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From: Date.

State of Florida
DEPARTMENT OF ENVIRONMENTAL REGULATION

Interoffice Memorandum

TO: John Turner

THRU: Barry Andrews BA

FROM: John Reynolds JR

DATE: March 12, 1991

SUBJ: Sea Ray Boats, Inc. - Conceptual Plan
Permit Nos. AC 05-165270, 165271, 178450

*ALL 3 Reports included

AO 05-

The Conceptual Plan and Potential Course of Action prepared by Sea Ray Boats, Inc., has been reviewed as required by Specific Condition No. 9 of the above construction permits. The report proposes work practice controls, increased use of acetone substitutes, and conversion to low styrene resins as future measures for further reducing VOC emissions. Sea Ray's submittal satisfies the requirements of the construction permit condition. We recommend that the operating permits specify a reasonable schedule for implementation of the course of action presented in the report.

JR/plm

c: G. E. Cantelou, Jr., P.E.

CONCEPTUAL PLAN AND POTENTIAL COURSE OF ACTION
FOR THE

FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

PREPARED FOR

SEA RAY BOATS, INC.
SYKES CREEK FACILITY

PREPARED BY :

CANTELOU ASSOCIATES
CONSULTING ENGINEERS • PLANNERS
401 Park Avenue SW / P.O. Box 3102 / Aiken, S.C. 29801

A0 05-178450

TABLE OF CONTENTS

I. INTRODUCTION. (Sykes Creek).

The purpose of this document is to present background information and data that will support a conceptual plan and potential course of action regarding the reduction or elimination of air emissions from production operations to be considered by Sea Ray Boats, Inc. Implementation of the plan shall demonstrate to the Florida Department of Environmental Regulation that every reasonable effort has been undertaken to assure that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facilities property boundary. [F.A.C. Rules 17-2.200 and 17-2.620 (1) and (2)].

II. Process and Air Emissions. (Sykes Creek).

This chapter will discuss in general the fiberglass reinforced plastic boatbuilding industry and in particular the activities of Sea Ray Boats, Inc. The chapter is divided into three sections. The first will describe the industry in general. The second section will describe the manufacturing process and its emissions, and finally the manufacturing process and VOC/OS emissions at the Sea Ray facility.

Section 1. General.

The fiberglass reinforced plastic boat industry is defined within SIC Code 3732, Boat Building and Repairing. The industry as a whole is comprised of many small businesses with a wide range in the number of employees and size of boats manufactured. The size of fiberglass boats range from about twelve feet to two hundred feet in length. "Large" boats are classified as those greater than thirty feet in length and "small" boats are those less than thirty feet in length. Facilities may produce a range of more than fifty boats per day to less than one boat per month, all depending on boat size and plant capabilities.

Section 2. General - Production Process and Emissions.

There are several methods employed in the production of fiberglass boats. The following discussion, however, is limited to the primary method used within the industry. That process is called "contact open molding". There are air emissions (VOC/OS) associated with that process and they are derived from polyester resin, gel coat resin, paints, carpet glue and cleaning solvents. Various factors and manufacturing techniques influence significantly the quantity of cleaning solvent emissions.

2.1. Production Process for Fiberglass Boats and Methods of Lamination

The Radian Corporation presented a thorough discussion of the manufacturing process for fiberglass boats and it is reproduced here as follows:

"The contact molding method consists of applying layers of resin impregnated fiberglass reinforcement (laminated) on an open female or male mold. The laminate is built up to the required thickness and then allowed to harden or cure. After the cure is completed, the part is removed and the mold is reused. A male mold is convex leaving a smooth inner surface and a female mold is

concave leaving a smooth outer surface on the product. Since a smooth outer surface is normally desired, female molds are most commonly used in fiberglass boat production.

The primary type of resin used in fiberglass boat production is polyester resin. Polyester resins typically consist of 45 percent styrene monomer and 55 percent polyester solids. Before applying the resin, the necessary catalyst and accelerator are added to initiate curing. During curing, the styrene monomer polymerizes forming a thermo-setting plastic. This is an exothermic process, and because styrene monomer reacts more rapidly at elevated temperatures, the reaction is autocatalytic.

The general production process steps used in the industry for manufacturing fiberglass boats are shown in Exhibit "A". The different parts of the boat (deck, hull, small parts) are fabricated in the molding room. The decks and hulls are fabricated in the main area of the molding room while the small parts are fabricated in the small parts booth. The first step in the production

process is coating the mold with a releasing agent such as wax. A gel coat is then applied on the mold with a spray gun in a ventilated spray booth. The gel coat is a pigmented polyester resin which forms the outer smooth surface of the molded part. After spraying, the gel coat hardens or cures with a smooth surface against the mold and a tacky outer surface which enhances later bonding of the first layer of laminate.

After the gel coat cures, the first layer of resin and fiberglass laminate is applied using one of the lamination methods described below. The lamination procedure is repeated until the desired thickness is achieved. Structural reinforcements such as wood, plastic, and metal are also added during lamination. Lamination is a batch process with time between laminates dependent on cure time of the resin. After the final lamination has cured, the excess is trimmed from the part and the part is removed from the mold.

After the parts are removed from the mold, they are then taken to the assembly room where they are sanded and the boat is assembled. In addition, carpet and accessories are often installed to produce the finished product.

There are two methods of lamination used in the fiberglass boat manufacturing industry. These are hand lay-up and spray-up. Each method offers advantages and disadvantages over the other and a combination of the two is often used.

In the hand lay-up method, resin is applied with a resin gun or in rare cases with a brush. If a resin gun is used to apply the resin, a brush is usually employed to even out the resin. After a thin coat of resin has been applied to the gel coat or previous layer of laminate, fiberglass reinforcement is placed over the wet resin. The primary fiberglass reinforcements used in hand lay-up are woven roving, cloth, and mat. Squeegees or metal rollers are then used to force the resin up through the reinforcement and remove any entrapped air (wet out). The resin is allowed to gel and the lamination process is repeated until the desired thickness of fiberglass laminate is obtained.

Three types of resin guns may be used in hand lay-up. These are catalyst injection, dual component, and hot pot. The most common type used in the industry are catalyst injection resin guns. Catalyst injection resin guns mix accelerated resin

and the catalyst in the proper proportion inside the gun spray head and then spray the mixture through a single spray nozzle. With dual-component resin guns, two streams of resin are sprayed simultaneously. One stream consists of resin premixed with accelerator and one stream consists of resin premixed with catalyst. The spray nozzles are aimed so the two spray streams mix outside the spray gun and then form a single spray stream. Hot pot resin guns have a pressure pot attached to the gun head. The laminator mixes the resin, accelerator, and catalyst in the pressure pot by hand. All of the resin must be sprayed once it has been mixed in the pot or it will gel inside the spray gun.

The spray-up method is an alternative to hand lay-up for hull and deck fabrication and is the most common method of small parts production. The spray-up method employs a chopper gun to simultaneously apply resin and chopped strands of glass reinforcement. Brushes and rollers are then used to spread the mixture and remove entrapped air. This process is repeated until the desired thickness is obtained.

The spray-up method is restricted to laminates using chopped glass strand as the reinforcement. Due to the type of reinforcement, laminates produced in spray-up have lower glass to resin ratios than the woven roving or cloth laminates produced in hand lay-up. Because the strength to weight ratio is proportional to the glass to resin ratio, laminates produced in spray-up also have lower strength to weight ratios than woven roving or cloth laminates. Laminates produced in hand lay-up with mat reinforcement are similar to those produced in spray-up because mat reinforcement is just chopped strand with a binder.

The advantage of using hand lay-up with woven roving or cloth laminate over spray-up is that a product with a higher strength to weight ratio is produced. However, the fabrication process takes longer when the hand lay-up method is used. A common practice in the industry is to combine these two methods. With this combination, parts of a boat that need to be strongest are fabricated using hand lay-up while parts that do not need as much strength, such as small parts, are fabricated using spray-up. This results in a lightweight boat that is produced in the minimum amount of time."

2.2. Emissions Sources

There are generally two sources of emissions from the fiberglass boat manufacturing processes that produce volatile organic vapors and organic solvent vapors. These originate in the lamination area due to resin application and cleanup operations or the assembly area of the plant due to painting and carpet installation.

Emissions from the lamination process are due to the evaporation or vaporization of the styrene monomer contained within the gel coat and resin applied when the hull, deck, and small parts are manufactured. An additional portion of the styrene monomer contained in resin and gel coat is subject to evaporation after application and before polymerization occurs.

OSHA (Occupational Health and Safety Administration) mandates that worker exposure to styrene concentrations not exceed 25 parts per million. As a result of this requirement, the air contained within the building is vented to the outside and completely replaced by fresh air every ten minutes. In other words, six air changes are required for the total volume of the building every hour.

There are additional exhausts from spray booths to the outside.

The OSHA requirement is the primary factor controlling the rate at which air containing styrene within the lamination building is moved to the outside.

Vapors from clean-up solvents also contribute to the quantity of emissions from the lamination process. Tool and spray gun cleaning is required after each batch of resin is applied. When the spray guns are flushed some of the organic solvent used is vaporized. Also, employees must clean their hands frequently. When tools, spray guns and hands are washed with solvent an amount of solvent is carried from the container on these items and readily evaporates due to the large surface area exposed to air per volume of solvent.

Additional VOC/OS emissions occur in the assembly area during the painting of boat parts and application of glue during carpet installation. The glue solvent evaporates into the room air while vapors from paint application are exhausted to the outside.

2.3. Techniques and Factors Affecting Emissions from Organic Cleaning Solvents.

Cleaning solvent emissions (usually acetone) account for fifty to seventy-five percent of all air emissions from the plant operations. The major factors that influence these emissions are resin gel time, use of covers on storage containers, work habits of the employee, the number of employees, use of hand protection and protective clothing, and air movement within the plant building. Resin gel time affects emissions because it determines the number of times equipment and employees must be cleaned in a specific period of time. Resin gel times may vary from ten to thirty minutes with fifteen minutes being the average desired.

The evaporation of cleaning solvents may be reduced by covering the containers between cleanup operations. Other factors that effect rate of evaporation are the liquid level in the containers, air movement across the containers, and the room temperature. An increase in any of these will increase the evaporation rate.

Work habits of the employee can lower emissions by reducing the amount of resin or other product which must be removed from hands and arms

by cleaning solvents. Some employees are able to stay relatively clean while other employees may get considerably more on themselves. Employee work habits are influenced by training and supervision. The complexity of the mold can also significantly affect the amount of resin which an employee may get on his hands and arms. The more complex the mold, the more difficulty encountered for keeping the employee clean.

The number of employees involved in the lamination process affects emissions because each employee must clean his hands and tools after each operation. Usually, each employee has his own set of solvent containers, this practice increase the volume and surface area exposure to evaporation.

The use of hand protection reduces the number of times and employee must clean his hands. Without protection, cleaning of hands would occur after each resin application or every twenty to thirty minutes. Using gloves may reduce the clean-up of hands to as low as four times a day.

The factors discussed above are generally determined by the amount of organic cleaning solvent issued per employee. The amount of

cleaning solvent issued can be reduced if gloves are required to reduce hand cleaning and covered containers are used to slow evaporation. Room air ventilation reductions are not practical since this would increase worker exposure to the higher concentrations of styrene and other vapors. Temperature for resin curing is determined by the resin chemistry and cannot be changed easily.

Section 3. Sea Ray Boats, Inc. (Sykes Creek Plant) Production Process and Emissions

The production procedure utilized by Sea Ray Boats, Inc. at the Sykes Creek Plant are the same as those shown in Production Flow Diagram (Exhibit "A"). The Sykes Creek Plant has one gel coat booth and one small parts booth contained in the lamination area. The gel coat used consists of 40% styrene monomer, 0 % methyl methacrylate, and 60 % pigmented solids. Following the gel coat, Sea Ray uses a spray up method with application of woven roving and/or glass cloth hand rolled into place, with additional structural supports and stringers laid into the hull or deck and secured by additional resin and chopped reinforcement. The spray up method is used for small parts.

Batches of promoted resin and catalyzed resin are prepared, the two resins flow thru independent lines and are mixed at the nozzle of the spray gun. The gel time is approximately twenty minutes. The resin used is a general purpose polyester resin containing approximately 40 % styrene and 60 % resin solids.

The VOC/OS emissions at the Sykes Creek Plant are shown in Exhibit "B", (Florida Department of Environmental Regulation, Operation Permit for Air Pollution Source). These emissions result from the evaporation of styrene, acetone, paint and carpet glue solvents. As shown in Exhibit "B", the major sources of VOC/OS emissions are styrene evaporation during hull and deck fabrication, styrene and methyl methacrylate evaporation during gel coat application, and acetone vapors emitted during cleanup. These sources account for over 70% of the emissions so permitted. Emissions from this source according to the operation permit (Exhibit "B") shall not exceed 17.8 tons per year.

Sea Ray's VOC/OS emissions resulting from the cleanup and lamination operations are forced to the atmosphere by exhaust fans in the building sidewalls. The air flow rate of these exhaust fans is rated at 200,000 cfm. These fans are permitted to operate a maximum of 16 hours a day, five days per week. Concentrations within the air exiting these points have

not been measured. The calculated average concentration based on permitted quantities is 5.6 ppm styrene, 4.2 ppm acetone. Other emissions from this source shall be considered fugitive emissions and cannot be identified with any one point.

The Sykes Creek Plant purchases approximately 1,100 gallons of acetone each year and produces 95 gallons of spent acetone per year. This difference represents the emissions of acetone to the air as a result of the production process. The spent acetone is purchased and carried off-site by a licensed carrier to be recycled. Therefore, the volume carried off-site will not contribute to the Sykes Creek's emissions inventory.

III. Emission Control Techniques.

The discussion that follows in this chapter will cover techniques that may be utilized by the Sykes Creek facility to reduce or eliminate VOC emissions from the boat building operations. The first section will discuss process alterations to control acetone emissions, while the second section will consider changes that serve to reduce styrene emissions. Section three will examine add-on controls for exhaust air leaving the facility.

Section 1. General - Acetone Emission Controls.

Acetone emissions may be controlled using three separate approaches. Substitution of non-volatile solvents or emulsifiers, work practice, and spent acetone reclamation.

1.1. Substitution Other Products for Acetone.

There have been products introduced to replace some of the acetone usage. These products vary from strong emulsifiers to non-volatile organic solvents. These emulsifier type products may be used successfully in hand cleaning of tools used in the lamination process. Non-volatile solvents have also seen success in these areas. It should be noted however that the final cleaning of these

tools needs to be accomplished using acetone. Acetone has been found to be the safest product for use in order to remove residue from the initial cleaning operation (i.e. water droplets and other debris). See Exhibit "C", containing manufacturers data on acetone substitutes.

1.2. Work Practice Controls.

The primary work practice controls to reduce acetone emissions in the building of fiberglass boats are as follows:

(a) hand protection,

(b) covered acetone containers,

(c) limiting the issuance of acetone.

1.2.a. Within the boat building facility the resin application methods vary from spray-up to lay-up, the workers are exposed to resin thru handling the tools and overspray from the spray-up. The issuance of gloves, disposable garments and shoe covers eliminates to a great degree the cleaning of hands, other exposed skin areas, and clothing that may come into contact with the resin. This will reduce the amount of acetone to be issued to each employee.

1.2.b. Covering the acetone containers that hold the new acetone as well as the dirty acetone will reduce loss thru evaporation. This provision will also limit the amount of acetone to be required by the employee.

1.2.c. The employer may study each employees use and cleaning techniques and unilaterally reduce the quantity of acetone provided to the employee. The employee recognizing the reduced quantity will be forced into conservation and prudent use of the product.

1.3. Spent Acetone Reclamation.

Emissions can be reduced by recycling the spent acetone. Two options offering economic and environmental benefits exist regarding the disposal of spent acetone. They are on-site recovery or distillation and the delivery of the spent product to a commercial reclaiming facility.

