	95	95	90.3
			Catalytic	650	5.0	95	95	90.3
2-Reduce Fan* Speed	14,000	100°F	Direct Fire	1500	6.4	95	95	90.3
			Catalytic	650	2.5	95	95	90.3
3-Mobile Zone*	8,000	130°F	Direct Fire	1500	3.6	95	95	90.3
			Catalytic	650	1.4	95	95	90.3
4-Mobile Zone for Reduced Flow,	5,000	175°F	Direct Fire	1500	2.2	55	95	52.3
Treatment of One Booth & Oven Emissions			Catalytic	650	0.8	55	95	52.3

*Both spray booth and the oven ducted to control device

SECTION 4

ECONOMIC ANALYSIS OF ALTERNATIVES

Two types of control devices for removing VOCs have been considered - catalytic and direct-fired incinerators. For comparison purposes, costs were developed for four systems. Both direct-fired and catalytic incinerators were evaluated for each of these systems. Option one represents adding an incinerator to the existing system with no physical or operating modifications except the necessary electrical and pneumatic connections. Option two reflects the same physical plant as option one but sized to treat the lower gas volume achievable by reducing face velocity to 60 ft/min. Option three reflects a "middle-of-the road" estimate of the flow rate resulting from use of a Mobile Zone System, and Option four includes the same hardware for flow reduction but treating only 5000 cfm of exhaust (oven-2000 cfm, 1 booth-3000 cfm).

BASIS OF EVALUATION

The capital costs for the incinerators were developed as follows. Purchased equipment costs for the incinerator, including the fans, instrumentation and controls were estimated from the EAB manual (Ref. 7). These costs were then converted from 1986 to 1988 dollars using Chemical Engineering's Plant Cost Index (ratio = 1.059). The EAB manual states that the cost estimates are accurate to ± 50%. We compared the 1988 EAB estimates to 15 quotes (1986 to 1988 quotes, adjusted to 1988 dollars) for thermal and catalytic units of capacities from 5,000 scfm to 25,000 scfm. These quotes were obtained from ES records from other recent study and design projects (11) as well as quotes obtained specifically for this evaluation (4). The quoted prices were higher than predicted by approximately 13% for catalytic systems and were approximately equal for thermal systems, so the EAB values were adjusted by a factor of 1.13 for catalytic systems. Auxiliary ductwork was sized and costs calculated as described in the EAB manual.

Total installed equipment costs are comprised of the purchased hardware plus added cost elements described in the EAB manual in terms of a fraction of purchased equipment. Adjustment factors were established based on size and complexity of the system using engineering judgement. The list below identifies where an adjustment factor other than 1.0 was used and why. Operating costs were determined similarly, using the values of labor, utilities, and cost of capital as presented in the Radian analysis.

ITEM	ADJUSTMENT FACTOR USED	REASON
Instruments	0.0	Included with system
Erection and Handling	0.5	Packaged, skid-mounted
Insulation	2.0	Exposed ductwork, cold climate
Painting	0.0	Outside items, already painted
Construction/Field Expenses	0.5	Modular system
Construction Fee	0.5	Pre-engineered
Performance Test	4.0 - 5.0	Back calculated to yield approximately $12,000 fixed price test
Contingencies	2.0	Limited data on structure, power supplies, etc.

Burner capacities were determined using simple linear heat transfer equations and average values with the appropriate heat exchange efficiency (70% for catalytic, 70% for direct-fired). These heat exchange efficiencies are those on which the EAB manual costs were based. Cost effectiveness ($/ton pollutant removed) were determined by assuming 18.75 lbs/hr VOC uncontrolled, 55 or 95% capture, 95% destruction and 4,992 hours/year operation. Table 3 summarizes the total capital costs and the annual costs of the systems evaluated. The designer of the Mobile Zone System estimated that a system could be designed and installed (hardware included) at Leed for about $150,000. This value is included in the capital costs for options three and four. The detailed costs are included in Appendix C.

A thorough analysis of the significance of capital and operating costs on Leed's profitability and ability to service the debt is beyond the scope of this analysis. However, a limited evaluation can be developed from the production and cost data provided by Leed during plant visit.

At the 4,992 hour/year operating rate, Leed's coating operation could paint 1.4 to 1.9 million ft^2 per year. The annual costs added to the painting operation by the emission controls would range from as high as \$.389/ft^2 to as low as \$.097/ft^2, calculated from lowest production/highest cost to highest production/lowest cost using the annual costs presented in Table 3. The actual cost of coating depends on many factors, but Leed estimates that the average cost is \$1.00-\$1.50/ft^2. If the product mix and coating specifications did not change, the addition of controls could increase painting costs anywhere from 6.5 percent to 38.9 percent.

TABLE 2

COST SUMMARY

System (cfm)	Type	Total Capital Costs, $	Annual Costs, $ Direct Operating	Indirect Operating	Total	Cost Effect. $/ton
1-27,000*	Direct-Fired	540,000	403,200	140,800	544,000	12,880
	Catalytic	738,000	224,500	183,800	408,300	9,670
2-14,000*	Direct-Fired	400,000	228,700	110,500	339,200	8,030
	Catalytic	446,000	136,100	120,400	256,500	6,070
3- 8,000*	Direct-Fired	471,000	146,800	125,900	273,600	6,480
	Catalytic	461,000	94,800	123,600	218,400	5,170
4- 5,000**	Direct-Fired	444,000	107,000	112,000	227,000	9,280
	Catalytic	406,000	72,700	111,700	184,400	7,540

*Both spray booths and the oven ducted to the control device
**One spray booth and the oven ducted to the control device

SECTION 5

SUMMARY AND CONCLUSION

The technical and economic evaluations lead to several conclusions. The capital and operating costs for addition of a control system to the facility as it currently stands are lower than the estimates provided by Leed via the Radian analysis for conventional thermal treatment. Further, our estimates are about equal to the combination carbon adsorption/catalytic incineration system discussed in that report, but derive from lower capital costs (less debt service). Catalytic incineration appears more cost-effective than direct-fired, regardless of size.

Reducing the flow rates to 14,000 scfm and thus reducing capital and operating costs of the treatment system yields significant savings compared to treating 27,000 scfm.

The Mobile Zone System appears to provide the most cost-effective control. This system has not been commercially demonstrated, so the cost data are questionable.

Controlling emissions would permit Leed to increase production and the revenues from the production increase could offset, at least in part, the added cost of the emission controls. The cost data provided here can also be used to estimate emission rates and costs of alternatives involving partial emission control.

SECTION 6

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1. Radian Corporation, "Best Available Control Technology Assessment for Leed Architectural Products Paint Spray Booth Operation." Research Triangle Park, NC, April 1, 1988.

2. "Control Techniques for Volatile Organic Compound Emissions from Stationary Sources." Third Edition, Draft.

3. "Guide for Inspecting Capture Systems and Control Devices at Surface Coating Operation." U.S. Environmental Protection Agency. Research Triangle Park, NC, May 1982.

4. DeVilbiss Co., Specifications for Leed Spray Booths.

5. Telecons with various manufacturers:

   Durr Industries; Bob Taylor
   George Koch Co.; Bill Walker
   Bilco Industries; Steve Cots
   Binks Co.; Bob Wagner
   DeVilbiss Co.; Terry York
   JBI, Inc.; Paul Kenderiman
   Protectaire, Inc.; Paul Farkas

6. Letter from Clyde Smith, Smith Engineering, November 29, 1988.

7. "EAB Control Cost Manual, Third Edition". EPA 450/5-87-001A. U.S. Environmental Protection Agency, OAQPS-EAB. Research Triangle Park, NC, February, 1987.

APPENDIX A

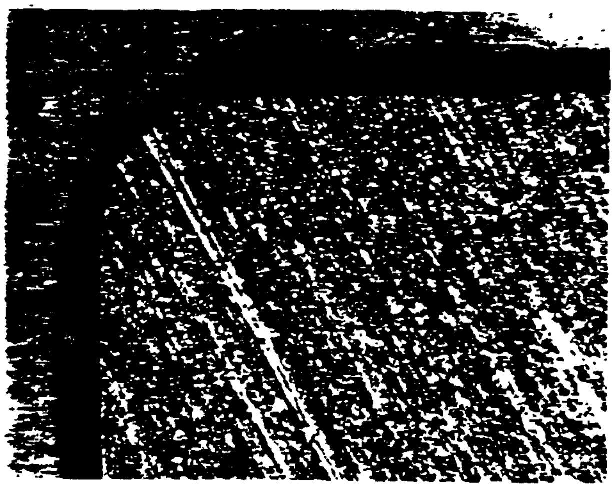
SIGMA PVDF POWDER COATINGS

SIGMA COATINGS, THE SPECIALIST IN EXTERIOR PAINT
SYSTEMS, INTRODUCES SIGMA PVDF,
A NEW GENERATION OF POWDER COATINGS

SIGMA
COATINGS

A NEW GENERATION: POWDER COATINGS BASED ON PVDF

Architects and designers are familiar with polyester powder coatings. And they are familiar with long lasting PVDF based wet spray and coil coatings. Sigma Coatings offers a wide range of high performance coating systems utilizing both techniques. But, keeping abreast of the needs of architects and applicators alike. Sigma has now developed the ultimate exterior finish. SIGMA PVDF – powder coating based on Pennwalt's KYNAR® PVDF (polyvinylidene fluoride).


Microphotograph: illustration of edge covering by Sigma's PVDF powder coating.

Design for enduring beauty *and* durability. As with PVDF wet systems, aluminium profiles and cladding coated with the new PVDF powder are assured of unsurpassed outdoor protection. Whether a building is baking in the heat of a blistering sun, awash with salt spray from the sea or being attacked by industrial pollution, colour and gloss will remain virtually unchanged. Once applied, the architect's design is protected by a heavy fluoropolymer film that will last for years to come.

The SIGMA PVDF powder system was developed to meet the needs of architectural designers who wanted a superior alternative to today's powder coatings. At the same time, it solved the applicators' demand for a more efficient, emission free spray system. The result has not only satisfied market demand, but increased the durability and value of coated metal buildings – Sigma guaranteed.

Sigma Coatings is one of the oldest paint manufacturers in the world. It is from their continuing research that they now bring on the market an exterior finish that is as tough as it is beautiful. Sigma knows that architects will want to consider the prestigious new SIGMA PVDF because it allows them both *durability and design versatility.* Building owners will also recognize the opportunity to enhance and ensure their investment with *lasting beauty and long term economy.*

COLOUR AND PROTECTION

Design with colour and confidence. New SIGMA PVDF based powder coating has the same protective qualities as all fluoropolymer coatings, with even better mechanical properties: one coat of SIGMA PVDF is thicker than two or three wet spray applications. Therefore, architects can expect:

- extremely high outdoor resistance to weathering, industrial pollution, maritime climates
- excellent resistance to corrosion (in particular, filiform)
- superior colour retention and light fastness
- unsurpassed gloss retention (non-chalking)
- optimal edge covering
- maximum durability with high abrasion and shock resistance
- good flexibility and impact resistance.

And of course, SIGMA PVDF ensures the economy of long life to first maintenance. With such low dirt collection, buildings coated with SIGMA PVDF remain practically maintenance free.

Sigma's new PVDF based powder coating is available in many beautiful, exciting RAL colours – colours that will remain fresh and sparkling without the need for repainting for many years. Special colours can also be formulated.

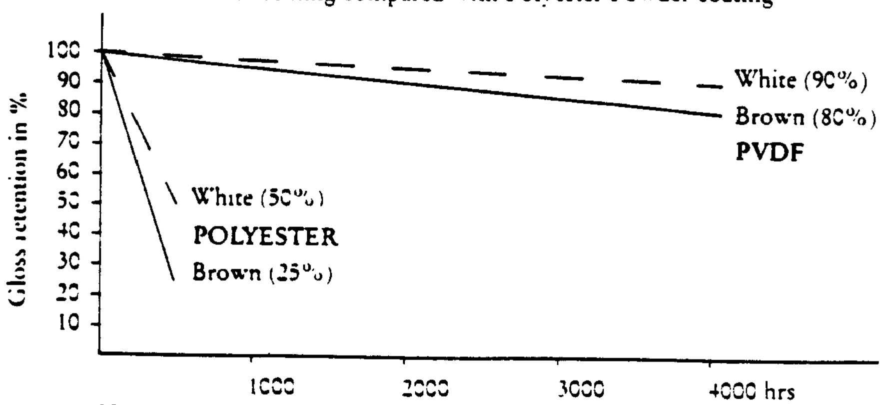
The system has been fully tested by the Dutch TNO Paint Research Institute following the VMR Quality Requirements of Aluminium Windows, Doors and Fronts, edition 1986.

END-USES

SIGMA PVDF based powder is ideal for aluminium cladding and profiles. Components coated with this remarkable powder coating can be bent, shaped, bored and crimped after coating, or in the case of extrusions and preformed shapes, sprayed after fabrication.

ACCELERATED WEATHERING Q.U.V.

PVDF Powder coating compared with Polyester Powder coating



Hours exposition time Q.U.V.

Wall panels, roofs, windows or any aluminium profile can be designed with imagination by combining structural beauty with performance. The colour uniformity of PVDF based powder coatings will ensure realization of the original design and allow building extensions or additions with perfect colour match for many years.

THE GUARANTEE

Incorporating ceramic pigments and PVDF fluoropolymers means a durable coating. SIGMA PVDF is guaranteed for durability of gloss and colour retention, light fastness, resistance to chalking and protection against corrosion (filiform), no loss of adhesion and no cracking or blistering.

When SIGMA PVDF is applied by one of Sigma's approved applicators and meets with Sigma's high standard requirements for quality control, a written guarantee is issued for durability for at least 10 years.

SIGMA PVDF POWDER COATING
TECHNICAL INFORMATION

Weather-O-Meter	ASTM G 23 / G 26 2000 hours: Loss of gloss less than 10%. No chalking. No significant colour change.
Saltspray	ASTM B 117 2000 hours: No blistering. Undercutting from cross hatch less than 1 mm.
Acidic Saltspray	ASTM B 287 2000 hours: No blistering. Undercutting from cross hatch less than 1 mm.
Humidity	DIN 50017 1000 hours: No blistering or loss of adhesion. No loss of hardness 24 hrs. after test.
Flexibility	ASTM D 2794 (Impact resistance) 3.0 Nm: No defects.

Adhesion	DIN 53151	: Gt 0	no pick-off with Scotch-tape
	after 1000 hours humidity (DIN 50017)	: Gt 0	
	after 1000 hours immersion (ASTM D 870)	: Gt 0	
Hardness	DIN 53153 (Buchholz)	: 100	
	ASTM D 3363 (Pencil hardness)	: F	
Resistance to concrete mortar according to	ASTM C 207	: No defects.	

The information above has been extracted from the technical experiences with SIGMA PVDF Powder System applied on chromated aluminium. It is for information purposes only. Full performance data of SIGMA PVDF Powder Coating will be given on request.

SIGMA
COATINGS
Industrial Coatings Division
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APPENDIX B

MOBILE ZONE SYSTEM DESCRIPTION

Mobile Zone: Final Solution to Spray Booth VOC Emission Control

presented by Clyde Smith
1988 Air Pollution Congress
Dallas, Texas
revisions 9/19/88

Acknowledgements

I wish to thank Mr. James Berry of the Environmental Protection Agency for extending an invitation to me to address this meeting. I wish to thank those attending this meeting, for you represent the opinion makers and decision makers who will largely influence the course of events in the future. Hopefully, I will be able to report significant progress from the field to you at the next Congress.

Introduction

My name is Clyde Smith and I reside in Nashville, Tennessee. I am a mechanical engineer in private practice having graduated in 1974 from the Georgia Institute of Technology. I have been heavily involved in industrial ventilation and pollution control the last fourteen years and waste reduction techniques the last three.

The Mobile Zone represents very advanced waste reduction technology rather than control technology. Mobile Zone is a name which I have applied to a series of designs for reducing the quantity of air required to safely and efficiently operate spray booths by up to 95 percent. In turn, this will reduce the capital and operating cost of heating, cooling and VOC emission control equipment by the same percentage. From the beginning, the goals of these designs were to maintain or improve productivity, production quality, safety, and compliance with EPA, NFPA 33 and OHSA. This has been achieved. As the inventor, I have patents pending on these designs. The Mobile Zone legal counsel and patent attorney is Mr. John Behringer of Sutherland, Asbill & Brennan of Washington, D.C.. The Mobile Zone technical consultant is Mr. William H. White of Perrysburg, Ohio. Mr. White is the retired chief of engineered systems for the DeVilbiss Company, a leading builder of spray booths. Mr. White is currently the secretary of Committee 33 of the National Fire Protection Association which writes the national standards for spray booth design.

This presentation will describe one of a number of designs which I have developed for reducing the quantity of air required to safely operate spray booths. The other designs are based on the same principle, although differently configured to accommodate small parts (such as ball point pens), large products (such as transport aircraft), side draft, down draft, continuous and batch operation. As an add on device, it is equally suitable for installation into new or existing facilites. I believe these designs solve the spray booth VOC emission problem. In this presentation, I hope to convince you as well that the Mobile Zone is the final solution to the problem of spray booth VOC emissions. The spray booth VOC emission problem has two major components: first, it requires effective VOC control technology; secondly, it requires an affordable price tag. The first component of the problem has been solved by the vendors of regenerative incinerators and carbon adsorption units. The second component of the problem which is one of cost has been solved by the Mobile Zone control system. For if control equipment is not installed due to its high cost, then its real effectiveness against VOCs is not 90, 95 or 95+ percent but rather zero percent.

VOC Emission Control Technology

The existing VOC emission control technology is quite good and is readily available commercially. The REECO regenerative incinerator is a good example although there are others. For instance, the REECO units are 95 percent plus effective in the destruction of VOCs. The units work well throughout a wide range of ambient temperature and humidity conditions. They are tolerant of high exhaust air particulate loading. They work well regardless of VOC concentration. They work well throughout a wide range of exhaust air flow rates. The units have a long service life; they are mechanically simple and as a result highly reliable. The units work unattended with little routine or preventative maintenance required. In short, the REECO units in their present form represent an effective, mature, and desirable control technology. Therefore it can be safely said that effective VOC emission control technology for spray booth exists and is readily available.