On-site recycling can reduce disposal emission by 90%. The recycling units (stills) are available commercially in various sizes, compatabile with the industrial requirement. Their installation requires electricity and cooling water. A safety hazard also exists with the operation of the still.

As an alternative, there are commercial waste handlers that reclaim spent acetone. The emissions can be eliminated entirely by sending the spent acetone off-site for reclamation. There is an added advantage to the manufacturer in that he also gets rid of the solid waste in the acetone.

Section 2. General - Styrene Emission Control.

Styrene is the cross-linking agent in polyester resins and also it it used as a solvent in the compound that can be used to increase or decrease the viscosity or workability of the resin.

Styrene emissions can be reduced by the manufacturer, if his process will allow him to convert to a new resin designed to limit styrene losses. These new resins may contain a supressant (wax) or may be designed to function with a low-styrene content.

2.1 Supressed Resin.

Supressed resins entrap the styrene monomer that would be emitted as vapor during the exothermal curing of the resin compound. These supressed resins can reduce total styrene emissions by as much as fifty percent. However, a study of manufacturers indicates poor performance of the

finished product. Delamination of the resin has been cited by most as a serious problem. Before a supressed resin could be placed in production, the manufacturer should require extensive testing in the lab and field to determine the products reliability.

2.2. Low Styrene Resin.

Another method of reducing styrene emissions is the conversion by the manufacturer to a low styrene resin. This conversion will reduce emissions because the styrene monomer in the resin can be lowered to as much as thirty-five percent. This can be compared to forty or forty-five percent in conventional resins. Emission reductions during curing due to conversion may be seventeen to thirty percent, this would equate to an overall reduction of ten to twenty percent.

Section 3. Add-On Control.

Add-on controls apply to the boat building industry in the area of exhaust air from the building. The exhaust from spray booths and building ventilation fans can be captured and treated by chemical scrubbing or incineration.

3.1. Chemical Scrubbers.

Chemical scrubbing removes organic vapors from the air by absorbing them into a liquid. The absorbed materials are destroyed by the chemicals in the liquid.

A major problem exist with this approach. Waste stream would be created with the chemical used to absorb air contaminants and the handling of the volume of the chemical waste created by this approach would render the operation impractical.

3.2. Contaminant Incineration.

Two types of incinerators are available, thermal and catalytic. Thermal incineration involves the oxidation of organic vapors to carbon dioxide and water. The solvent laden air is exposed to a high temperature of 1000 to 1500 degrees Farenheit and in some cases a direct flame for a period of 0.3 to 0.6 seconds. Catalytic incinerators use a catalyst bed to oxidize the organic vapors and operate at reduced temperatures of 750 to 1000 degrees Farenheit. Important incineration design factors are residence time, gas stream flow rate, operating temperature, and waste gas heat content.

When collected, most waste gases have low heat contents. This is due in part to OSHA and insurance regulations which limit the maximum concentration of organics to 25 percent of the lower explosive limit (LEL) when no LEL meter is used. If an LEL meter is present to constantly monitor the gas stream then the organic concentration can be as high as 40 percent of LEL. In either case supplemental fuel is needed to raise the off gases to the required operating temperature.

Heat recovery equipment may also be used with incinerators to reduce the amount of supplemental fuel required. It is generally divided into primary and secondary recovery. Primary heat recovery uses heat exchangers to recover heat from the incinerator exhaust gases to heat the incoming air. Secondary heat recovery recovers heat from the exhaust gases for use in plant processes such as ovens, dryers, etc.

The destruction efficiency of both thermal and catalytic incinerators depends on the residence time and temperature. In general these devices can be designed to achieve between 90 and 99+ percent destruction of VOC.

Incinerators have not been demonstrated as VOC control devices in the fiberglass boat manufacturing industry. The main problem results from the low VOC concentrations in the exhausts and high exhaust air flows. Calculated VOC concentrations in the exhaust streams average approximately 5.6 ppm for styrene and 4.2 ppm for acetone. These conditions would result in the exhaust stream having a low heat content thus resulting in high supplemental fuel requirements.

IV. Conclusion - Potential Course of Action.

Sea Ray Boats, Inc., has assessed the technical and economic feasibility of the alternatives presented herein. The potential course of action selected by the Sykes Creek Plant and presently being implemented are work practice controls, commercial recycling of acetone, substitution of emulsifiers for acetone where practical and conversion to low styrene resins.

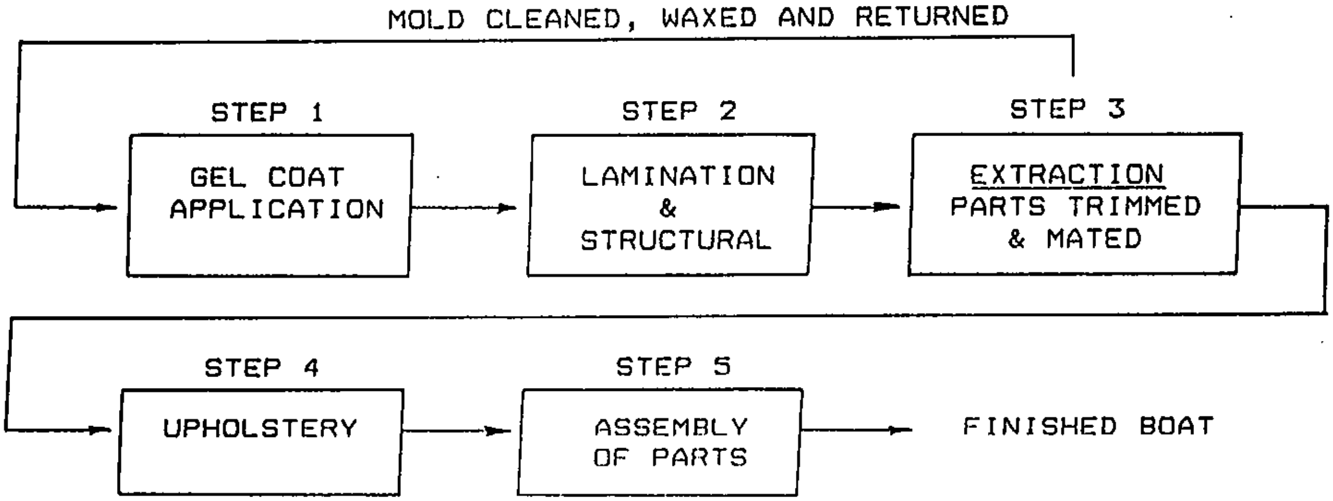
1. Work Practice Controls include the use of hand protection, covered acetone containers, limitation on the issue of acetone to employees and use of Rez-a-way, a commercial product (emulsifier) for cleaning of hands and tools. As discussed in the earlier sections this action should reduce emissions by approximately fifty percent from acetone.
2. The conversion to low styrene resins was selected over use of supressed resins because of the delamination problems experienced by manufacturers using the styrene supressed resin. The fact that the styrene emissions could be reduced using this low styrene resin by at least ten percent was discussed in Section III - 2.2.

Preliminary estimates showed controls by chemical scrubbing and incineration to be so expensive they were

dropped from further consideration. Both of these actions would require an extensive reconstruction of existing facilities, additional capital cost involving the purchase and installation of equipment, and a continuous operation and maintenance expense.

In addition, there would be an impact on waste stream if chemical scrubbing was used and possible risk of water pollution. Incinerators have not been demonstrated as VOC control devices in boat building industry because of low VOC concentration, high exhaust air flows, and the resulting high supplemental fuel requirements because of the low heat content in exhaust air.

PRODUCTION FLOW DIAGRAM



Florida Department of Environmental Regulation

Central District ● 3319 Maguire Boulevard, Suite 232 ● Orlando, Florida 32803-3767 ● 407-894-7555

Bob Martinez, Governor
Dale Twachtmann, Secretary
John Shearer, Assistant Secretary
Alex Alexander, Deputy Assistant Secretary

NOTICE OF PERMIT

Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Attention: Jeff Skuda, Plant Manager

Brevard County - AP
Fiberglass Boat Plant (East)

Dear Mr. Skuda:

Enclosed is Permit Number AO05-178450, dated 6-28-93, to operate the above referenced source, issued pursuant to Section 403.087, Florida Statutes.

Persons whose substantial interests are affected by this permit have a right, pursuant to Section 120.57, Florida Statutes, to petition for an administrative determination (hearing), unless the right to petition has been waived. The petition must conform to the requirements of Chapters 17-103 F.A.C., and must be filed (received) in the Department's Office of General Counsel, 2600 Blair Stone Road, Tallahassee 32399-2400, within fourteen (14) days of receipt of this notice. Failure to file a petition within that time constitutes a waiver of any right such person has to an administrative determination pursuant to Section 120.57, Florida Statutes.

The petition shall contain the following information; (a) the name, address and telephone number of each petitioner, the applicant's name and address, the Department Permit File Number and the county in which the project is proposed; (b) A statement of how and when each petitioner received notice of the department's action or proposed action; (c) A statement of how each petitioner's substantial interests are affected by the department's action or proposed action; (d) A statement of the material facts disputed by Petitioner, if any; (e) A statement of facts which petitioner contends warrant reversal or modification of the department's action or proposed action; (f) A statement of which rules or statutes petitioner contends require reversal or modification of the department's action or proposed action; and (g) A statement of the relief sought by petitioner, stating precisely the action petitioner wants the department to take with respect to the department's action or proposed action.

This Order (Permit) is final and effective on the date filed with the Clerk of the Department unless a petition is filed in accordance with the above paragraph. Upon the timely filing of a petition this Permit will not be effective until further Order of the Department.

Any party to the Order has the right to seek judicial review of the Order pursuant to Section 120.68, Florida Statutes, by the filing of a Notice of Appeal pursuant to Rule 9.110, Florida Rules of Appellate Procedure, with the Clerk of the Department in the Office of General Counsel, 2600 Blair Stone Road, Tallahassee, Florida 32399-2400; and by filing a copy of the Notice of Appeal accompanied by the applicable filing fees with the appropriate district Court of Appeal. The Notice of Appeal must be filed within 30 days from the date the Final Order is filed with the Clerk of the Department.

Executed in Orlando, Florida.

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL REGULATION

A. Alexander
Deputy Assistant Secretary
3319 Maguire Boulevard
Suite 232
Orlando, Florida 32803

FILING AND ACKNOWLEDGEMENT
FILED, on this date, pursuant to Section 120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

E. B. Williams 8/28/90
Clerk Date

ADB

AA/jtj

Copies furnished to:
G. E. Cantelou, Jr., P.E.

CERTIFICATE OF SERVICE

This is to certify that this NOTICE OF PERMIT and all copies were mailed before the close of business on 8-28-90 to the listed persons, by D. Jones.

Florida Department of Environmental Regulation

Central District • 3319 Maguire Boulevard, Suite 232 • Orlando, Florida 32803-3767 • 407-894-7555

Bob Martinez, Governor
Dale Twachtmann, Secretary
John Shearer, Assistant Secretary
Alex Alexander, Deputy Assistant Secretary

Permittee:
Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Attention: Jeff Skuda, Plant Manager

I. D. Number:
Permit/Certification
Number: A005-178450
Date of Issue:
Expiration Date: August 25, 1995
County: Brevard
Latitude/Longitude:
28°24'26"N/80°42'03"W
UTM: 17-529.3 KmE; 3142.1 KmN
Project: Fiberglass Boat Plant (East)

This permit is issued under the provisions of Chapter(s) 403, Florida Statutes, and Florida Administrative Code Rule(s) 17-2. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the department and made a part hereof and specifically described as follows:

The permittee can operate the Fiberglass Boat Plant (East) facility to produce fiberglass pleasure boats. The process includes gel coat application, lamination and structural, extraction, upholstery, and assembly of parts.

These sources are located at the boat plant facility located on the eastern side of the Sea Ray Boats property near Sikes Creek at 350 Sea Ray Drive, Merritt Island, Brevard County, Florida.

General Conditions are attached to be distributed to the permittee only.

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations and restrictions set forth in this permit, are "permit conditions" and are binding and enforceable pursuant to Sections 403.141, 403.727, or 403.859 through 403.861, F.S. The permittee is placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of these conditions.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in subsections 403.087(6) and 403.722(5), F.S., the issuance of this permit does not convey any vested rights or any exclusive privileges. Neither does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state, or local laws or regulations. This permit is not a waiver of or approval of any other Department permit that may be required for other aspects of the total project which are not addressed in this permit.

4. This permit conveys no title to land or water, does not constitute State recognition or acknowledgement of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the State. Only the Trustees of the Internal Improvement Trust Fund may express State opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, or plant life, or property caused by the construction or operation of this permitted source, or from penalties therefore; nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

6. The permittee shall properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed and used by the permittee to achieve compliance with the conditions of this permit, as required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law and at reasonable times, access to the premises where the permitted activity is located or conducted to:

   (a) Have access to and copy any records that must be kept under conditions of the permit;

   (b) Inspect the facility, equipment, practices, or operations regulated or required under this permit; and

   (c) Sample or monitor any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules.

   Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately provide the Department with the following information:

   (a) A description of and cause of noncompliance; and

   (b) The period of noncompliance, including dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the noncompliance.

   The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or for revocation of this permit.

GENERAL CONDITIONS:

9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source which are submitted to the Department may be used by the Department as evidence in any enforcement case involving the permitted source arising under the Florida Statutes or Department rules, except where such use is prescribed by Section 403.111 and 403.73, F.S. Such evidence shall only be used to the extent it is consistent with the Florida Rules of Civil Procedure and appropriate evidentiary rules.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance; provided, however, the permittee does not waive any other rights granted by Florida Statutes or Department rules.

11. This permit is transferable only upon Department approval in accordance with Rule 17-4.120 and 17-30.300, F.A.C., as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit or a copy thereof shall be kept at the work site of the permitted activity.

13. This permit also constitutes:

    ( ) Determination of Best Available Control Technology (BACT)

    ( ) Determination of Prevention of Significant Deterioration (PSD)

    ( ) Certification of compliance with state Water Quality Standards (Section 401, PL 92-500)

    ( ) Compliance with New Source Performance Standards

14. The permittee shall comply with the following:

    (a) Upon request, the permittee shall furnish all records and plans required under Department rules. During enforcement actions, the retention period for all records will be extended automatically unless otherwise stipulated by the Department.

    (b) The permittee shall hold at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation) required by the permit, copies of all reports required by this permit, and records of all data used to complete the application for this permit. These materials shall be retained at least three years from the date of the sample, measurement, report, or application unless otherwise specified by Department rule.

    (c) Records of monitoring information shall include:

        1. the date, exact place, and time of sampling or measurements;
        2. the person responsible for performing the sampling or measurements;
        3. the dates analyses were performed;
        4. the person responsible for performing the analyses;
        5. the analytical techniques or methods used;
        6. the results of such analyses.

15. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware the relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be corrected promptly.

PERMITTEE:	I. D. Number:
Sea Ray Boats, Inc.	Permit/Certification Number:
	A005-178450
Attention: Jeff Skuda, Plant Manager	Date of Issue:
	Expiration Date: August 25, 1995

GENERAL CONDITIONS:

16. No objectionable odors will be allowed, as per Rule 17-2.620(2), F.A.C.

17. This permit does not preclude compliance with any applicable local permitting requirements and regulations.

SPECIFIC CONDITIONS:

OPERATING LIMITS

1. The operation of this source shall be in accordance with the capacities and specifications stated in the permit.

2. The plant shall be allowed to operate for up to 1920 hours per year.

EMISSION LIMITS

3. Visible emissions from the dust collectors shall not be greater than 5% opacity and compliance shall be demonstrated at 90-100% of permitted capacity using DER Method 9 in accordance with F.A.C. Rule 17-2.700.

4. Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 18.5 lbs/hour, 296 lbs/day (30 day average), and 17.8 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors.