As effective as the existing control technology is, it only represents a partial solution to the spray booth VOC problem. The other part of the problem is the high price tag. In fact, it is the high price tag which has insured that spray booth VOC emissions are presently controlled only at a handful of sites throughout the entire United States. Installed VOC emission control equipment can cost of upwards of

$40 per cubic foot of exhaust air treated. This translates into an installed cost per VOC source of between $200,000 and 10 million dollars. The prospect of reducing the capital and operating cost for treating a cubic foot of exhaust air is bleak. There are no exotic alternative technologies on the horizon and even with a mass market for VOC emission control equipment the cost per cubic foot of exhaust air treated is likely to decline by only 20 to 30 percent which still leaves the price tag too high. The only other logical approach left is to reduce the quantity of exhaust air which must be treated. The John Deere recirculation method and the Mobile Zone are two such approaches. Both of these approaches differ from normal spray booth design and operation and as a result the issues addressed by NFPA 33 and OHSA must be considered.

NFPA 33

NFPA 33 stands for the National Fire Protection Association Committee #33 which writes standards for the design and operation of spray booths as they relate to workplace safety, specifically the fire and explosion issue. The principal objective of the NFPA 33 standards is that under no circumstances should there be a volatile concentration of over 25 percent of the Lower Explosive Limit (LEL) anywhere in the workplace. To achieve this objective a number of design standards are suggested. NFPA 33 has no enforcement powers; however a number of organizations which do have coercive powers have adopted NFPA 33 standards. These organizations include the local fire department which enforces the fire codes, the factory insurance companies and OHSA.

OHSA

OHSA stands for Occupational Health and Safety Administration and is a governmental organization which has regulations for the design and operation of spray booths as they relate to workplace safety, specifically the worker toxic chemical issue. The OHSA regulations include some of the NFPA 33 standards in addition to its own. The principal objective of the OHSA regulations is that under no circumstances will a worker be exposed to a solvent concentration of over 100 parts per million during an eight hour shift or solvent specific peak exposures. To achieve this objective a number of design standards are suggested.

NFPA 33 and OHSA Variances

Variances are granted to the spray booth owner upon petition to the appropriate authority to achieve the objective by a different means than is described in the standards or regulations. Variances are not granted for failure to meet the objectives of the NFPA 33 standards or OHSA regulations. It is up to the booth owner or his agent to convince the authorities to grant a variance; it is by no means automatic. In fact, a variance once granted can be revoked at any time. Should disaster strike, the booth owner is in a weaker position from the liability point of view if he is operating under a variance.

Recirculation Method vs. Mobile Zone

The ventilating air used in a spray booth is an integral part of the spray operation; it removes overspray which otherwise would damage the finish and blind the painter from seeing his workpiece. It is not essential to the spraying operation that the ventilating air be fresh. Recirculated exhaust air contaminated with VOCs but free of particulate will work fine. This is the basis of the John Deere recirculation method. The only exhaust air which must be treated by VOC emission control equipment is the air corresponding to the quantity of fresh air purposely introduced into the booth to maintain the explosive gases at a concentration under 25 percent of the Lower Explosive Limit. Of course with the recirculation method, the painter will have to work in an environmentally sealed suit supplied with fresh outside air since he will be working in a sealed room filled with explosive and toxic gases. Needless to say, the recirculation method requires extensive spray booth modification, variances, special training and special insurance. On the other hand, the Mobile Zone provides fresh ventilating air to the painter and the spraying operation. To reduce the quantity of exhaust air the cross section of the ventilated zone must be considerably less than the entire cross section of the booth. Since the painter and spraying operation will invariable shift in location within the booth this zone must be made mobile as well. Thus the name Mobile Zone is an accurate description of how these designs function. It is also clear that to substantially reduce the spray booth exhaust air will require either the recirculation method or the Mobile Zone; anything else defies the physical laws of nature. The particular Mobile Zone design which I will shortly disclose to you is superior to the recirculation method. The Mobile Zone design requires no spray booth modification, no variances, no special training and no special insurance. The recirculation method is forbidden in government facilities. It has been rejected by several labor unions and it has received unfavorable rulings from the Surgeon General and OHSA.

Mobile Zone

For work activity which requires ventilation, the Mobile Zone provides zone of fresh air within a work chamber for the benefit of a worker and his work activity. The work activity contemplated includes surface coating, surface stripping, surface cleaning as well as manufacturing and fabrication operations which require ventilation such as the spray and lay-up of fiberglass products. This zone of fresh air shifts in response to shifting locational needs of the work activity. The Mobile Zone provides a movable opening through which fresh air flows over the spray operator. Additionally, the opening may be in a structure which serves as a conduit for the fresh air, a conduit for the ingress and egress of the spray operator and mobile work platform for the spray operator. In this way, the linkage between booth size and quantity of air exhausted to the atmosphere is broken. This is directly analogous to having a smaller mobile spray booth within a larger stationary spray booth. The smaller booth would be occupied by the spray operator while the larger booth containing the product remains unoccupied. This differs substantially from present practice, since the introduction of fresh air into the booth is limited to the area immediate to the spraying activity and the openings for the entrance and exit of product. This is accomplished by means of either a Mobile Zone Damper Panel, Mobile Zone Curtain Panel, Mobile Zone Cab or combination. A circulation scheme can be incorporated with the Mobile Zone to promote laminar flow and provide additional overspray control. In this way, the cross section of the booth (work chamber) will be uniformly ventilated.

Curtain Panel

The Mobile Zone Curtain Panel contains two or more sets of opposing curtains. The curtains are moveable. The opposing curtains will be rigidly linked by a member of fixed or variable length. This linkage will provide a standoff between the curtains to define an opening. The location of the opening can be varied at will by advancing one curtain while retracting the other by a like amount. Were both the opposing curtains to be completely retracted at the same time, the ventilating air flow would be uniform throughout the cross section of the panel. Were both the opposing curtains to be completely advanced at the same time, the ventilating air would be substantially blocked from flowing through the panel. With the Mobile Zone Curtain Panel, a zone of ventilating air can be created whose location can be shifted by coordinated movement of the curtains. In addition, since the opening is not ever encumbered or blocked while in use, the Curtain Panel can be located in the work chamber and used as a shield. The operator can stand on the upstream side and spray his material through the opening onto the work piece located on the downstream side. The combination of the curtain as a physical barrier and the flow of ventilating air through the opening will prevent the sprayed material from contaminating the operator side of the Curtain Panel. A variation of this arrangement would include a cab attached to the opening in which the operator could ride as he shifted location and spray his material.

There will be a difference in air pressure from one side of the Curtain Panel to the other during operation. The difference in air pressure caused by the fan will cause a draft through the opening. The dimensions of the draft will be defined by the dimensions of the opening. The velocity of the draft will be established by the magnitude of the pressure differential from one side of the opening to the other.

Mobile Zone featuring Curtain Panel with Laminar Flow Option

In the Mobile Zone control system using Curtain Panels with laminar flow the entire cross section of the booth is uniformly ventilated as is a conventional booth. However, a small portion of the cross section is fresh Mobile Zone air with the balance being laminar flow air. The net effect of this arrangement is that the spray operator is supplied with fresh ventilating air; the air exhausted to VOC equipment or atmosphere is greatly reduced and yet the entire work chamber is uniformly ventilated with non-turbulent, laminar airflow just as in a conventional booth.

VOC enforcement action when it occurs involves high production facilities; this tends by nature to be conveyorized spray booths. This Mobile Zone is particularly well suited to a conveyorized booth. It needs only to be attached to the booth through the laminar flow duct and it requires very little floor space. However it will work with any booth in which the product occupies a well defined area, the painter occupies a well defined area and the spraying takes place predominantly in one direction. These are easy constraints to meet; there are few spraying operations which would not benefit from this orderliness and organization alone.

As an example, for a side draft booth with a cross section of 10 feet high by 15 feet wide, the total air flow would be 22,500 cubic feet per minute based on 150 square feet of cross section at 150 feet per minute ventilating velocity. Assuming only one painter at a time used this booth, then only one cab would be required. If the cab dimensions were 4 feet wide and 7 feet tall, then the fresh Mobile Zone air flow would be 4,200 cubic feet per minute based on 28 square feet of cab cross section at 150 feet per minute ventilating velocity. Thus for the total air flow of 22,500 cubic feet per minute, the laminar flow component will be 18,300 cubic feet per minute with a fresh component of 4,200 cubic feet per minute. As a result, with the Mobile Zone control system every minute 4,200 cubic feet of fresh air is introduced into the booth and the same amount of spent exhaust air is discharged to the atmosphere. This compares to 22,500 cubic feet per minute of air which is required in booth without the Mobile Zone control system. This represent an 81 percent reduction in the ventilating air required to safely operate the booth.