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	73.0	0.06	4.38
Styrene (Gel Coat)	15.6	0.30	4.69
MEKP	0.06	1.00	0.06
1,1,1-Trichloroethane	3.5	0.67	2.34
Acetone	3.82	1.00	3.82
Acetone (form-adhes)	1.54	0.35	0.54
Bottom Paint and Misc			
Bottom Paint	2.67	0.23	0.61
Form Adhes	1.54	0.28	0.43
Form Adhes	1.54	0.19	0.29
Misc	0.69	1.00	0.69
Carpet Bond	3.44	0.08	0.28

COMPLIANCE TESTING

5. Each dust collector must be tested annually from the date of March 15, 1990 for visible emissions in accordance with DER Method 9.

PERMITTEE:
Sea Ray Boats, Inc.

Attention: Jeff Skuda, Plant Manager

I. D. Number:
Permit/Certification Number:
A005-178450
Date of Issue:
Expiration Date: **August 25, 1995**

6. This office (Florida Department of Environmental Regulation, Air Permitting, Orlando) shall be notified at least fifteen (15) days in advance of the compliance tests so that we can witness them (Rule 17-2.700(2)(a)5, F.A.C.).

7. The required test report shall be filed with the department as soon as practical but no later than 45 days after the last sampling run of each test is completed (Rule 17-2.700(7)(a),(b) and (c), F.A.C).

8. Each calendar year on or before March 1, submit for each source, an Annual Operations Report DER Form 17-1.202(6) for the preceding calendar year in accordance with Rule 17-4.14, F.A.C. This report shall be utilized to demonstrate compliance with Specific Condition No. 4.

9. By January 31, 1991, Sea Ray Boats shall submit a conceptual plan and potential course of action that will provide the Department with reasonable assurance that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facility's property boundary or where the public has access, whichever is closest, pursuant to F.A.C. Rules 17-2.200 and 17-2.620(1) and (2). The plan should contain at a minimum, but not be limited to, various control system strategies that might be installed to reduce or eventually eliminate emissions of VOC/OS from each type of operation, associated time and cost analyses, and VOC/OS substitutes.

EXPIRATION DATE

10. An operation permit renewal must be submitted at least 60 days prior to the expiration date of this permit (Rule 17-4.09, F.A.C.).

ISSUED 8-28-90

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL REGULATION

cmc

A. Alexander
Deputy Assistant Secretary
3319 Maguire Boulevard
Suite 232
Orlando, Florida 32803

April 1990

FABRICATION NEWS

OFFICIAL PUBLICATION OF THE FIBERGLASS FABRICATION ASSOCIATION

A Practical Guide to Replacing Acetone

Replace Acetone Successfully –A Practical Guide–

The pace of movement away from acetone as a cleanup solvent has certainly quickened lately. To help you keep up, Dr. Reidar Halle, an acknowledged world-class expert on peroxides, and Joe Brennan have teamed for this very informative and easy-to-follow article.

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Replace Acetone Successfully —A Practical Guide—

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San Francisco, CA 94124
Telephone: 415-467-7887

• Introduction to Emulsifier Technology
• General comments

Like the revolutions in Eastern Europe, the revolution within the FRP Industry away from acetone as a cleanup solvent had a slow, sluggish and hesitant start. Now, the pace of both revolutions is brisk and broadly-based!

FRP laminators have two acetone replacement technologies available: resin emulsifiers and higher boiling point organic solvents. Emulsifier technology costs less than acetone and is significantly safer and more environmentally sound! In addition, emulsifiers, used correctly, actually clean better than acetone. Emulsifiers can easily replace 75-100% of the cleanup acetone in most shops—almost all used for cleaning rollers, brushes and hands. Sometimes, more elaborate techniques are needed to clean internal-mix spray guns and pultrusion dies.

In the past, there was some worker resistance to substitute any product for acetone—the only resin cleaner ever used by most laminators. Today, many FRP shops have implemented acetone replacement systems to comply with health, environmental and fire regulations. Many of these shops, both workers and management, now sing the praises of the safety, ease, efficiency and economy of their new emulsifier systems.

Both emulsifiers and high boiling point solvents reduce VOC (Volatile Organic Compounds) emissions, but the emulsifiers in most cases have the added advantage of not generating hazardous waste. Replacing acetone with high boiling solvents is initially a simpler process; however, the contaminated solvents must be distilled and/or hauled away for waste treatment. Also, solvent still bottoms present disposal problems in more and more states.

Why then does this technology, with its inherent advantages of lower fire, health and environmental dangers, fail to be adopted quickly by every FRP fabricator? The answer to this enigmatic question seems to be a widespread lack of understanding of the new emulsifier technology within the FRP industry. As a result, some FRP shops have neglected to implement an ongoing training programs to teach employees how to use emulsifiers effectively.

Unfortunately, far too many fabricators were presented with a sample of an emulsifier (identified as "an acetone replacement") for evaluation; accompanied only with an MSDS—no demonstrations or detailed instructions were offered! Therefore, in the absence of any other advice, many FRP companies evaluated the emulsifiers in the same manner they used acetone, rather than as a new technology with different techniques. Some laminators complained bitterly to management about the difficulty of cleaning with emulsifiers; and justifiably so, acetone methods don't work with emulsifiers. These complaints frequently led to the abandonment of the acetone replacement project.

On the other hand, if you examine those FRP shops that have successfully implemented emulsifier systems vis-à-vis the unsuccessful shops, you will conclude: The successful shops have the common thread of hands-on management commitment to eliminate hazardous waste generation, close supplier support, and a company-wide training program.

The following is a step-by-step look at the fundamentals of emulsifier technology and the recommendations for FRP shops to choose the correct system to successfully make the transition from acetone to emulsifier technology.

• Emulsifiers versus Solvents
• How does an emulsifier differ from acetone?

Separation versus dissolving: Organic solvents, whether acetone or higher boiling point products, clean the resins by dissolving them homogeneously, creating a dilute solution of the resin—also hazardous waste and varying levels of VOCs. In the process of cleaning resins with acetone, the sticky resin is diluted and spread around, rather then removed from the cleaning solution as with emulsifier technology.

The result is: The efficiency of solvents used for resin cleanup declines rapidly after the first use. Emulsifier cleaning solutions, on the other hand, actually become clearer as the resin settles to the bottom, allowing continued use of the cleaning solution.

The most important differences are:

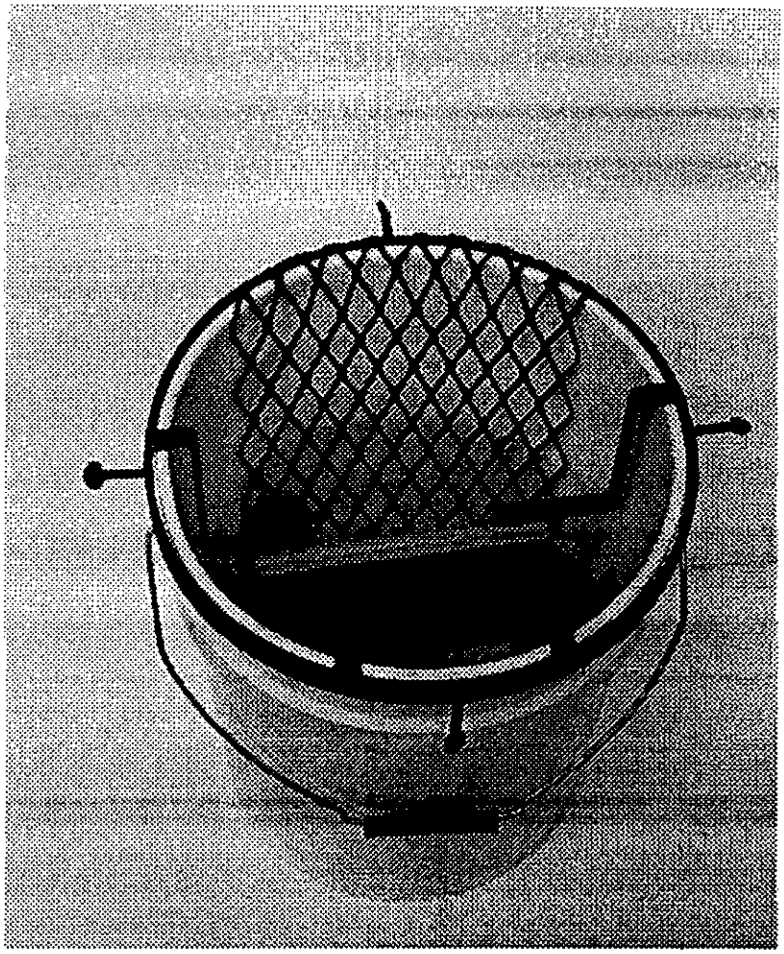
Hazardous Waste Generation: Solvents used for cleaning resins always generate hazardous waste, emulsifiers usually don't.

VOC Emissions: Acetone generates 6,600 pounds of VOCs for each 1,000 gallons consumed in cleaning; typically, 75-100% evaporates. In addition, recycling

Replace Acetone Successfully

solvents, regardless of boiling point, eventually loses all the solvent to evaporation, spillage or still bottoms. A comparable amount of a low-solvent emulsifier cleaner generates only 30-50 pounds of VOCs—a >99% reduction. This point becomes more critical when increased FRP production levels threaten to exceed total plant VOC allowable limits.

Fire & Health Hazards: Emulsifiers are water-based solutions that present no fire danger—preferred by fire marshals and insurance companies. Organic solvents often burn; some, such as acetone, burn vigorously and are red label. Solvents often have workplace air concentration and exposure limits to protect workers; emulsifiers pose no air quality problems.



- **How does an emulsifier work?**

An emulsifier formulation for resin cleaning is a mixture of surfactants (surface tension modifiers), combined with wetting and complexing agents in water—the system is usually alkaline. Some emulsifier formulations contain excess amounts of solvents; this initially improves the cleaning action of the formulation, but has some serious drawbacks. Solvents dissolve metal salts (Cobalt), styrene, and other organic compounds that can cause disposal problems. In general, a FRP shop manager should check the data sheet and MSDS of the emulsifier product before the evaluation to determine the potential for sewer disposal problems.

An emulsifier surrounds the globules of tacky resin and renders them tack-free by chemical action. These globules, unable to fight gravity by sticking to a surface, fall to the bottom of the cleaning vessel, where they cure, if catalyzed. The emulsified resin in the cleaning vessel should separate to the bottom efficiently to keep the cleaning solution free from resin. Emulsifier products that contain inefficient surfactants, high solvent content, or require heating, can retard this desirable quality of efficient separation. There is a simple resin screening test (covered later in this article) to determine qualitatively the separation capabilities of various emulsifiers.

The emulsifier cleaning solution can continue to be used until the product is depleted—roughly twice as long as solvents—then discharged into the sewer when the proper procedures are followed, and the neccesarry sewer permits are obtained. The cured resin at the bottom of the emulsifier cleaning vessel should be removed, dried and can be discarded with other solid nonhazardous waste.

- **Why have acetone-replacement projects failed?**

Most FRP shops that have had little or no success switching from acetone to emulsifiers haven't approached the project as an engineered system designed for the plant's unique needs. A system—integrating a basic understanding of the technology in choosing an emulsifier and hardware, a workers' training program, and a disposal method for the spent emulsifier—is essential for the successful conversion from acetone to emulsifier technology.

Typically, companies that failed to make the transition from acetone to emulsifiers on the first attempt did not fully understand that emulsifier cleanup was a different technology involving new strategies and techniques.

Technology Change: Using the long established techniques developed for acetone cleanup will not work with water-based emulsifiers. FRP laminators have to change their work techniques, and sometimes the type of tools and the cleanup systems employed. Actually, acetone replacement is not a direct product replacement, but a technology change.

Laminators can not merely dip-rinse and soak hand tools as with acetone. Tools must be cleaned immediately free of resin.

Instead of simply dissolving resin from the surfaces as solvents do, emulsifiers work best when the liquid bond of the resin to the surface is physically broken by mechanical brushing or swirling. Once the bond is broken, the emulsifier coats the resin, making it nonsticky. The critical step for FRP shops is to select the best mechanical device—brushes in most cases set in place on racks suspended in the emulsifier solution.

Also, there has been some confusion over the technique of cleaning rollers and brushes, as well as dewatering the tools before returning to the laminate. Emulsifier techniques are specific and often re-

feature

Replace Acetone Successfully

serted, is the best solution to this problem. Mechanical devices in combination with emulsifiers clean efficiently and allow higher dilution ratios and better cost effectiveness.

- **Spray guns**

Spray guns, both internal and external-mix, are cleaned with a 1:5 dilution ratio.

- **Hand & light-wipe cleaning**

Simple hand cleaning and wiping down a cured FRP part requires a dilution of 1:15 to 1:20 in most cases. A hands-only type of Jiffy-Cleaner (with softer brushes) is recommended for best results. Hands must be rinsed in clear water to remove the residual emulsifier to prevent skin irritation or rash.

Using spray bottles of emulsifier diluted 1:20 in water is the best approach to wiping off cured gel coat surfaces and laminates. This minimizes the fire and air pollution dangers posed by acetone cleaning.

- **Dilution methods**

Management should determine a standard method of emulsifier dilution and appoint an employee to be responsible for preparing the emulsifier solution. This step avoids inconsistent results (over dilution) and waste (under dilution). Either batch mixing or the use of a proportioning hose connection gives satisfactory results.

- **How to clean with emulsifiers**
  - **Roller & paint brushes**

The following are directions for cleaning rollers and brushes in a Jiffy-Cleaner—the most popular and versatile cleaning tool:

Fill a diluted emulsifier solution into a Jiffy-Cleaner to a level of 1" above the top of the brushes. Fill a second pail with clean water to approximately three-quarters full; change the rinse water periodically as needed.

Insert rollers soiled with resin between the Jiffy-Cleaner scrub brushes and plunge the rollers three or more times between the brushes. The bottom bracket of the Jiffy-Cleaner is elevated several inches from the bottom of the bucket so the rollers do not touch the curing resin collected there.

Shake off excess emulsifier and suds and briefly dip the rollers in the clear water pail. Give three to four sharp snaps of the wrist to dispel water from the surface of the rollers. In most cases the rollers are now dry enough to return to the laminate. If not, hang the rollers to dry for several minutes. All tools must be cleaned immediately in order to avoid the resin curing on parts. This is important: Soaking tools before cleaning is unnecessary—and a problem, if the resin is allowed to cure on the tools. Rollers cleaned with emulsifiers are nonsticky and noticeably cleaner than those cleaned with organic solvents.

A small number of FRP shops use the larger felt paint-type of rollers to apply resin uniformly to the laminates. These rollers clean well in a 1-inch or 2-inch Jiffy-Cleaner. After the felt cover is cleaned and rinsed in clear water, it should be wrung by hand and hung on a peg to dry. The removable felt cover should have a plastic core, not paper or cardboard. The roller holder can be cleaner in the Jiffy-Cleaner and dried before another felt roller cover is attached.

<u>For brushes, the technique is important:</u>

Insert the paint brushes in the Jiffy-Cleaner by pressing the bristles against the top of the Jiffy-Cleaner brushes on one side. Move the handle of the paint brush downward along the open space between brushes to scrub the interior paint brush bristles clean. The bristles should be pointing upward and be spread out like a bird's tail. Pull up. Turn the paint brush over and repeat. Depending upon the size of the brush, repeat this technique several times until the paint brush is free from resin. Squeeze the bristles to expel the excess emulsifier and suds.

Rinse the paint brush in clear water by forcing the bristles against the side of the pail beneath the water. Wring the bristles and hit them against the top of the bucket rapidly several times to dispel water droplets from the brush. Hang brush to dry if still moist, or use dry air.

Use splash goggles to prevent emulsifier solution from getting into the eyes. Read MSDS and product data sheets before use.