Benefits

Production quality will be maintained or improved. Since the Mobile Zone provides air over the spray gun in a direction predominately parallel to the spray gun's operating direction, the paint transfer efficiency should improve and eddy induced overspray deposits eliminated. Productivity will improve since the Mobile Zone provides mechanized mobility to the operator to speed access to the product's surface and reduce fatigue. The cost of owning and operating a spray booth will be substantially reduced since the Mobile Zone will reduce the ventilating air required by between 75 and 95 percent. In turn, this will reduce the capital and operating cost of heating, air conditioning and pollution control equipment by a like amount. These costs represent a major portion of the costs of a surface coating facility and a principal area of energy consumption in a manufacturing plant. Over a period of years the energy costs saved by the Mobile Zone alone will be several times greater than the initial capital cost of the surface coating facility. Many industrial firms presently must choose between either products with inferior surface coatings or production schedules subject to the whims of the weather because they can not afford humidity and temperature control such as air conditioning. The Mobile Zone will make this climate control affordable, again improving productivity and quality. The objectives and regulations of the EPA are met by reducing the quantity of pollutants generated thereby making abatement practical and affordable. The objectives and standards of NFPA #33 are met by introducing the required fresh air to keep volatile concentrations below 25 percent LEL. In fact, fire and explosion danger is greatly reduced since the spray booth work chamber is contained and isolated from the rest of the facility to a much greater degree than is possible with a conventional design. The objectives and regulations of OHSA are met by providing both fresh air over the worker and his spraying activity as well as a physical barrier between the worker and contamination. In fact, worker safety is greatly enhanced compared to a conventional design since the worker is provided with a smoke and fire free path from the booth. Additionally, by design the fresh Mobile Zone air always passes first over the worker's breathing zone and then to the work area providing positive protection to his breathing zone. This is in sharp contrast to conventional design where by common practice the worker often is downstream of his spraying activity and the overspray is blown back over him thereby contaminating him and his breathing zone.

Conclusion

Detail descriptions and drawings are included in this presentation. A working scale model is present for your examination and illustrates the simplicity of the design and operation. The Mobile Zone finally breaks the linkage between booth size and exhaust air rate, thereby allowing larger booths without penalty. In most cases, the Mobile Zone is simply add on equipment with little down time required for installation. Therefore the fundamental booth design whether new or existing is still appropriate and valid. As a result, the Mobile Zone represents easier to accept 'evolution' rather then 'revolution'. For the industrial firm, high control costs are no longer a barrier to cleaning up VOC emissions and VOC emissions are no longer a barrier to plant expansion. By significantly reducing pollution and energy usage, the Mobile Zone provides the industrial firm with its only means to manage future liability and cost risk in these areas. Any booth without the Mobile Zone is obsolete; for the Mobile Zone represents preparation for the future.

ILLUSTRATIONS

Figures 11, 13 & 14 illustrate a configurations of a Mobile Zone featuring Curtain Panels with laminar flow option.

Figure 11 illustrates schematically a booth (down draft or side draft) of the present invention. Just outside the Work Chamber 53, two Curtain panels 55 and 56 are located; an opening through both Curtain Panels is defined by a cab 57. As illustrated in figure 11, in response to the manipulation of an manual position sensor by the operator, the cab 57 moves at the rate and in the direction selected by the operator to provide proper access to the products in the work chamber 53. In conjunction with the movement of the cab 57, one curtain of each curtain panel 55 and 56 retracts while the other curtain in each panel advances. Curtain Panel 56 forms the upstream boundary and Curtain Panel 55 forms the downstream boundary of laminar flow chambers 70. Exhaust air enters each laminar flow chamber 70 by means of conduit 54. The volume of air entering each laminar flow chamber is controlled by flow control damper 60 in response to the proportion of each curtain area exposed in Curtain Panel 55. The exhaust air 59 exits the laminar flow chambers into the work chamber 53 through perforations in the curtains of Curtain Panel 55. Fresh Mobile Zone ventilating air 58 enters the work chamber 53 through the cab 57. The entire work chamber is uniformly ventilated by a combination of laminar flow air 59 and fresh air 58. This ventilating air then enters the exhaust chamber 13 and passes through filter 15 which removes overspray. The exhaust air exits through the exhaust fan (not shown) in housing 17 whereupon the exhaust air is split. The larger portion is diverted into the laminar flow duct 54 and the smaller portion exits to the atmosphere through exhaust stack 19. The volume of air exiting is controlled by flow control damper 18. The ratio of air exhausted to laminar flow air is proportional to the ratio of area of the opening as defined by the cab 57 in the Curtain Panels 55 & 56 to the total area of perforated curtain in Curtain Panel 55 in the booth cross section.

In Figures 13 & 14 is depicted a conveyorized spray booth of the present invention utilizing a Curtain Panel and the laminar flow feature as described in the Figure 11 schematic. Figure 13 is a frontal isometric view and Figure 14 is a sectional side view. Suspended from the ceiling 23 are monorail conveyor trays 41 that slowly transport the objects to be sprayed (not shown) through the booth. Monorail 40 extends through the booth. Booth end walls 52 have openings 39 for the passage of the conveyor trays 41. The operator 51 (shown only in Figure 14) rides back and forth the full cross section of the booth in a motorized cab which is comprised of floor 47, walls 48 and ceiling 49. The operator sprays the coating from his vantage point in the cab, thereby avoiding the fatigue of pacing back and forth all day dragging his paint hoses. Like partitions, the cab further defines the opening in the two Curtain Panels. In this instance, the cab has the dimensions of four feet wide and eight feet high. The walls 48 of the cab have windows 50. The cab is equipped with manual operator control (not shown) to signal the controller 26 which will in turn cause the cab to stop or move it in a particular direction and speed. The Curtain Panels are comprised of opposing curtains 43, 44 and opposing curtains 61, 62 which are fabricated from narrow interlocking steel slats. These curtains 43, 44, 61 and 62 spool in and out from drums inside housing 46. Tension is maintained on these curtains 43, 44, 61 and 62 by tensioning devices 42 connected to the drums. The curtains and the cab operate in tracks 45. A laminar flow chamber 64 is formed and bounded peripherally by the floor, walls, ceiling and the two Curtain Panel comprised of curtains 43, 44, 61 and 62. The downstream curtains 61 and 62 are perforated to permit exit of the laminar flow air supplied by laminar flow duct 63 from exhaust fan 22. In addition, the perforated curtains 61 and 62 act as diffusers to evenly distribute the laminar flow air across the booth cross section.

The overspray laden air is drawn through the exhaust chamber 24 by an exhaust fan 22 to exit to the atmosphere through the exhaust stack 21. The exhaust chamber 24 is separated from the work chamber 38 by the lower wall portion 32. A pool of scrubbing water 29 stands in the exhaust chamber 24. The water is recirculated by pump 27 to spray header 28. The spray constantly wets baffles 30 and 31 which along with the spray constitute a water wash filter, which extends the entire length of exhaust chamber 24. Openings (not shown) near the bottom of baffle 30 allow water 29 to stand at the same level throughout exhaust chamber 24.