- **What system tools are required?**

<u>Fixed Brushes</u>

A Jiffy-Cleaner was invented to aid in the cleaning of the tools using emulsifiers. The Jiffy-Cleaner, with fixed brushes on a rack, is widely used to clean rollers and brushes. It is a versatile tool that is available in various container sizes (5, 15 & 55-gallon) and brush configurations.

<u>Air-driven brushes</u>

Air-driven brushes, despite their lack of versatility and mobility, are well suited for some specialty cleaning: Very large or odd-sized tools and rollers; intricate parts and dies. Air-driven brush machines cause a powerful churning action that finely disperses the emulsified resin in suspension for a considerably longer time. This vortex flow also stirs up the resin collecting at the bottom of the cleaning reservoir—this tends to decrease the efficiency of the emulsifier solution and possibly poses a sewer disposal problem. For this reason, air-driven brush systems should have deep reservoirs equipped with baffles.

<u>Heated Baths</u>

Heated reservoirs are not widely used, but do have specific applications (e.g., intricate parts, pipes, dies). They suffer from the same lack of versatility and mobility as air-driven brush machines. Hot water baths do improve cleaning somewhat by reducing the resin viscosity and improving the emulsifying action. However, heated baths increase the levels of styrene, cobalt salts, MEKP, etc. in the emulsifier solution, and can cause sewer disposal problems.

- **Hands**

Hands are cleaned best in a dedicated hand Jiffy-Cleaner, followed by a clear water rinse to remove residual emulsifier. Soft sponges and hand brushes also clean well. Hands may be dried with towels or air. Insufficient rinsing and drying of hands, or a combination of emulsifier residue with solvents and resins can cause skin irritation.

- **Spray & gel coat guns**

Due to wide variations in emulsifier effectiveness with various resins and fillers, it is difficult to give specific cleaning instructions for internal-mix and gel coat spray guns. Spray gun manufacturers and emulsifier suppliers should be consulted. External-mix guns can be cleaned with an emulsifier spray bottle and small brush, and dried with clean cloths similar to solvent cleaning.

- **Dies and molds**

This normally involves heavily-filled resins with specialty additives that even make acetone cleanup difficult due to stickiness. An emulsifier system, with air-driven brushes and heated reservoir, can do a

more effective job than solvents. Almost every system is unique, but all are based on the basic principles of emulsifier technology: Use of mechanical energy to break the resin liquid bond with the surface; emulsification and separation of the resin; clear water rinse and drying.

• Wipe off of cured FRP parts

Emulsifiers diluted to 1:20 in spray bottles can be used with clean cloth wipes to clean oil, dirt or liquid resin from cured resin parts. This type of cleaning is similar to acetone cleaning. However, acetone spreads a portion of the diluted residue over the entire surface; emulsifiers remove the resin, oil or dirt from the surface.

• Cured resin

Cleaning cured resin is a problem for emulsifiers as well as acetone. Methylene Chloride is somewhat effective, but is being restricted as a resin cleanup solvent. Most solvents that remove cured resins also carry health and environmental warnings. Preventive maintenance is essential to minimize this problem by dealing with the resin waste before it cures.

• How to solve cleaning problems

• Introduction

If possible, FRP managers should get an in-plant demonstration from their emulsifier supplier. This allows management and production personnel to see the proper techniques and procedures to clean their currently used resins from their own tools first hand from experienced professionals. If demonstrations are not possible, complete "How to Use..." and "How to Dispose of..." instruction guides are available from suppliers. Finally, follow-up training is necessary to ensure that proper procedures are maintained.

• Cleaning efficiency

Cleaning efficiency with emulsifiers is dependent on the speed of separation of the emulsified resin to the bottom of the cleaning vessel. Even if the chemical separation is good, if the vessel is shallow (especially critical with air-driven brushes), the curing resin is stirred up into the cleaning zone, causing inefficient cleaning. Therefore, it is important to use deep containers (5-gallon minimum) with fixed brushes that are at least two inches off the bottom; air-driven brushes should be considerably higher because of the churning action caused by the rotating brushes. If more than 4-5 laminators are cleaning tools, additional cleaning buckets should be set up. Regular changing of the emulsifier cleaning solution is best—daily changing, if that works in your operation.

• Possible pitfalls

Below is a summary of the typical problems with the use of emulsifiers if the proper procedures are not performed. All of the pitfalls associated with rollers, brushes and hands can be avoided by using the proper hardware tools and techniques to clean, rinse and dewater the rollers.

• Rollers

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and correct technique.

Water in barrel

Remedy: Learn technique of snapping wrist to force water from rollers.

Barrel freeze

Remedy: Use Jiffy-Cleaner and learn technique to rinse and dewater. Also, use quick-release rollers to minimize barrel freeze.

• Brushes

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and learn the technique of cleaning the interior bristles of the paint brush, and use the proper dewatering method.

Water in handle

Remedy: Punch holes in the ferrule on the handle to allow excess water to drain; hang up to dry with bristle toward the ceiling to minimize the drying time.

Moisture

Remedy: Brushes may be air dried or forced dried with compressed air.

• Hands

Inadequate cleaning

Remedy: For inadequate cleaning—sticky hands—use a hand brush or soft-brush Jiffy-Cleaner to remove the resin before rinsing. Hand rinsing with clear water is essential to prevent skin rash or discomfort. Hand cleaner systems should be placed at or close to waist level for the best results.

Moisture on hands

Remedy: Supply soft clean towels or air driers near the hand cleaning station.

• Spray guns

Cleaning spray guns, especially internal-mix and gel coat guns, is not a simple task. It will probably involve the technical assistance of your emulsifier supplier and your gun manufacturer. Certain resin types, fillers and pigments can cause inefficient cleaning and excessive plugging of guns if the proper emulsifier is not used. It is strongly suggested that this conversion be made last after the replacement of the open acetone containers used for cleaning rollers, brushes and hands. It is essential for each plant to establish and follow a standard procedure for cleaning spray guns.

• Training

Almost all pitfalls outlined above can be avoided or minimized by good training, follow-up programs and the help of your suppliers. An in-plant demonstration is worth thousands of words. Call your supplier.

• How to handle your spent cleaning solution

Liquid solution

Filter the solid resin from the emulsifier cleaning solution at the end of each day. The cleaning solution can continue to be used until it is completely spent. When the cleaning solution is no longer effective, allow at least 24 hours settling time before the final filtering. Then, the spent emulsifier liquid can be discharged into the sewer if permits have been obtained.

Resin sediment

The wet resin sediment, separated from the liquid portion of the spent solution, must be dried before disposal. Spread the wet solid for ease of drying. The dried, cured resin can be disposed of as solid nonhazardous waste along with the hardened resin and trim. Note: Only catalyzed resins cure to a solid.

★• How to dispose of the waste

Liquid effluent

The spent emulsifier solution can be discharged into the sewer if the Federal, State and Local regulations have been met. However, navigating the maze of regulations necessary to obtain a sewer disposal permit is difficult, detailed and time-consuming. Contact your emulsifier supplier for assistance and guidance.

Normally, spent emulsifier solutions from plant operations would not be classified as a hazardous waste. However, any

Replace Acetone Successfully

mixture with a hazardous waste listed in 40 CFR Part 261 Subpart D, Proposition 65, or similar state regulations, etc., would make the resultant waste stream hazardous.

In addition, if a waste stream generated from the use of an emulsifier exhibits one or more of the characteristics of hazardous waste (Corrosivity, EP toxicity, reactivity, or ignitability), it likewise would be subject to the hazardous waste regulations. If in doubt, have your waste stream analyzed.

Use splash goggles to prevent eye injuries when handling.

Septic systems

Septic systems are local issues, and it may not be possible to dispose of the effluent into leaching fields. Consult your emulsifier supplier.

Evaporation

Evaporation by heating of the water phase of the spent emulsifier solution is possible, but it is energy-intensive and expensive.

Cleaning water for recycling

This a costly affair, but it might be of interest to large companies that already have recycling/treatment plants.

Dried cured resin residue

The generated solid cured resin, when dried, may be able to be disposed of as nonhazardous waste. If the residual resin is not completely cured, add a small amount of catalyzed resin to complete the cure before disposal.

Cost comparison with solvents

The purchase price of cleanup solvents—without disposal costs included—are from $2+ per gallon for acetone to 3-4 times as much for higher boiling solvents.

Diluted emulsifier solutions typically cost $1.00 per gallon and last at least twice as long as solvents. The cost effectiveness of emulsifiers versus solvents is substantial, even if the solvents are recycled—only 50-60% of all cleanup solvents are reclaimed. Emulsifiers offer considerable cost advantages even before the additional hidden costs of solvent recycling losses and disposal are factored into the comparison.

• Summary

Replacing acetone with emulsifiers is a technology change. At least 75% of all acetone used for cleanup can be replaced easily by emulsifiers, but most FRP shops initially require the close involvement of their emulsifier supplier to accomplish this.

FRP shops should begin by replacing the solvents used for cleaning tools and hands first; this switch is the easiest and represents the biggest cost reduction and environmental benefits. The remaining areas, such as spray gun cleaning, require a more detailed and systematic approach.

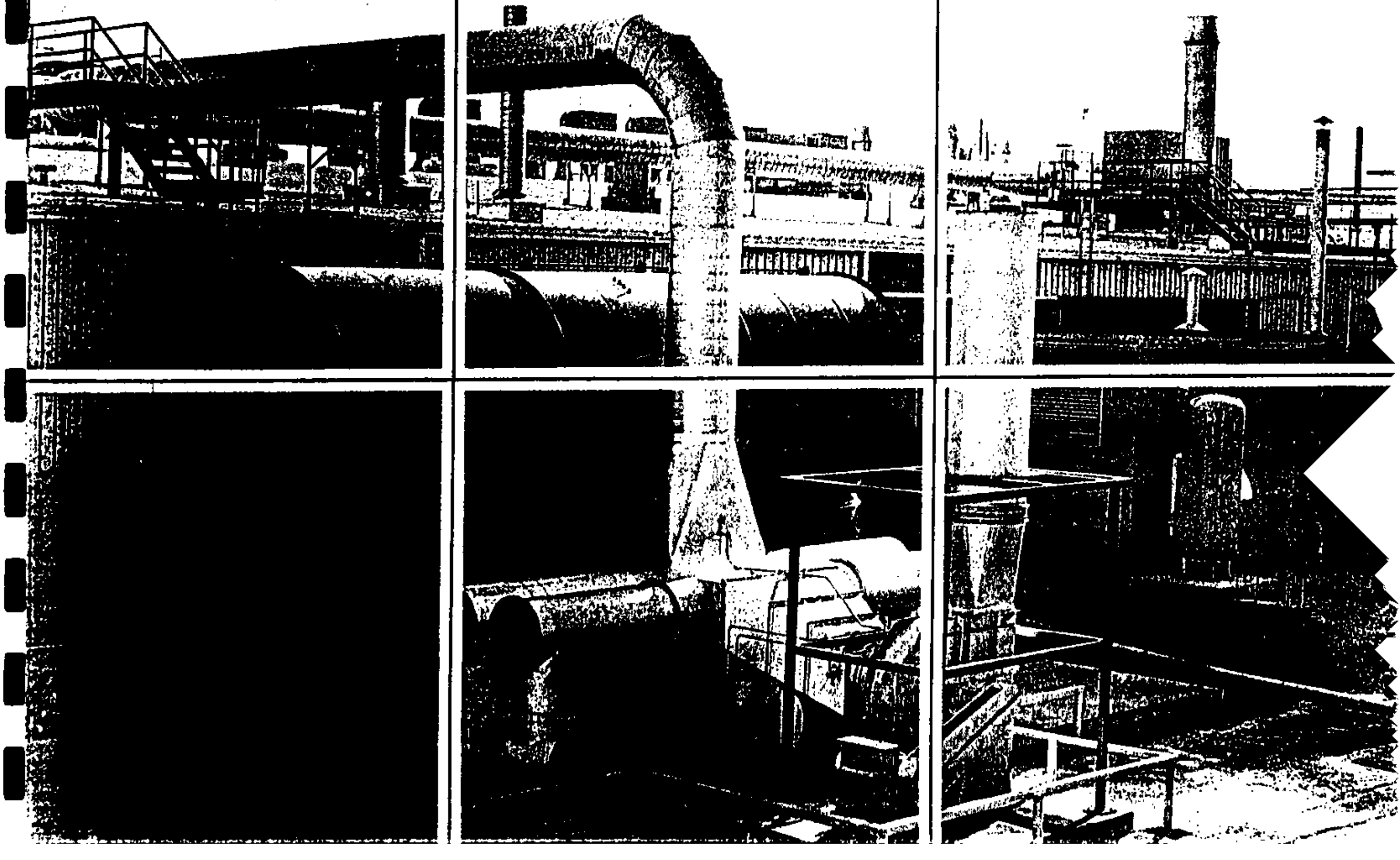
The bottom line is: The choice of emulsifier suppliers is critical because the FRP fabricator often must rely on his supplier for his resin-cleaning systems for the 1990s, worker training, disposal methods and a sewer discharge permit.

JWP INC. ENERGY AND ENVIRONMENT

HES

**HUNTINGTON
ENERGY
SYSTEMS, INC.**

Huntington Energy Systems designs and installs the most thermally efficient fume oxidation systems available to industry today.



HUNTINGTON ENERGY SYSTEMS

Preserving the environment and meeting EPA standards in a cost efficient manner requires state-of-the-art engineering. HES engineers, manufactures and installs the most technologically advanced and thermally efficient fume oxidation systems available to industry today, through its patented designs. With a staff of experienced engineering and sales professionals, supported by advanced Computer Aided Design (CAD) equipment, HES has delivered systems to customers and industries ranging from local printers to major manufacturers. Over the years, HES has developed a reputation for high quality, reliability and low maintenance life cycle costs.

System Operation—The HES Regenerative Fume Oxidation system destroys noxious fumes containing organic solvents, hydrocarbons and odors by oxidation at temperatures in the realm of 1500 degrees Fahrenheit. The fumes are converted to harmless water vapor and carbon dioxide. The regenerative cycle stores combustion heat energy for reuse to preheat process emissions prior to oxidation, providing the most thermodynamically efficient system of fume oxidation. It is, therefore, the most cost effective means available for compliance with government requirements for pollution control.

System Simplicity—The concept of the HES design is simplicity. The patented single valve drive shaft minimizes operation and maintenance problems. All other systems utilize multiple electric operators or complicated hydraulics. This also substantially reduces the amount of field wiring required.

System Performance—The HES Regenerative Fume Oxidation System incorporates the latest fume oxidation technology. Its patented design destroys the pollutants in contaminated exhaust streams while recovering up to 95% of the input heat energy for preheating the process emissions. The requirement for auxiliary fuel is thereby minimized to the lowest possible level. The system will meet and/or exceed the current VOC destruction requirements mandated by local and federal Environmental Protection Agencies.

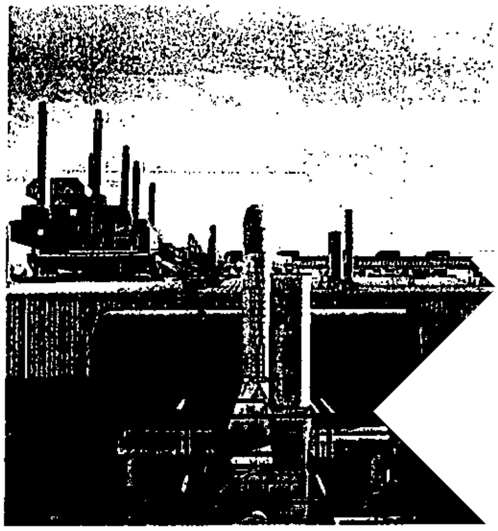
Total System Responsibility—HES takes full responsibility for the installation and start-up of its systems on a turnkey contract basis, including the design and modification of connected processes, e.g. air-volume reduction.

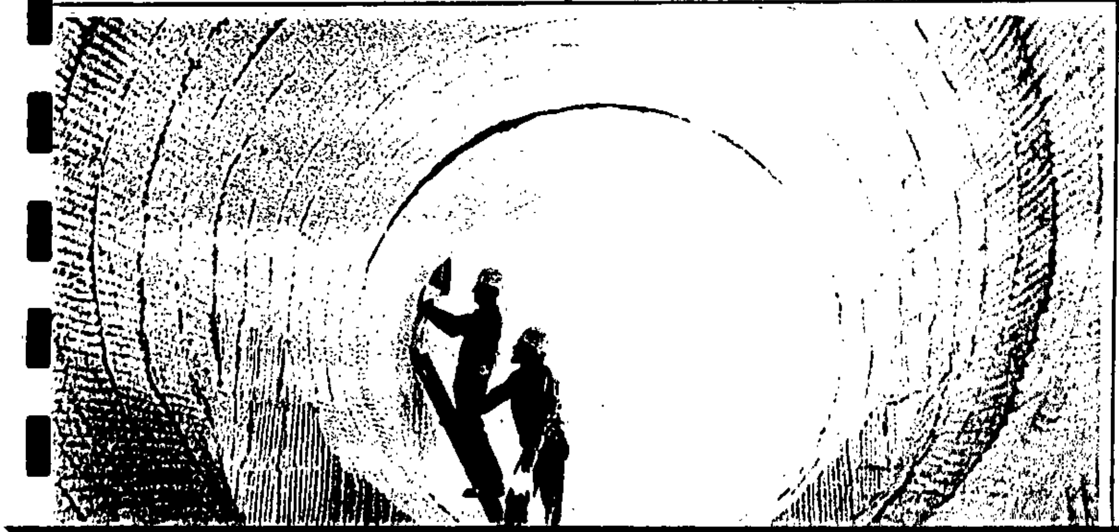
System Economy—"Life-Cycle Cost" ...the cost of owning and operating capital equipment is the total of its capital cost, its operating cost and the cost of maintaining the equipment over the period of its anticipated useful life. The life-cycle cost of HES's Regenerative Fume Oxidation system is substantially lower than that of alternate systems.

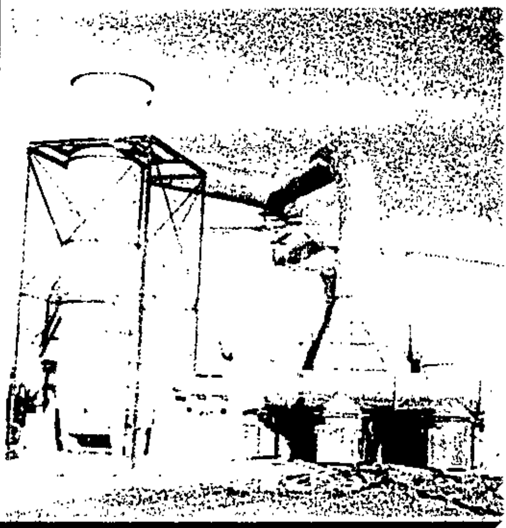
Who Is HES? HES is a wholly owned subsidiary of JWP, INC., a NYSE corporation with annual sales well in excess of a billion dollars. HES customers can expect systems to reflect dedication to quality performance.

Application: A major manufacturer of military tract vehicles such as tanks, troop carriers and construction vehicles. The final stage of manufacturing requires painting of the vehicle with solvent-based coatings. The HES System destroys air pollutants emitted from the paint spraying and drying processes. (Size: 20,000 SCFM)

Application: A residential wood cabinet manufacturer which coats the wood with stain, antiquing, sealants, and other finishes. Prior to discharge into the atmosphere, these predominantly solvent-based coatings are oxidized by the HES System, allowing the manufacturer to meet EPA standards in a cost efficient manner. (Size = 75,000 SCFM).







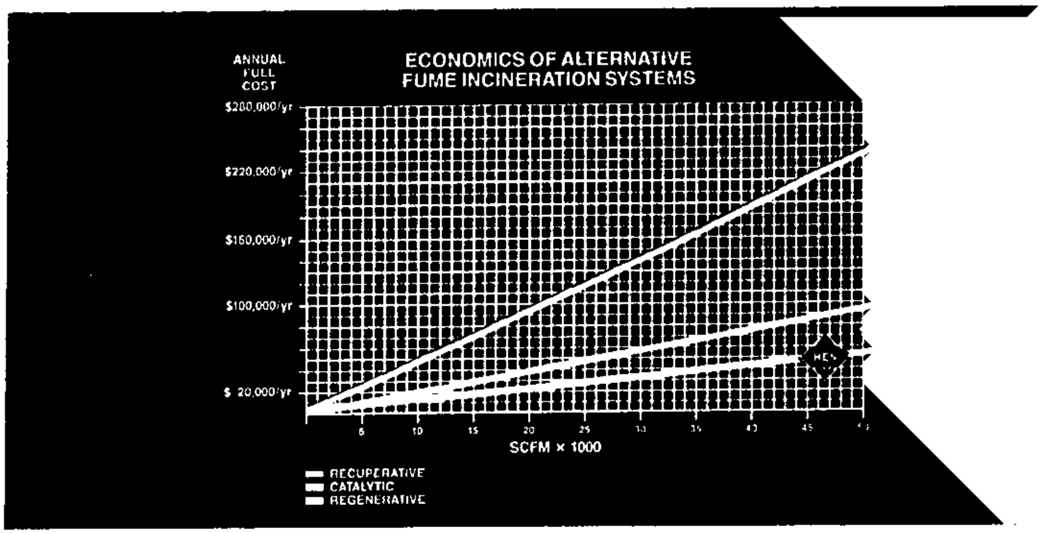
"MINIMIZING THE COST OF FUME EMISSIONS CONTROL"

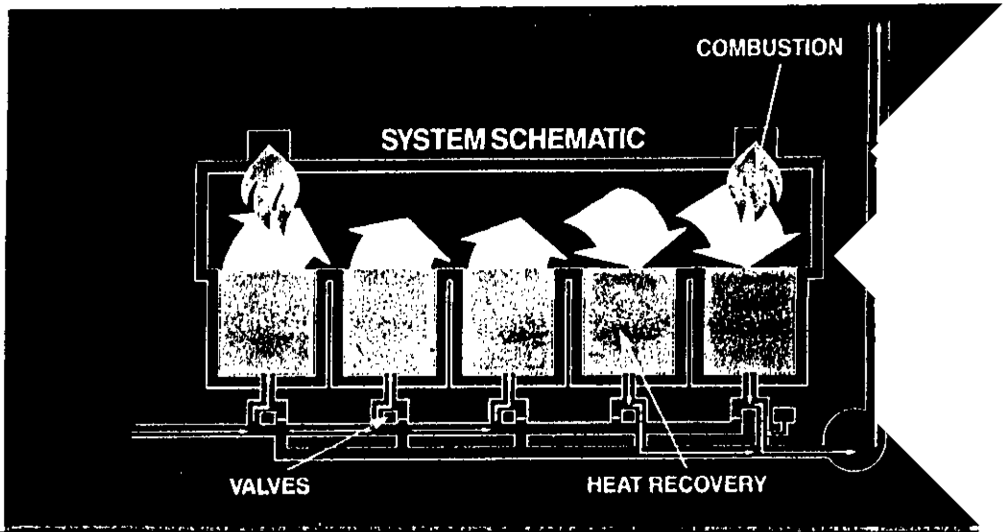
Application: a major vinyl floor covering manufacturer, which was required to meet the new clean air standards. Its problem was dealing with the VOCs released during the printing of resilient vinyl sheet flooring. By installing an HES regenerative fume oxidation system specifically designed for its needs, the firm has been able to heat the plant with recycled air resulting in a substantial fuel cost savings. This processor is also realizing additional savings on natural gas. (Size = 36,000 SCFM)

Not every system can have substantial savings designed into it because of the many variables involved, but we analyze every system for potential savings as well as for changes required to meet state and federal EPA requirements.

STANDARD FEATURES

- Single operator valve drive system
- Independent control and gas pipe trains for each burner
- Machined cast steel valves
- 1/4" ASTM A 36 steel housing
- Stainless steel ceramic support grids
- IRI/FM burner system
- 2400° soft ceramic insulation
- Programmable logic controller
- Expansion capabilities
- Prewired & Tested control panel





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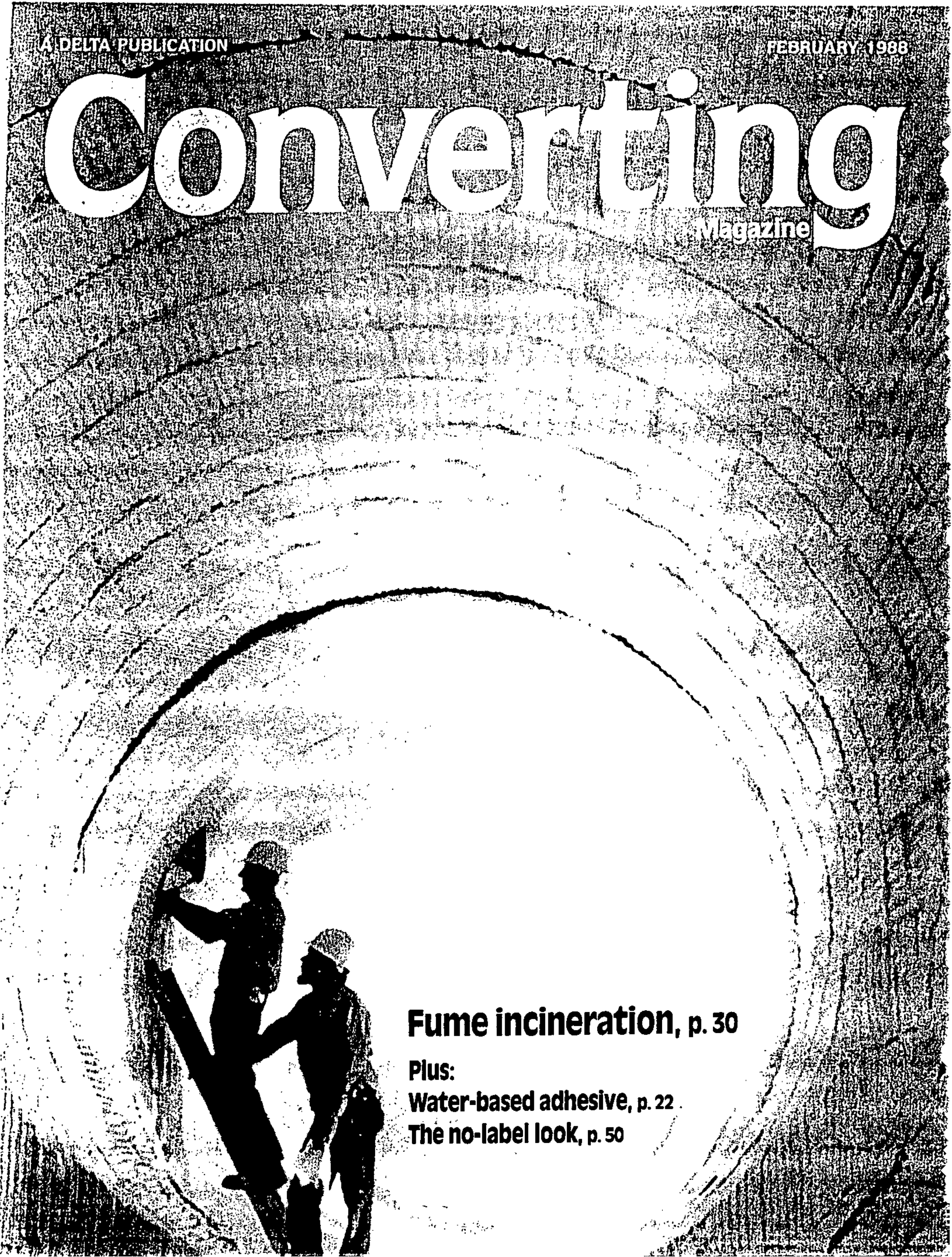
JWP INC. Company

A DELTA PUBLICATION

FEBRUARY 1988

Converting
Magazine



Fume incineration, p. 30

Plus:

Water-based adhesive, p. 22

The no-label look, p. 50

Technical Forum

Shopping for FUME INCINERATION

The purchase of an incineration system will impact not only on the state of EPA compliance, but can affect total operations in the long run. Knowing what to look for will greatly increase the chances of a successful selection. . . . by **Richard J. Greco**, vice president of engineering, Huntington Energy Systems

In order to meet the stringent clean-air standards set by the Environmental Protection Agency, a substantial segment of American industry is choosing to install fume incineration systems as the method of compliance.

The choice of the proper system can mean much more than just meeting EPA requirements. It can mean a significant impact on profit. In fact, the proper system can actually pay for itself within a few years and lower manufacturing costs thereafter.

Fume incineration systems incorporate thermal oxidizers that destroy volatile organic compounds (VOCs) by high-temperature conversion of hydrocarbon-laden fumes to simple, harmless water vapor and carbon dioxide. While the various types of systems have acceptable clean-up efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks.

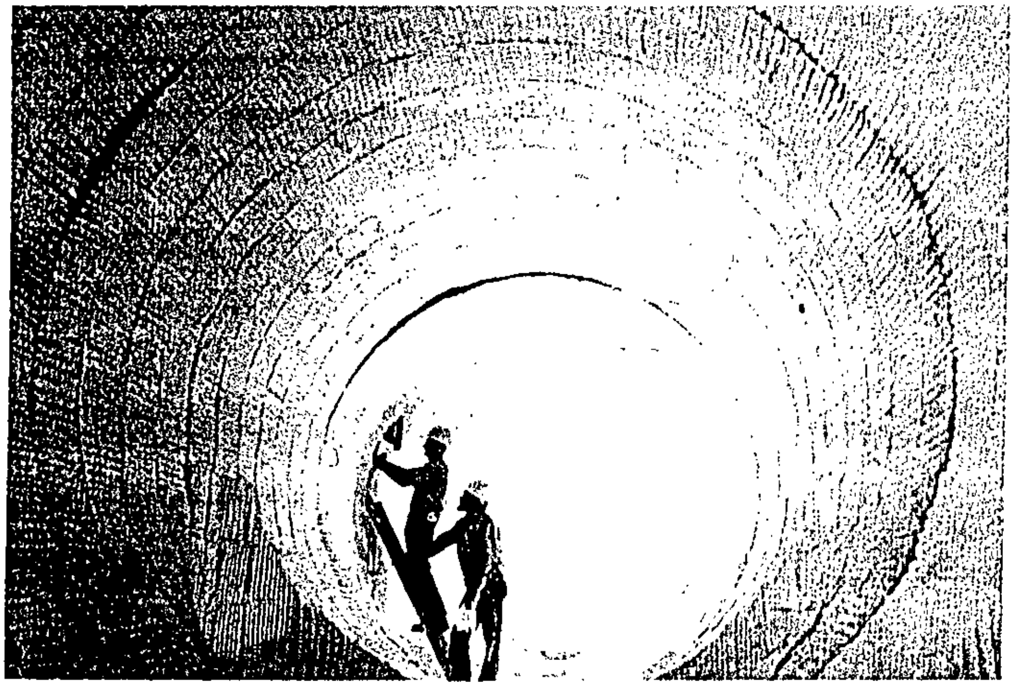
There are four types of fume incineration systems: common afterburner; catalytic converter; recuperative thermal oxidizer; and regenerative thermal oxidizer.

- ***Common afterburner*** (see Figure 1):

Function: Raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually ¼ sec at 1,400 deg F.

Benefits: The afterburner is relatively inexpensive to manufacture and install.

Drawbacks: It is not designed for efficient use of



Workmen put the finishing touches on the interior of a Huntington Energy Systems regenerative fume incinerator. The system is typical of those Huntington installs at converting operations. The incinerator is lined with Manville Z-Blok® refractory ceramic fiber modules to withstand temperatures up to 2,300 deg F and 1,000 AFPM air flow velocity.