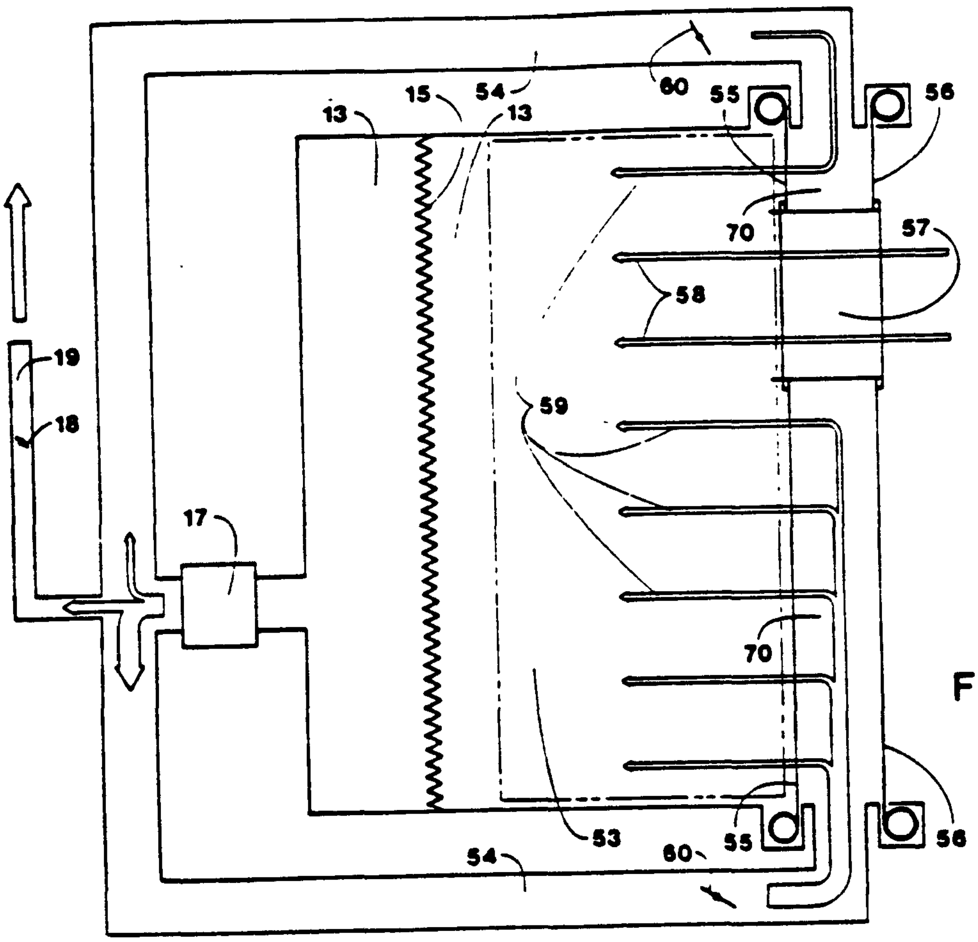
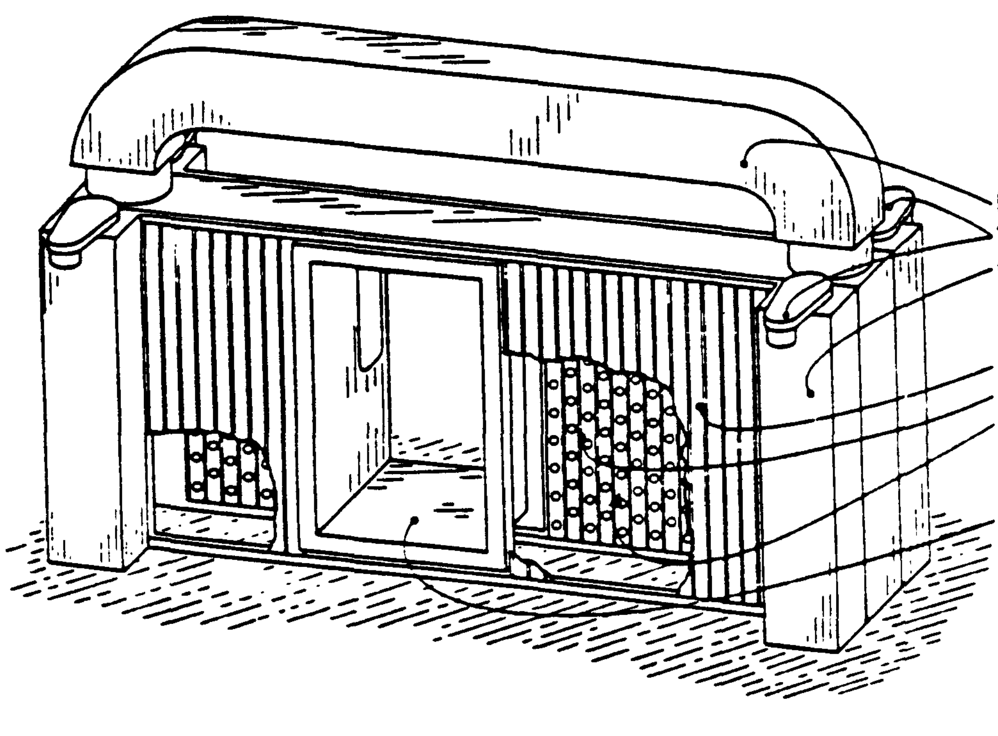


FIG 11



MOBILE ZONE

Mobile Zone Control System — Patents Pending
Property of Clyde Smith of Nashville, Tennessee
Figures 1 & 2 of 4

FIG 13

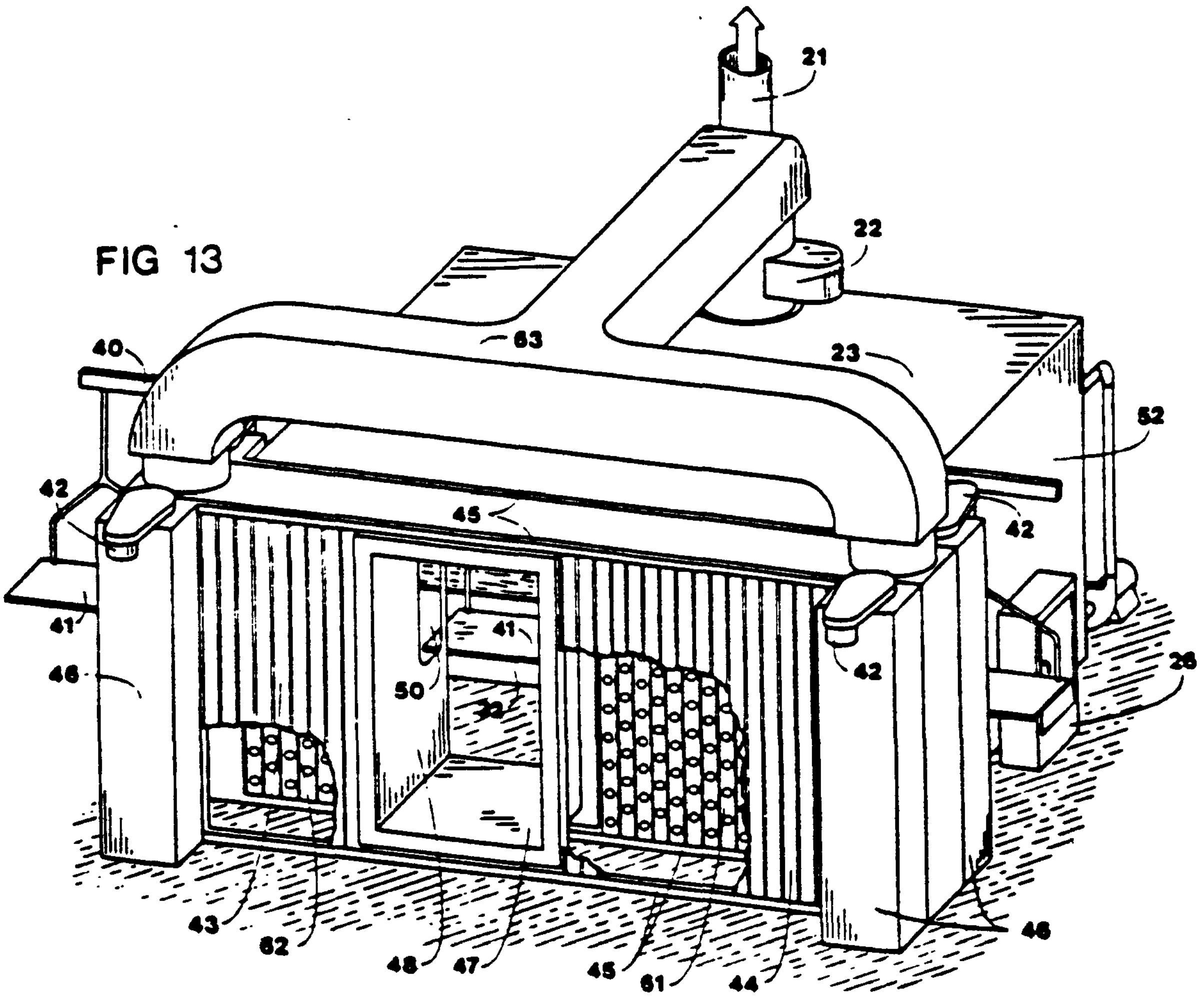
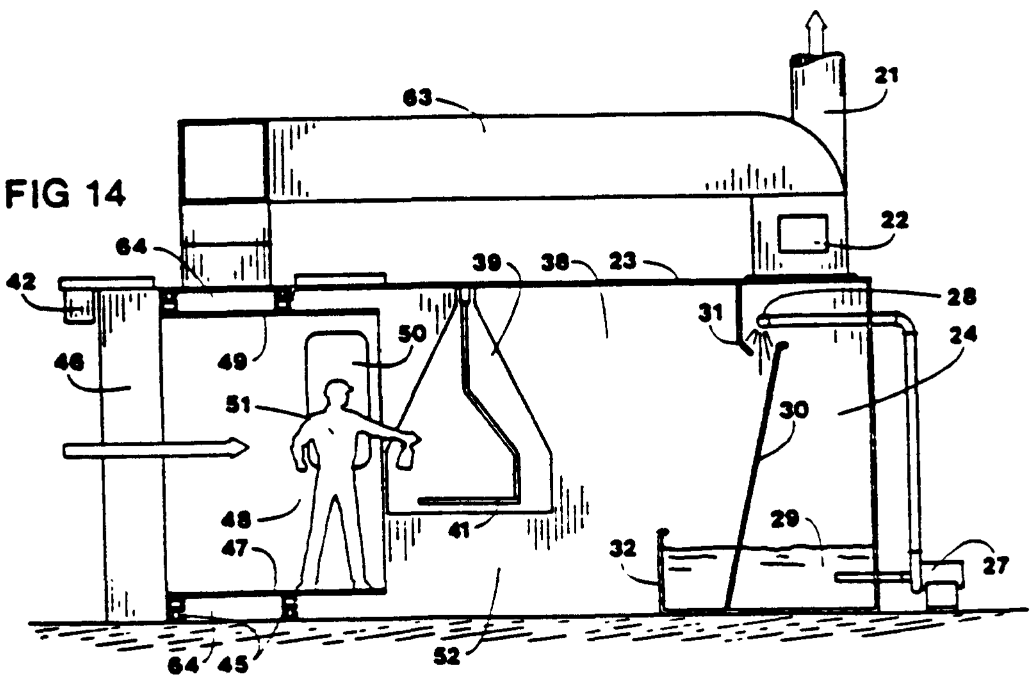