FIGURE 1

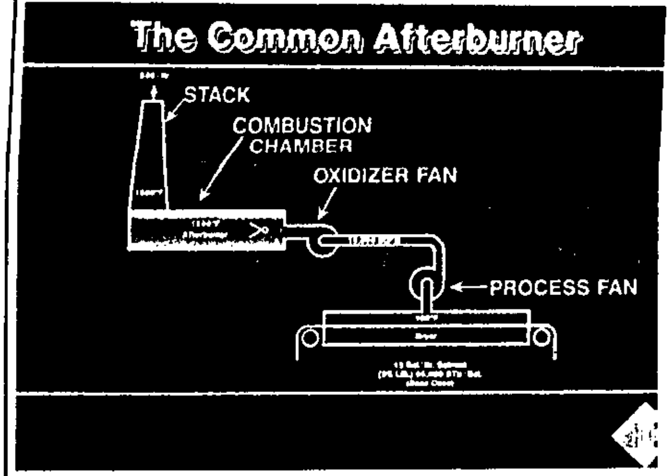

The Common Afterburner

FIGURE 2

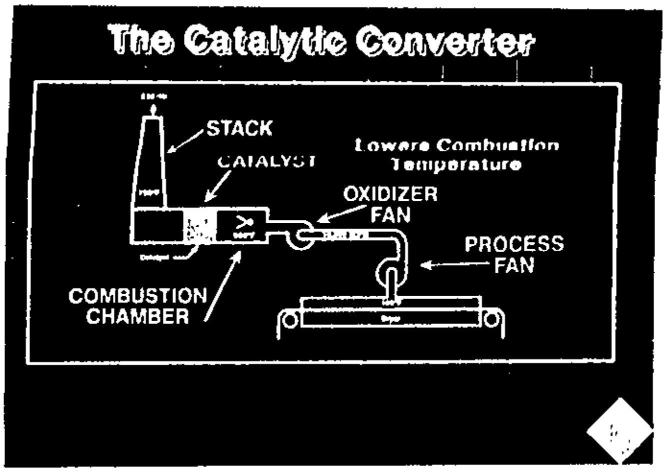
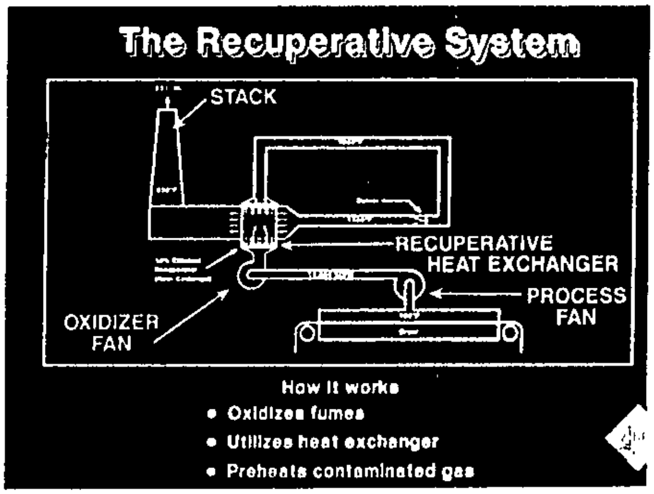
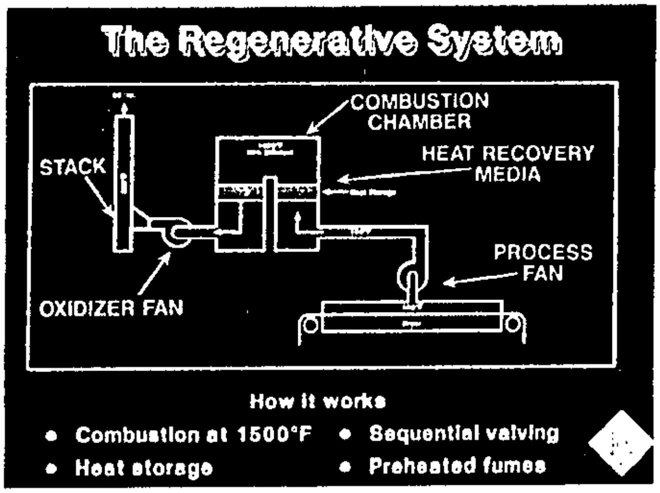

The Catalytic Converter

FIGURE 3


The Recuperative System

How it works
- Oxidizes fumes
- Utilizes heat exchanger
- Preheats contaminated gas

FIGURE 4


The Regenerative System

How it works
- Combustion at 1500°F
- Sequential valving
- Heat storage
- Preheated fumes

fuel and typically consumes 2,000 percent more fuel than other systems.

Industries/processes for which suitable: Small processes of 500 SCFM (Standard Cubic Feet Per Minute) or less.

Cost: Installed cost of equipment only is under $150,000 for a 500 SCFM unit. The cost to operate is approximately $10,000 for 2,000 hrs/yr, or about $20/SCFM year.[1]

- ***Catalytic converter*** (see Figure 2):

Function: Hydrocarbon-laden fumes are pushed by a fan through a preheat section wherein the temperature of the fumes is raised to a maximum of 700 deg F. The fumes then pass through another section of the system containing the catalyst, which reduces the oxidation temperature to 700 deg F, at which the hydrocarbons are thermally oxidized.

Benefits: The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams).

Drawbacks: It performs poorly with fumes contaminated with ash, paper, dust, resin, heavy metals or silicone—commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also reduces flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation. Ultimately, the catalyst becomes useless and the system becomes clogged, forcing the catalytic converter to function in the same way as a common, fuel-intensive afterburner.

Industries/processes for which suitable: clean ink processes; no silicone.

Cost: Costs to install depend on type of catalyst used. For a 10,000 SCFM unit, approximate cost to

Richard J. Greco is vice president of engineering for Huntington Energy Systems, Inc., a JWP Inc. subsidiary. He has been a mechanical engineer in the field of pollution control and combustion since 1965 and has designed and managed the installation of approximately 30 fume incinerator systems throughout the United States.

operate is $13,000 for 2,000 hrs/yr, or $1.30/SCFM year.

- ***Recuperative thermal oxidizer*** (see Figure 3):

Function: This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1,500 deg F gas by passing it through the low-temperature inlet gas stream via an indirect shell and tube heat exchange—thus preheating the incoming contaminated gas to within 65 percent (maximum of 80 percent) of oxidation temperature.

Benefits: The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to overcome the fuel required for combustion. The 20 to 35 percent of the heat lost during incineration can be reused for indirect building heat or steam, or it can be returned to the process.

Drawbacks: Auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as size, heat transfer coefficients and stress limit the system's preheat efficiency. Reusing the 20 to 35 percent lost heat requires an additional investment for heat transfer equipment and its maintenance.

Industries/processes for which suitable: High solvent concentrations above 25 percent LEL (lower explosive limit), coil coating and gravure printing.

Cost: No fuel usage when LEL is above 25 percent.

- ***Regenerative thermal oxidizer*** (see Figure 4):

Function: Oxidized gases exit the combustion chamber, passing through a porous heat-transfer section, storing by conduction 95 percent of its heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where, by conduction, fumes are preheated to within five percent of oxidation temperature by the already-stored heat on its way up to the combustion chamber. There is a continuous cycle of storing and releasing heat alternately within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

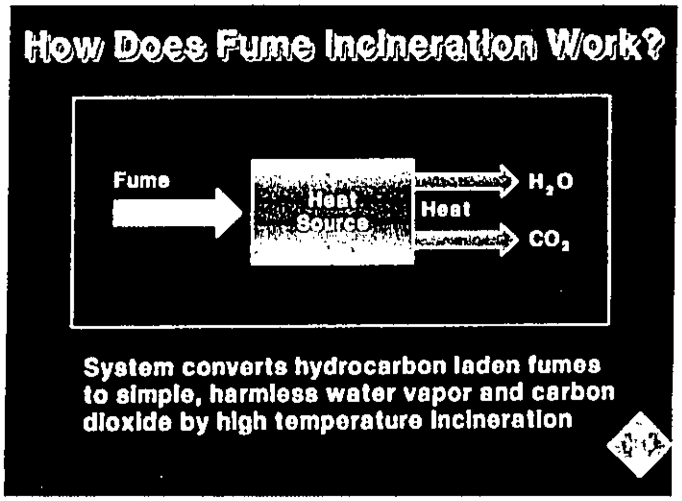
Benefits: The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5 percent of normally-required fuel is needed for oxidation. In many cases, just a burner pilot is sufficient when coupled with the 95 percent preheat efficiency.

Drawbacks: Most available systems are maintenance-intensive because they use hydraulic or electric drive valving components. However, there **are systems available that alleviate most of the maintenance because they utilize a single speed-reducer mechanical valving system.**

Industries/processes for which suitable: Recommended for larger process flows with lower solvent concentrations because the high primary heat recovery will reduce operating fuel costs. Five percent LEL or greater will result in almost no fuel usage.

Cost: Cost of equipment and system is approximately $45/SCFM.

(Note: The difference between a 95-percent-efficient regenerative unit and a 65-percent-efficient recuperative unit in terms of fuel use may *not* be 30 percent, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel use difference could be as high as 40 percent.)


How Does Fume Incineration Work?

System converts hydrocarbon laden fumes to simple, harmless water vapor and carbon dioxide by high temperature incineration

The following checklist covers the many factors to take into account when considering installation of a fume incineration system.

1. **Operating characteristics of process:**
   - Type of process
   - Emission exhaust volume (SCFM). Are there multiple sources, and what are the maximum and minimum exhaust volumes? At what flow rate is the system operating the majority of the time?
   - Hood exhaust volume (SCFM)
   - Oven exhaust temperature (deg F)
   - Oven temperature (deg F)
   - Process temperature of the stream going to the oxidizer (deg F)
   - Fuel used in process (oil, natural gas)

---

*Twenty-five percent LEL equals 10,000 SCFM/1 GPM (gal/min) air solven ratio.

- Cost of fuel ($/Million BTUs)
- Type of solvent used in process
- Gallons/hour of solvent used on product
- Solvent load at various flow conditions (lb/hr)
- Percent of each constituent in solvent
- Hours/day of process operation
- Days/week of process operation
- Hours/year of process operation
- Percent downtime (flow going to oxidizer without solvent)
- Number of startups/year. (Is unit down every weekend?)
- Contaminants in the stream that could cause problems, e.g., silicone, heavy metals, chlorides, particulates. If no contaminants now, might there be some in the future?

2. Regulatory requirements:

- What level of hydrocarbon destruction must be obtained? (Typically, an overall destruction level is established, which is a combination of collection efficiency at the process and destruction by the oxidizer.)
- What is the schedule? When must the oxidizer be installed and operational?
- What method of test will be required by the regulatory agency? (Various methods are accepted by different states and regions, e.g., flame ionization, gas chromatograph, etc.)
- Must the oxidizer include instrumentation to continuously monitor inlet/outlet temperature, inlet/outlet hydrocarbon concentrations or other constituents in the exhaust, such as CO and NOX?

3. Insurance factors:

- Are there specific insurance approval requirements, such as Factory Mutual (FM) or Industrial Risk Insurers (IRI)?
- Upon system startup, will the process be purged through the oxidizer or indirectly to the atmosphere? (Insurance requirements will dictate that both the process and the oxidizer must be purged with clean air before any burners can be lit, to ensure there are no dangerous concentrations of hydrocarbons built up that may cause an explosion.)

4. Return on investment:

If you want the system to give you a return on your investment, such as using recycled air to heat or cool the building, you must know the following:

- Type of building heating system
- Square footage of building being heated
- Type of installed air conditioning
- Tons of air conditioning
- Capacities of individual air conditioners (tons).

5. Operating costs:

- What are the comparative utility costs, e.g., natural gas and electricity?

6. Ease of maintenance of system:

- Need for adequate maintenance staff to handle technical aspects of the different systems.

7. Expandability of system:

- Does the equipment lend itself to future expansion, should production schedules dictate?

8. Location of system:

- Will the oxidizer be located outdoors, indoors, at grade, on roof?
- What is the availability of utilities, e.g., natural gas, oil, propane?
- What is the electrical service available, and is there sufficient capacity?
- Is noise pollution a consideration? (Is there housing nearby?)
- Are soil conditions adequate for the foundation?
- Is there sufficient access for construction equipment?
- Is the site selected clear of any underground obstructions, such as drain sewers, tanks, etc?
- Where is the control panel to be located?

9. Bid evaluation:

- Is this to be a turnkey project? Many companies prefer a single-source, including installation.
- Are you comparing equivalent bids? Has each of the vendors included all of the necessary equipment and services? Has a bidder left something out in order to better his price position? (Compare your bids to each other, and to all the guidelines enumerated here, to avoid accepting an incomplete bid.)
- Has each vendor supplied the proper performance guarantees and equipment warranties?
- Are the terms of payment acceptable?
- Has freight been included in the price?
- Does the vendor have proven operating field installations?
- Can the vendor meet the necessary schedules?
- Carefully evaluate the following for quality of workmanship: construction materials and thicknesses; equipment suppliers for controls, fans, etc; methods of assembly.
- What happens to the oxidizer in the event of excessive solvent loads? Will it over-temperature and cause problems?
- Have the proper safeguards been incorporated in the control scheme, e.g., high-temperature shutdown, audible alarms in the event of shutdown?

Summary

The above information should serve to guide you in evaluating which fume incineration system would be best for your business. It should also help you to initiate meaningful discussions with equipment suppliers and/or independent environmental consultants, and to analyze vendor bids.

In the end, EPA regulations will do more than create a cleaner environment for all of us; they will force us to take a hard look at our manufacturing processes, very possibly resulting in lower production costs in the long run. #

Reprinted from CONVERTING MAGAZINE February 1988

HES

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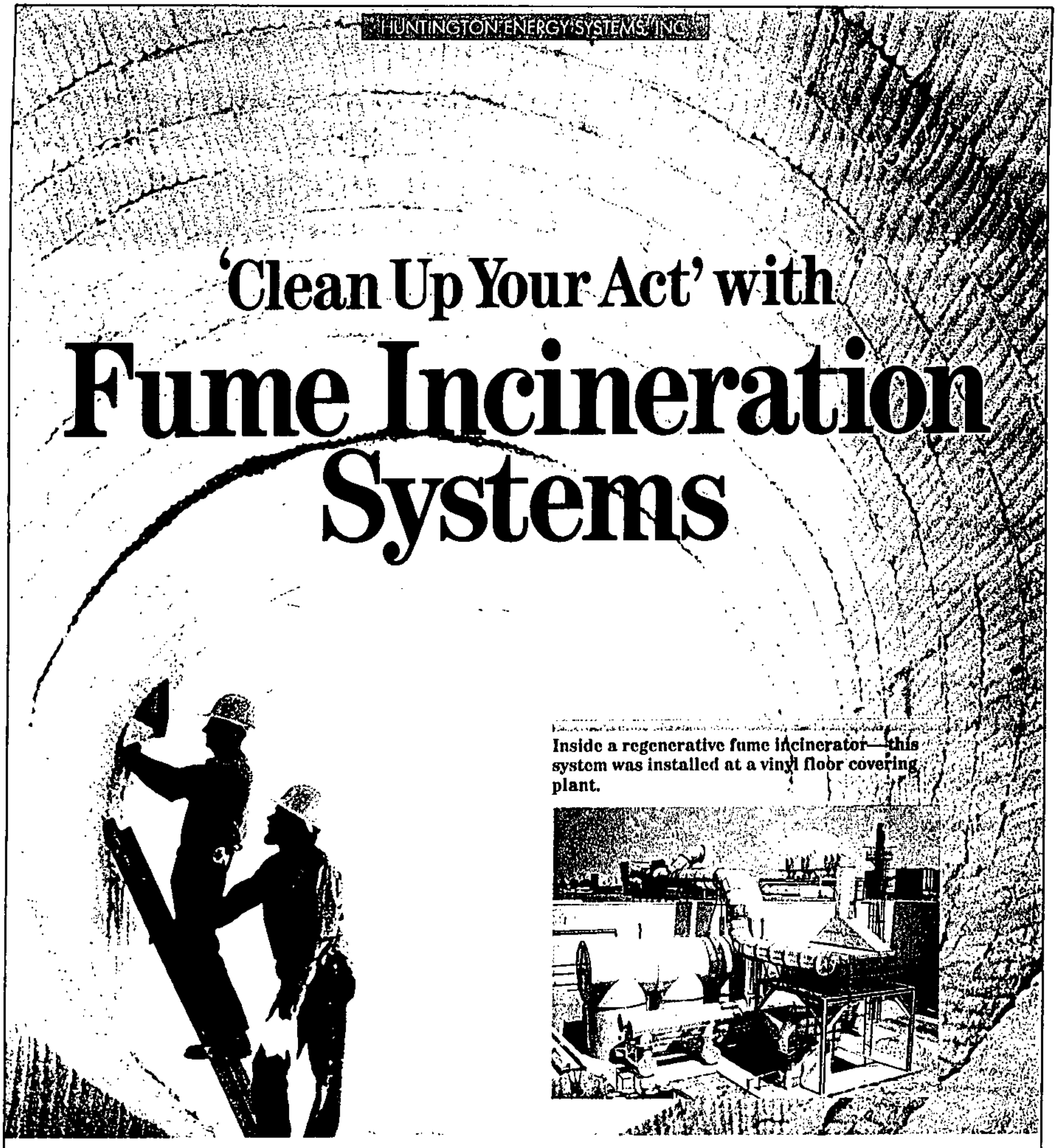
'Clean Up Your Act' with Fume Incineration Systems



HUNTINGTON ENERGY SYSTEMS, INC.