FIG 14



Mobile Zone Control System — Patents Pending
Property of Clyde Smith of Nashville, Tennessee
Figures 3 & 4 of 4

APPENDIX C

DETAILED COST CALCULATIONS

DETAILED COST CALCULATIONS

FILENAME KEY

Option	Filename Thermal	Catalytic
1	27KCAT	27KDFIRE
2	14KCAT	14DFIRE
3	8KCAT	8KDFIRE
4	5KCAT	5KDFIRE

Note: For options 3 & 4, capital cost of mobile zone system is included in auxiliary equipment (Line A)1)b)

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	18763
SCFM	SLAS	5000
ACFM	SLAA	6000
GAS TEMP. DEG. F	TI	175
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	126
COMBUSTION CHAMBER TEMP, DEG. F	TC	650
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.55
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	0.77

SYSTEM DESCRIPTION

CATALYTIC INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$159,200
b) AUXILIARY EQUIPMENT	AS REQ'D			$96,216
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$7,662
e) FREIGHT	1a+b *	0.05 *	1.0	$12,771
SUBTOTAL PURCHASED EQUIPMENT				$275,849
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$20,433
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$17,879
c) ELECTRICAL	1a *	0.04 *	1.0	$6,368
d) PIPING	1a *	0.02 *	1.0	$3,184
e) INSULATION	1a+b *	0.01 *	2.0	$5,108
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$52,973
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$25,542
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$6,385
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$12,771
d) STARTUP	1a+b *	0.02 *	1.0	$5,108
e) PERFORMANCE TEST	1a+b *	0.01 *	4.7	$12,005
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$15,325
SUBTOTAL INSTALLATION INDIRECT				$77,136

SUMMARY - TOTAL CAPITAL COSTS		
PURCHASED EQUIPMENT		$275,849
INSTALLATION DIRECT		$52,973
INSTALLATION INDIRECT		$77,136
	TIEC	$405,958

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 0.77 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 38627 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 318 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 508 DEG. F

FAN POWER, KWH/HR

SG = 0.062 LBS/FT3
DP = 25 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 1.679 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 2 FT3

= 0.12 TONS

PROJECT: LEED ARCH. PRODS. COST EVAL. FILE:5KCAT

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		1.0	$6,000
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$1,006
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$22,099
	$0.5714 /CCF OVER	55000		$0
SUBTOTAL DIRECT OPERATING COSTS				$72,718
B) INDIRECT OPERATING COSTS				
7) OVERHEAD	0.60 * (OL+SL+ML+MM)			$23,587
8) PROPERTY TAX	0.01 * TIEC			$4,060
9) INSURANCE	0.01 * TIEC			$4,060
10) GENERAL AND ADMINISTRATIVE	0.02 * TIEC			$8,119
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST	0.1770 * TIEC			$71,855
SUBTOTAL INDIRECT COSTS				$111,680

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$72,718
INDIRECT OPERATING	$111,680
TOTAL ANNUAL COST	$184,398
COST EFFECTIVENESS, $/TON REMOVED	$7,541

DATE: 02/02/89

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	18763
SCFM	SLAS	5000
ACFM	SLAA	6000
GAS TEMP. DEG. F	TI	175
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	126
COMBUSTION CHAMBER TEMP, DEG. F	TC	1500
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.55
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	2.16

SYSTEM DESCRIPTION

DIRECT FIRED INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$183,600
b) AUXILIARY EQUIPMENT	AS REQ'D			$96,216
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$8,394
e) FREIGHT	1a+b *	0.05 *	1.0	$13,991
SUBTOTAL PURCHASED EQUIPMENT				$302,201
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$22,385
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$19,587
c) ELECTRICAL	1a *	0.04 *	1.0	$7,344
d) PIPING	1a *	0.02 *	1.0	$3,672
e) INSULATION	1a+b *	0.01 *	2.0	$5,596
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$58,585
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$27,982
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$6,995
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$13,991
d) STARTUP	1a+b *	0.02 *	1.0	$5,596
e) PERFORMANCE TEST	1a+b *	0.01 *	4.3	$12,032
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$16,789
SUBTOTAL INSTALLATION INDIRECT				$83,385

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SUMMARY - TOTAL CAPITAL COSTS		
PURCHASED EQUIPMENT		$302,201
INSTALLATION DIRECT		$58,585
INSTALLATION INDIRECT		$83,385
	TIEC	$444,171

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 2.16 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 107749 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 572.5 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 1102.5 DEG. F

FAN POWER, KWH/HR

SG = 0.062 LBS/FT3
DP = 15 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 1.008 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 2 FT3

= 0.12 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		0.0	$0
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$604
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$30,141
	SUBTOTAL DIRECT OPERATING COSTS			$107,045
B) INDIRECT OPERATING COSTS				
7) OVERHEAD		0.60 * (OL+SL+ML+MM)		$23,587
8) PROPERTY TAX		0.01 * TIEC		$4,442
9) INSURANCE		0.01 * TIEC		$4,442
10) GENERAL AND ADMINISTRATIVE		0.02 * TIEC		$8,883
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST		0.1770 * TIEC		$78,618
	SUBTOTAL INDIRECT COSTS			$119,972

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$107,045
INDIRECT OPERATING	$119,972
TOTAL ANNUAL COST	$227,018
COST EFFECTIVENESS, $/TON REMOVED	$9,284

PROJECT: LEED ARCH. PRODS. COST EVAL. FILE:8KCAT

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	32311
SCFM	SLAS	8000
ACFM	SLAA	9000
GAS TEMP. DEG. F	TI	130
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	135
COMBUSTION CHAMBER TEMP, DEG. F	TC	650
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	1.36

SYSTEM DESCRIPTION

CATALYTIC INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$192,500
b) AUXILIARY EQUIPMENT	AS REQ'D			$98,208
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$8,721
e) FREIGHT	1a+b *	0.05 *	1.0	$14,535
SUBTOTAL PURCHASED EQUIPMENT				$313,965
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$23,257
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$20,350
c) ELECTRICAL	1a *	0.04 *	1.0	$7,700
d) PIPING	1a *	0.02 *	1.0	$3,850
e) INSULATION	1a+b *	0.01 *	2.0	$5,814
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$60,970
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$29,071
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$7,268
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$14,535
d) STARTUP	1a+b *	0.02 *	1.0	$5,814
e) PERFORMANCE TEST	1a+b *	0.01 *	4.1	$11,919
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$17,442
SUBTOTAL INSTALLATION INDIRECT				$86,050

SUMMARY - TOTAL CAPITAL COSTS	
PURCHASED EQUIPMENT	$313,965
INSTALLATION DIRECT	$60,970
INSTALLATION INDIRECT	$86,050
TIEC	$460,985

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 1.36 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 67658 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 286 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 494 DEG. F

FAN POWER, KWH/HR

SG = 0.067 LBS/FT3
DP = 25 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 2.722 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 3.2 FT3

= 0.192 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		1.0	$9,600
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$1,631
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$7,233
SUBTOTAL DIRECT OPERATING COSTS				$94,765
B) INDIRECT OPERATING COSTS				
7) OVERHEAD		0.60 * (OL+SL+ML+MM)		$23,587
8) PROPERTY TAX		0.01 * TIEC		$4,610
9) INSURANCE		0.01 * TIEC		$4,610
10) GENERAL AND ADMINISTRATIVE		0.02 * TIEC		$9,220
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST		0.1770 * TIEC		$81,594
SUBTOTAL INDIRECT COSTS				$123,621

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$94,765
INDIRECT OPERATING	$123,621
TOTAL ANNUAL COST	$218,386
COST EFFECTIVENESS, $/TON REMOVED	$5,170

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	32311
SCFM	SLAS	8000
ACFM	SLAA	9000
GAS TEMP. DEG. F	TI	130
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	135
COMBUSTION CHAMBER TEMP, DEG. F	TC	1500
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	3.57

SYSTEM DESCRIPTION

DIRECT FIRED INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS		RATE		AF	COST
A) DIRECT COSTS						
1) PURCHASED EQUIPMENT						
a) CONTROL DEVICE	AS REQ'D					$199,300
b) AUXILIARY EQUIPMENT	AS REQ'D					$98,208
c) INSTRUMENTS AND CONTROLS	1a	*	0.10	*	0.0	$0
d) TAXES	1a+b+c	*	0.03	*	1.0	$8,925
e) FREIGHT	1a+b	*	0.05	*	1.0	$14,875
SUBTOTAL PURCHASED EQUIPMENT						$321,309
2) INSTALLATION DIRECT						
a) FOUNDATIONS AND SUPPORTS	1a+b	*	0.08	*	1.0	$23,801
b) ERECTION AND HANDLING	1a+b	*	0.14	*	0.5	$20,826
c) ELECTRICAL	1a	*	0.04	*	1.0	$7,972
d) PIPING	1a	*	0.02	*	1.0	$3,986
e) INSULATION	1a+b	*	0.01	*	2.0	$5,950
f) PAINTING	1a+b	*	0.01	*	0.0	$0
g) SITE PREPARATION	AS REQ'D					$0
h) FACILITIES AND BUILDINGS	AS REQ'D					$0
SUBTOTAL INSTALLATION DIRECT						$62,534
B) INDIRECT COSTS						
3) INSTALLATION INDIRECT						
a) ENGINEERING AND SUPERVISION	1a+b	*	0.10	*	1.0	$29,751
b) CONSTR. AND FIELD EXPENSES	1a+b	*	0.05	*	0.5	$7,438
c) CONSTRUCTION FEE	1a+b	*	0.10	*	0.5	$14,875
d) STARTUP	1a+b	*	0.02	*	1.0	$5,950
e) PERFORMANCE TEST	1a+b	*	0.01	*	4.0	$11,900
f) MODEL STUDY						
g) CONTINGENCIES	1a+b	*	0.03	*	2.0	$17,850
SUBTOTAL INSTALLATION INDIRECT						$87,765