Inside a regenerative fume incinerator—this system was installed at a vinyl floor covering plant.

To avoid an expected EPA crackdown on VOC emissions, fume incineration may be your best bet. Here's a look at available equipment.

Many plastics processors, along with a substantial segment of the rest of American industry, will soon be forced to install fume incineration systems in order to meet existing EPA clean-air standards, and provisions of possible amendments to the Clean Air Act, or even entirely new environmental bills which Congress may pass. The Federal Environmental Protection Agency has already designated localities that are currently not meeting minimum requirements for the control of volatile organic compound (VOC) emissions, and agency spokesmen have said recently that they will be cracking down on manufacturers located in "non-attainment" areas. There have even been new rules instituted recently that are aimed specifically at application of coatings to plastic business-machine housings (see *PT, March '88, p. 113*).

Plastics processors within these areas that use solvent-based paints,

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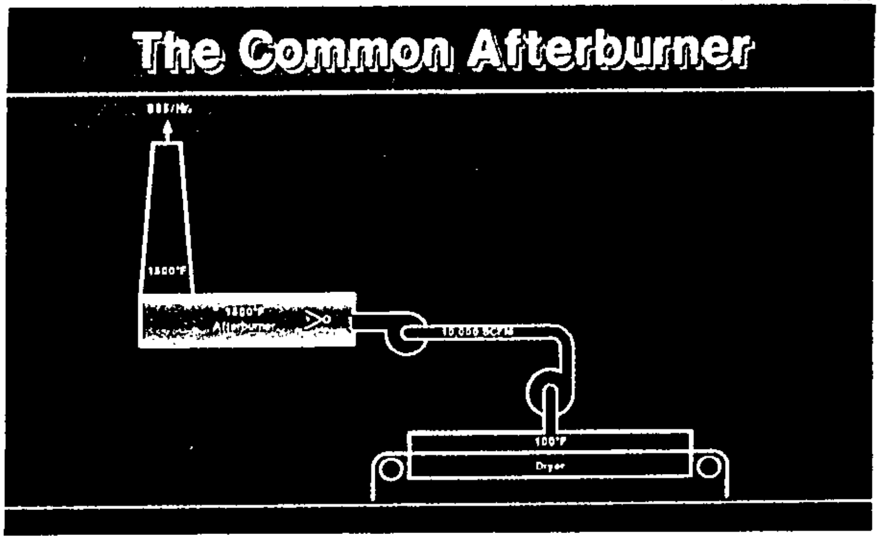
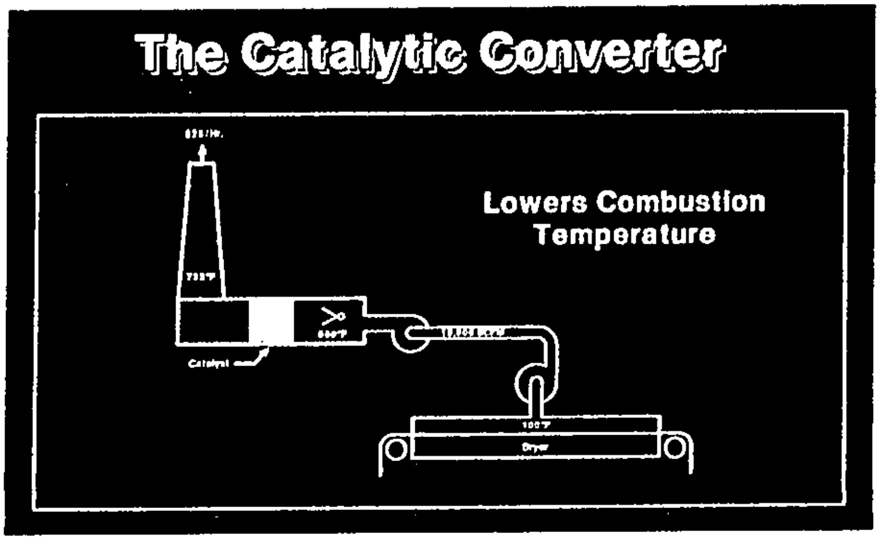
inks, or other coatings will be required by law to measure VOC emissions at their own facilities. The burden of proof will be on them to show compliance, and their testing procedures will also be regulated by the EPA. Specific rules and regulations for compliance will vary between different EPA jurisdictions, but penalties for noncompliance can include fines, annual production limitations, or even plant shutdowns.

The present Clean Air Act had scheduled the deadline for compliance for December 31, 1987, but that deadline was extended by Congress to mid-1988. The lawmakers may choose to extend it again or, more likely, take an even tougher stance on pollution emissions, while giving businesses a longer time to comply. There were still 76 nonattainment areas at the end of 1987, and it's not likely these areas will be within compliance soon.

Fume cleanup is needed to eliminate air contamination by hydrocarbons, such as MEK (methyl ethylketone), MIBK (methyl isobutylketone), toluene and alcohols. These are typically produced in the plastics coating and printing operations.

In addition, many processes that generate VOC and objectionable odors, such as plasticizers from flexible PVC calendering and plastisol processing, and styrene monomer from FRP fabricating, are coming under scrutiny. Whether or not the odor-producing volatile emissions must be cleaned up depends upon specific EPA regulations, as well as on the plant location. And, in addition to Federal EPA restrictions, local environmental regulations on VOC's—such as in Southern California—can also have major impact on plastics operations.


The Common Afterburner


The Catalytic Converter

Lowers Combustion Temperature

FOUR TYPES OF SYSTEMS

Unlike the problem of dealing with particulate-laden emissions—a relatively simple process utilizing familiar equipment, with minimal operating cost—meeting EPA standards for fume cleanup involves more sophisticated options. Most of these require major investment and operating costs. Therefore, the choice of the proper fume incineration system can have a significant impact on profit. The proper system can actually pay for itself within a few years, and lower manufacturing costs thereafter, in contrast with less efficient systems available.

There are basically four types of fume incineration systems, all of which incorporate thermal oxidizers that destroy VOC's by high-temperature conversion of hydrocarbon-laden fumes to harmless water vapor and carbon dioxide.

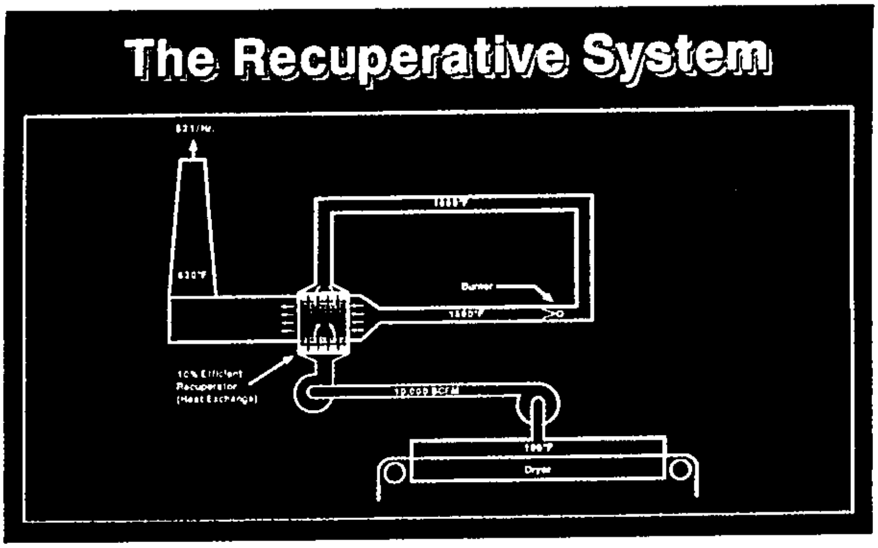
While all the various types of systems have acceptable cleanup efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks. The purpose of this article is to illustrate the differences between incineration systems, and to provide examples of current installations.

All costs discussed here are based on a 10,000-scfm (standard cubic foot per meter) system, operating at 2000 hr/yr, maintaining exhaust fume temperatures of 100 F, with fuel costs of $6/million Btu. For a physical description of each system, consult the accompanying diagrams.

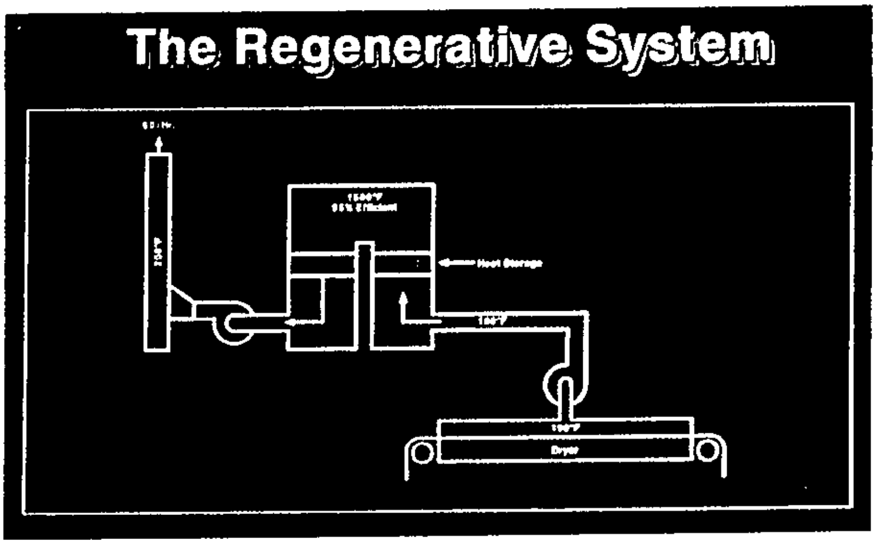
▶ **Common afterburner:** This system raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually 0.5 sec at 1400 F.

The afterburner is relatively inexpensive to buy and install. However, it is not designed for efficient use of fuel and, typically, consumes 2000% more fuel than other systems.

It is typically suitable for low-throughput applications, which require processing contaminated air at rates of



The Recuperative System



The Regenerative System

500 scfm or less. Capital investment can be around $70,000, with annual operating costs around $170,000. Installation costs can be $30,000-50,000.

▶ **Catalytic converter:** Hydrocarbon-laden fumes are pushed by a fan through a preheat section, wherein the temperature of the fumes is raised to a maximum of 700 F. The fumes then pass through another section of the system containing the catalyst, which is able to thermally oxidize the hydrocarbons at the reduced temperature of 700 F.

The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams). It performs poorly with fumes contaminated with particulates, resin, heavy metals or silicone — commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated or poisoned with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also may reduce flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation.

Catalytic converters are best suited for clean ink processes that involve no silicone. Typical equipment costs for a catalytic converter would run around $230,000, with annual operating costs around $24,000. Equipment installation costs of approximately $100,000 can be expected.

▶ **Recuperative thermal oxidizer:** This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1500 F gas by passing it through the low-temperature inlet gas stream via an indirect shell-and-tube heat exchanger, thus preheating the incoming contaminated gas to within 65-80% of oxidation temperature.

The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to replace the fuel required for combustion. The 20-35% of the heat lost during incineration can be reused for indirect building heat or generating steam, or be returned to the process. However, auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as equipment size, heat-transfer coefficients and stress, limit the system's preheat efficiency. Reusing the 20-35% lost heat requires an additional investment for heat-transfer equipment and its maintenance.

The recuperative thermal oxidizer is suitable for processes that need to incinerate fumes with a high solvent content—typically fumes with an air-to-solids ratio above 25% LEL (10,000 scfm/gpm [gal/min]). Capital equipment costs for these systems run around $200,000, with annual operating costs of around $50,000. Installment costs are estimated at $100,000.

▶ **Regenerative thermal oxidizer:** In this system, oxidized gases from the combustion chamber pass through a porous heat-transfer section, storing by conduction 95% of the heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where the fumes are preheated by conduction of the stored heat to within 5% of oxidation temperature on their way to the combustion chamber. There is a continuous cycle of alternately storing and releasing heat within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5% of normally required fuel is needed for oxi-

FUME INCINERATION SYSTEM COSTS*

Type of System	% Heat Recovery	Capital Cost, $/scfm	Operating Cost, $/scfm/year
Afterburner	0	7.00	17.55
Catalytic Converter	70	23.00	2.43
Recuperative Thermal Oxidizer	70	20.00	5.27
Regenerative Thermal Oxidizer	95	28.00	0.96

*Costs based on 10,000 scfm; operating 2000 hr/yr; process exhaust fume temperature of 100 F; fuel cost of $6/million Btu. Installation costs for afterburner, approx. $30,000-50,000 additional; for the other three, approx. $100,000 additional.

dation. In many cases, just a pilot burner is sufficient, when coupled with the 95% preheat efficiency. Up to now, most available systems have been maintenance-intensive, because they use hydraulic or electric valving. However, the newest systems eliminate most of the maintenance because they utilize a single-speed-reducer mechanical valving system.

Regenerative thermal oxidizers are recommended for larger process flows with lower solvent concentrations, because the high primary heat recovery will reduce operating fuel costs. A 5% LEL or greater will result in almost no fuel usage. Investment costs are typically around $280,000, with annual operating costs around $9,300.

RECUPERATIVE VS. REGENERATIVE

The difference between a 95%-efficient regenerative unit and a 65%-efficient recuperative unit, in terms of fuel use, may not be 30%; it may be higher, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel-use difference could be as high as 40%.

As for operating costs, the actual fuel-cost saving for a 10,000-scfm unit could be over $50,000/yr for the regenerative system, with no solvent present, compared with a typical recuperative system.

To further enhance the economics of regenerative thermal oxidation, the spent fumes, now slightly elevated in temperature, can be reintroduced into the process from which they came or, by use of a heat exchanger, used as building heat. What was once an undesirable pollutant becomes a desirable energy source, replacing up to 60% of the fuel used to heat the process.

A typical regenerative system receiving fumes at 200 F would return the clean air back to the process at 265 F, at 95% preheat efficiency.

CASE HISTORIES IN PLASTICS

As was stated at the beginning of this article, the choice of proper fume incineration system can mean not only that EPA requirements are met, but also that the system could pay for itself and, eventually, lower your cost of manufacturing. A recent example is a major vinyl floor-covering manufacturer, which now meets the new clean-air standards with a regenerative fume incineration system. This firm managed to turn a potentially unprofitable situation into a profitable one.