SUMMARY - TOTAL CAPITAL COSTS	
PURCHASED EQUIPMENT	$321,309
INSTALLATION DIRECT	$62,534
INSTALLATION INDIRECT	$87,765
TIEC	$471,608

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 3.57 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 178253 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 541 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 1089 DEG. F

FAN POWER, KWH/HR

SG = 0.067 LBS/FT3
DP = 15 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 1.633 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 3.2 FT3

= 0.192 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		0.0	$0
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$978
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$70,427
SUBTOTAL DIRECT OPERATING COSTS				$147,706
B) INDIRECT OPERATING COSTS				
7) OVERHEAD	0.60 * (OL+SL+ML+MM)			$23,587
8) PROPERTY TAX	0.01 * TIEC			$4,716
9) INSURANCE	0.01 * TIEC			$4,716
10) GENERAL AND ADMINISTRATIVE	0.02 * TIEC			$9,432
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST	0.1770 * TIEC			$83,475
SUBTOTAL INDIRECT COSTS				$125,926

SUMMARY - ANNUALIZED COSTS	
DIRECT OPERATING	$147,706
INDIRECT OPERATING	$125,926
TOTAL ANNUAL COST	$273,632
COST EFFECTIVENESS, $/TON REMOVED	$6,478

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	59574
SCFM	SLAS	14000
ACFM	SLAA	15000
GAS TEMP. DEG. F	TI	100
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	77
COMBUSTION CHAMBER TEMP, DEG. F	TC	650
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	2.51

SYSTEM DESCRIPTION

CATALYTIC INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

PROJECT: LEED ARCH. PRODS. COST EVAL. FILE:14KCAT

CAPITAL COSTS

	BASIS		RATE		AF	COST
A) DIRECT COSTS						
1) PURCHASED EQUIPMENT						
a) CONTROL DEVICE	AS REQ'D					$266,500
b) AUXILIARY EQUIPMENT	AS REQ'D					$11,296
c) INSTRUMENTS AND CONTROLS	1a	*	0.10	*	0.0	$0
d) TAXES	1a+b+c	*	0.03	*	1.0	$8,334
e) FREIGHT	1a+b	*	0.05	*	1.0	$13,890
SUBTOTAL PURCHASED EQUIPMENT						$300,020
2) INSTALLATION DIRECT						
a) FOUNDATIONS AND SUPPORTS	1a+b	*	0.08	*	1.0	$22,224
b) ERECTION AND HANDLING	1a+b	*	0.14	*	0.5	$19,446
c) ELECTRICAL	1a	*	0.04	*	1.0	$10,660
d) PIPING	1a	*	0.02	*	1.0	$5,330
e) INSULATION	1a+b	*	0.01	*	2.0	$5,556
f) PAINTING	1a+b	*	0.01	*	0.0	$0
g) SITE PREPARATION	AS REQ'D					$0
h) FACILITIES AND BUILDINGS	AS REQ'D					$0
SUBTOTAL INSTALLATION DIRECT						$63,215
B) INDIRECT COSTS						
3) INSTALLATION INDIRECT						
a) ENGINEERING AND SUPERVISION	1a+b	*	0.10	*	1.0	$27,780
b) CONSTR. AND FIELD EXPENSES	1a+b	*	0.05	*	0.5	$6,945
c) CONSTRUCTION FEE	1a+b	*	0.10	*	0.5	$13,890
d) STARTUP	1a+b	*	0.02	*	1.0	$5,556
e) PERFORMANCE TEST	1a+b	*	0.01	*	4.3	$11,945
f) MODEL STUDY						
g) CONTINGENCIES	1a+b	*	0.03	*	2.0	$16,668
SUBTOTAL INSTALLATION INDIRECT						$82,783

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SUMMARY - TOTAL CAPITAL COSTS		
PURCHASED EQUIPMENT		$300,020
INSTALLATION DIRECT		$63,215
INSTALLATION INDIRECT		$82,783
	TIEC	$446,018

DATE: 02/02/89

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 2.51 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 125232 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 265 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 485 DEG. F

FAN POWER, KWH/HR

SG = 0.070 LBS/FT3
DP = 25 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 4.740 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 5.6 FT3

= 0.336 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		1.0	$16,800
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$2,839
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$40,131
SUBTOTAL DIRECT OPERATING COSTS				$136,071

B) INDIRECT OPERATING COSTS		
7) OVERHEAD	0.60 * (OL+SL+ML+MM)	$23,587
8) PROPERTY TAX	0.01 * TIEC	$4,460
9) INSURANCE	0.01 * TIEC	$4,460
10) GENERAL AND ADMINISTRATIVE	0.02 * TIEC	$8,920
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST	0.1770 * TIEC	$78,945
SUBTOTAL INDIRECT COSTS		$120,373

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$136,071
INDIRECT OPERATING	$120,373
TOTAL ANNUAL COST	$256,445
COST EFFECTIVENESS, $/TON REMOVED	$6,072

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	59574
SCFM	SLAS	14000
ACFM	SLAA	15000
GAS TEMP. DEG. F	TI	100
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	77
COMBUSTION CHAMBER TEMP, DEG. F	TC	1500
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	6.39

SYSTEM DESCRIPTION

DIRECT FIRED INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$236,900
b) AUXILIARY EQUIPMENT	AS REQ'D			$11,296
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$7,446
e) FREIGHT	1a+b *	0.05 *	1.0	$12,410
SUBTOTAL PURCHASED EQUIPMENT				$268,052
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$19,856
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$17,374
c) ELECTRICAL	1a *	0.04 *	1.0	$9,476
d) PIPING	1a *	0.02 *	1.0	$4,738
e) INSULATION	1a+b *	0.01 *	2.0	$4,964
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$56,407
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$24,820
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$6,205
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$12,410
d) STARTUP	1a+b *	0.02 *	1.0	$4,964
e) PERFORMANCE TEST	1a+b *	0.01 *	4.8	$11,913
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$14,892
SUBTOTAL INSTALLATION INDIRECT				$75,203

SUMMARY - TOTAL CAPITAL COSTS

PURCHASED EQUIPMENT	$268,052
INSTALLATION DIRECT	$56,407
INSTALLATION INDIRECT	$75,203
TIEC	$399,662

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 6.39 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 318773 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 520 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 1080 DEG. F

FAN POWER, KWH/HR

SG = 0.07 LBS/FT3
DP = 15 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 2.844 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 5.6 FT3

= 0.336 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		0.0	$0
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$1,704
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$150,720
SUBTOTAL DIRECT OPERATING COSTS				$228,725
B) INDIRECT OPERATING COSTS				
7) OVERHEAD		0.60 * (OL+SL+ML+MM)		$23,587
8) PROPERTY TAX		0.01 * TIEC		$3,997
9) INSURANCE		0.01 * TIEC		$3,997
10) GENERAL AND ADMINISTRATIVE		0.02 * TIEC		$7,993
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST		0.1770 * TIEC		$70,740
SUBTOTAL INDIRECT COSTS				$110,314

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$228,725
INDIRECT OPERATING	$110,314
TOTAL ANNUAL COST	$339,039
COST EFFECTIVENESS, $/TON REMOVED	$8,027

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	118054
SCFM	SLAS	27000
ACFM	SLAA	28000
GAS TEMP. DEG. F	TI	85
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	40
COMBUSTION CHAMBER TEMP, DEG. F	TC	650
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	4.97

SYSTEM DESCRIPTION

CATALYTIC INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$448,800
b) AUXILIARY EQUIPMENT	AS REQ'D			$15,762
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$13,937
e) FREIGHT	1a+b *	0.05 *	1.0	$23,228
SUBTOTAL PURCHASED EQUIPMENT				$501,727
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$37,165
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$32,519
c) ELECTRICAL	1a *	0.04 *	1.0	$17,952
d) PIPING	1a *	0.02 *	1.0	$8,976
e) INSULATION	1a+b *	0.01 *	2.0	$9,291
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$105,904
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$46,456
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$11,614
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$23,228
d) STARTUP	1a+b *	0.02 *	1.0	$9,291
e) PERFORMANCE TEST	1a+b *	0.01 *	2.6	$12,079
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$27,874
SUBTOTAL INSTALLATION INDIRECT				$130,542

SUMMARY - TOTAL CAPITAL COSTS

PURCHASED EQUIPMENT	$501,727
INSTALLATION DIRECT	$105,904
INSTALLATION INDIRECT	$130,542
TIEC	$738,172

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 4.97 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 248106 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 255 DEG. F

PREHEAT TEMP, TP

TP = TI + HEX * (TC - TI)

TP = 481 DEG. F

FAN POWER, KWH/HR

SG = 0.072 LBS/FT3
DP = 25 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 9.101 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 10.8 FT3

= 0.648 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		1.0	$32,400
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$5,452
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$110,341
SUBTOTAL DIRECT OPERATING COSTS				$224,494
B) INDIRECT OPERATING COSTS				
7) OVERHEAD		0.60 * (OL+SL+ML+MM)		$23,587
8) PROPERTY TAX		0.01 * TIEC		$7,382
9) INSURANCE		0.01 * TIEC		$7,382
10) GENERAL AND ADMINISTRATIVE		0.02 * TIEC		$14,763
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST		0.1770 * TIEC		$130,657
SUBTOTAL INDIRECT COSTS				$183,771

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$224,494
INDIRECT OPERATING	$183,771
TOTAL ANNUAL COST	$408,265
COST EFFECTIVENESS, $/TON REMOVED	$9,666

BASIS OF DESIGN

PARAMETER	LABEL	VALUE
GAS FLOW		
LBS/HR	SLA#	118054
SCFM	SLAS	27000
ACFM	SLAA	28000
GAS TEMP. DEG. F	TI	85
SOLVENT LOADING		
LBS/HR	SLL	18.75
AVG. MOLEC. WT	MW	106
PPM	PPM	40
COMBUSTION CHAMBER TEMP, DEG. F	TC	1500
HEAT EXCHANGE EFFIC.	HEX	70.0%
CAPTURE EFFICIENCY	CE	0.95
DESTRUCTION EFFICIENCY	DRE	0.95
REQUIRED BURNER CAPACITY, MM Btu/HR	BC	12.45

SYSTEM DESCRIPTION

DIRECT FIRED INCINERATOR, COST FROM SEVERAL QUOTES, UPDATED TO 1988 DOLLARS; AUXILARY DUCTWORK NOT INCLUDED IN INCIN. PRICE; FAN AND INSTRUMENTATION/CONTROLS INCLUDED IN INCIN. PRICE

CAPITAL COSTS

	BASIS	RATE	AF	COST
A) DIRECT COSTS				
1) PURCHASED EQUIPMENT				
a) CONTROL DEVICE	AS REQ'D			$322,300
b) AUXILIARY EQUIPMENT	AS REQ'D			$15,762
c) INSTRUMENTS AND CONTROLS	1a *	0.10 *	0.0	$0
d) TAXES	1a+b+c *	0.03 *	1.0	$10,142
e) FREIGHT	1a+b *	0.05 *	1.0	$16,903
SUBTOTAL PURCHASED EQUIPMENT				$365,107
2) INSTALLATION DIRECT				
a) FOUNDATIONS AND SUPPORTS	1a+b *	0.08 *	1.0	$27,045
b) ERECTION AND HANDLING	1a+b *	0.14 *	0.5	$23,664
c) ELECTRICAL	1a *	0.04 *	1.0	$12,892
d) PIPING	1a *	0.02 *	1.0	$6,446
e) INSULATION	1a+b *	0.01 *	2.0	$6,761
f) PAINTING	1a+b *	0.01 *	0.0	$0
g) SITE PREPARATION	AS REQ'D			$0
h) FACILITIES AND BUILDINGS	AS REQ'D			$0
SUBTOTAL INSTALLATION DIRECT				$76,809
B) INDIRECT COSTS				
3) INSTALLATION INDIRECT				
a) ENGINEERING AND SUPERVISION	1a+b *	0.10 *	1.0	$33,806
b) CONSTR. AND FIELD EXPENSES	1a+b *	0.05 *	0.5	$8,452
c) CONSTRUCTION FEE	1a+b *	0.10 *	0.5	$16,903
d) STARTUP	1a+b *	0.02 *	1.0	$6,761
e) PERFORMANCE TEST	1a+b *	0.01 *	3.6	$12,170
f) MODEL STUDY				
g) CONTINGENCIES	1a+b *	0.03 *	2.0	$20,284
SUBTOTAL INSTALLATION INDIRECT				$98,376

SUMMARY - TOTAL CAPITAL COSTS

PURCHASED EQUIPMENT		$365,107
INSTALLATION DIRECT		$76,809
INSTALLATION INDIRECT		$98,376
	TIEC	$540,292

ANNUAL OPERATIONS

HOURS/DAY	16	
DAYS/WEEK	6	
WEEKS/YEAR	52	
HOURS/YEAR		4992
SHIFTS/YEAR		624

AUXILIARY FUEL NEEDS

DH = SLAS * CPg * (TC - TI) * (1 - HEX)

CPg = 0.0181 Btu/(ft3 * deg F)

DH = 12.45 MM Btu/HR

ANNUAL FUEL CONSUMPTION GAS Btu/CCF 100,000

AFC = DH * HOURS / Btu/UNIT

AFC = 621364 CCF

STACK TEMP, TS

TS = TI + (1 - HEX) * (TC - TI)

TS = 509.5 DEG. F

PREHEAT TEMP, TP

TP = TI + 0.7 * (TC - TI)

TP = 1075.5 DEG. F

FAN POWER, KWH/HR

SG = 0.072 LBS/FT3
DP = 15 in WC

FP = 0.746 * SLAA * DP * SG / (6356 *.65)

= 5.460 KWH/HR

CATALYST USE/DISPOSAL

WASTE = 2 FT3/MCFM * SLAS / LIFE [5 YRS]

= 10.8 FT3

= 0.648 TONS

ANNUAL COSTS

A) DIRECT OPERATING COSTS				
1) OPERATING LABOR				
a) OPERATORS	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) SUPERVISORS	15% OF OPER. LABOR	0.15		$1,872
2) OPERATING MATERIALS				
3) MAINTENANCE				
a) LABOR	HR/SHIFT @ $/HR	0.5	$40	$12,480
b) MATERIALS	100% OF OPER. LABOR	1.00		$12,480
4) REPLACEMENT PARTS	CATALYST $3,000 /FT3		0.0	$0
5) UTILITIES				
a) ELECTRICITY	$0.120 /KWH			$3,271
b) NATURAL GAS	$0.7928 /CCF 1ST	500		$396
	$0.7100 /CCF NEXT	5500		$3,905
	$0.6671 /CCF NEXT	49000		$32,688
	$0.5714 /CCF OVER	55000		$323,620
SUBTOTAL DIRECT OPERATING COSTS				$403,192
B) INDIRECT OPERATING COSTS				
7) OVERHEAD	0.60 * (OL+SL+ML+MM)			$23,587
8) PROPERTY TAX	0.01 * TIEC			$5,403
9) INSURANCE	0.01 * TIEC			$5,403
10) GENERAL AND ADMINISTRATIVE	0.02 * TIEC			$10,806
11) CAPITAL COST RECOVERY 10 YEARS, 12 % INTEREST	0.1770 * TIEC			$95,632
SUBTOTAL INDIRECT COSTS				$140,830

SUMMARY - ANNUALIZED COSTS

DIRECT OPERATING	$403,192
INDIRECT OPERATING	$140,830
TOTAL ANNUAL COST	$544,023
COST EFFECTIVENESS, $/TON REMOVED	$12,880

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
EPA 450/3-89-001		

4. TITLE AND SUBTITLE	5. REPORT DATE / 6. PERFORMING ORGANIZATION CODE
Evaluation of Emission Control Options at Leed Architectural Products	5. September 1989 6.

7. AUTHOR(S)	8. PERFORMING ORGANIZATION REPORT NO.
Engineering Science, Inc.	

9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT NO. / 11. CONTRACT/GRANT NO.
Engineering Science, Inc. Two Flint Hill 10521 Rosehaven Street Fairfax, VA 22030	10. 11. 68-02-4398

12. SPONSORING AGENCY NAME AND ADDRESS	13. TYPE OF REPORT AND PERIOD COVERED / 14. SPONSORING AGENCY CODE
U.S. Environmental Protection Agency Emission Standards Division Mail Drop 13 Research Triangle Park, NC 27711	13. 14.

15. SUPPLEMENTARY NOTES

16. ABSTRACT

The Connecticut Department of Environmental Protection requested assistance from the U.S. Environmental Protection Agency's Control Technology Center in evaluation of feasible alternatives to control emissions of volatile organic compounds (VOC) from a specialty aluminum coating facility. The facility desired to increase its use of high VOC content liquid polyvinylidene fluoride (PVF) Kynar® coatings. The report examines several options for emission control by incineration of spray booth and bake oven exhaust gases. The report also discusses the development of Kynar® powder coatings, other PVF powder coatings and triglycidyl isocyanurate (TGIC) polyester powder coatings with performance characteristics similar to liquid Kynar® coatings.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Surface Coating Architectural Aluminum Products Kynar® Coatings Powder Coatings		

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