Its problem was dealing with the VOC's released during the printing of resilient vinyl sheet flooring. By installing a regenerative fume incineration system specifically designed for its needs, the firm has been able to heat the plant with recycled air, resulting in a savings of $58,000/yr in fuel costs.

This processor is realizing additional savings of $200,000/yr in natural gas by using this system, instead of a less-efficient system with a conventional air-to-air exchanger. Thus, payback in cost of fuel alone will come in about four years.

Not every incineration system can have such substantial payback designed into it, because of the many variables involved. But every process must be analyzed not only for potential savings, but also for any changes that may be required in order to meet state and federal codes.

Regenerative incineration systems can save up to 40% in fuel consumption compared with other incineration alternatives, and operating costs can be $50,000/yr lower.

That's because it is no longer sufficient merely to destroy 95% of a facility's emissions. You are also now required to capture a specified quantity of hydrocarbons being generated within your facility, to yield an overall rate of capture/destroy efficiency. This rate depends on a number of variables, such as the nature of the process, type of VOC's emitted, annual production, and geographic location.

In the state of Connecticut, for example, plants doing flexographic printing on vinyl film must achieve a fume capture/destroy efficiency of 60-75%. This percentage may be different for other manufacturers within the state, or for the same sort of operation in other states. To determine what the regulations are for their specific process, manufacturers must check with their regional office of the state air-quality board.

A recent case in point is a firm doing printing on vinyl film. In order to meet local codes, it required a process modification whereby a "loop" was designed between the print stations and the dryer, which previously had been exhausted individually, as well as more efficient collection exhaust hooding. This hooding and recirculating loop lowered the total exhaust volume, while also making incineration more efficient by increasing solvent concentrations.

This new focus on higher fume collection and destruction efficiencies will obviously require higher capital equipment expenditures. Thus, the more efficient and simple the emission-control device, the lower the annual operating expense to offset ever-increasing capital expense. □□

R.J. Renko is technical sales manager of Huntington Energy Systems, Mountainside, N.J., which supplies incineration systems.

INTER/PORT

News and Views for the Recreational Boating Industry

Edited and produced in Chicago, Wednesday, December 12, 1990

HAPPY HOLIDAYS!

NMMA directors and staff wish you a Merry Christmas and a Happy New Year. *INTER/PORT* will not be published during Christmas week, so look for the next issue on or about January 2.

EPA GIVES STYRENE CLEAN BILL OF HEALTH

In a major development for fiberglass boatbuilders and other industries relying on molding processes, the Environmental Protection Agency has decided not to classify styrene as a carcinogen. The decision from EPA's Office of Drinking Water (ODW) comes after review of all existing evidence and the recommendations of its own Science Advisory Board. Comprised of many of the country's top scientists having expertise in this area, the EPA Science Advisory Board went on record as saying that there was no scientific justification for classifying styrene as a "probable human carcinogen."

The decision is particularly significant to boat manufacturers in light of measures included in the recently passed Clean Air Bill that provide for separate consideration of boat building in the development of styrene emission standards. Under the legislation, determination of emission standards must weigh specific capabilities of manufacturers to meet the standards, including economic costs and technical feasibility of proposed pollution control technology -- determinations which rest with the EPA. The ODW did say that it will set a maximum contaminant level for styrene in drinking water, as required by law for other chemicals, but these levels are not anticipated to pose any serious compliance problems for industry.

EPA's new stance on styrene is due in large part to the efforts of the Styrene Information and Research Center (SIRC), an organization which receives substantial funding from NMMA, and has worked closely with association staff and member firms over the past two years to fend off stringent styrene legislation at both state and federal levels. SIRC chairman Ken Harman was encouraged by EPA's decision. "It is consistent with earlier decisions by OSHA and the National Institute of Occupational Safety and Health (NIOSH) and also with the views of the leading scientific panel of the European Community," he said. "All have now agreed that the facts simply are not there to classify, regulate or label styrene as a carcinogen."

The "facts" that Harman refers to are part of a large body of evidence collected and compiled by SIRC over several years and recently presented at the group's annual meeting by Geoffrey Granville of Shell Canada, chairman of SIRC's

continued

FIGURE 8

Influence of Gel Time on Styrene Emissions

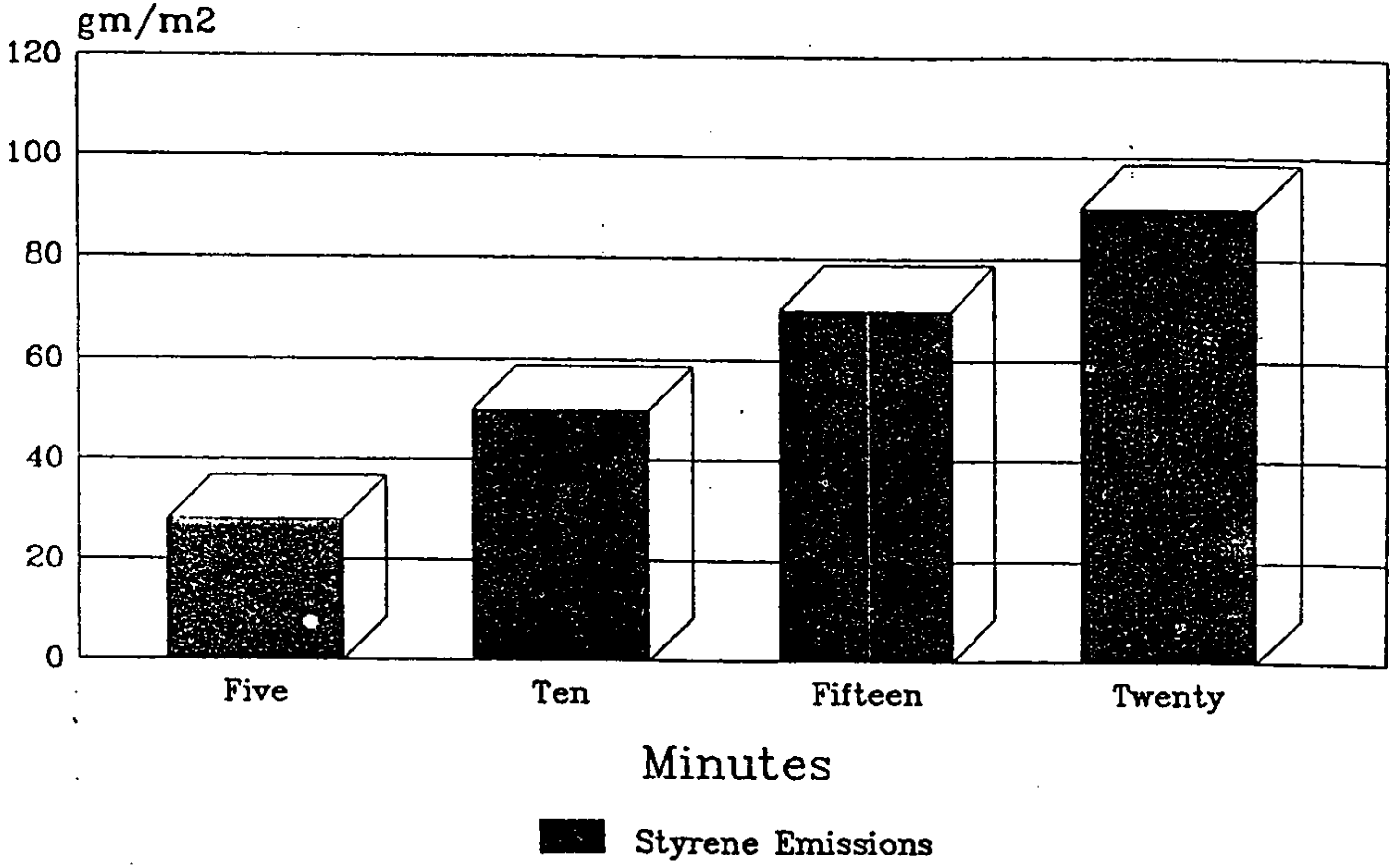


FIGURE 9

Influence of Temperature on Styrene Emissions

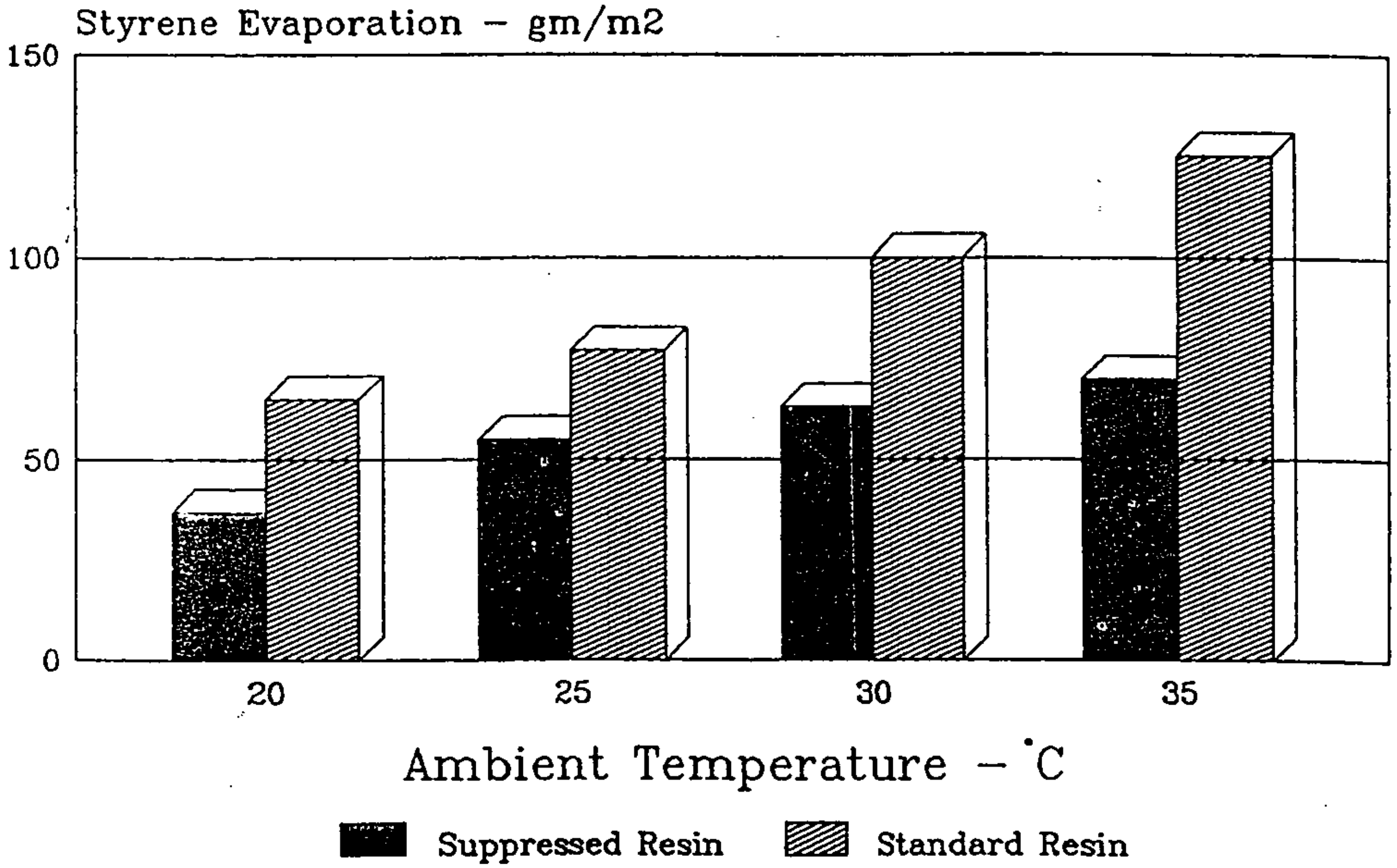


FIGURE 10

Influence of Air Flow Rate
on
Styrene Emissions

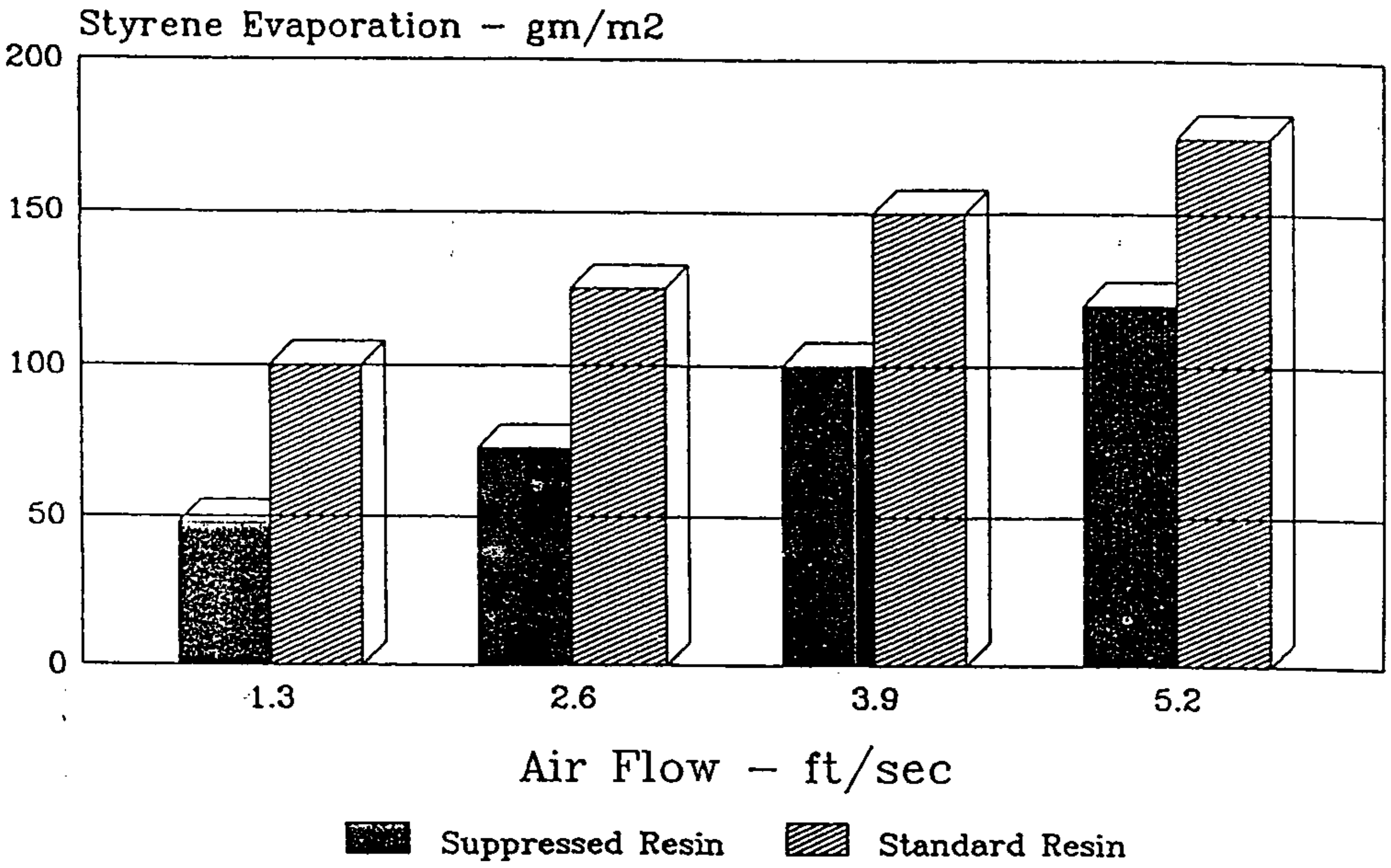


FIGURE 11

Influence of Styrene Content
on
Styrene Emissions

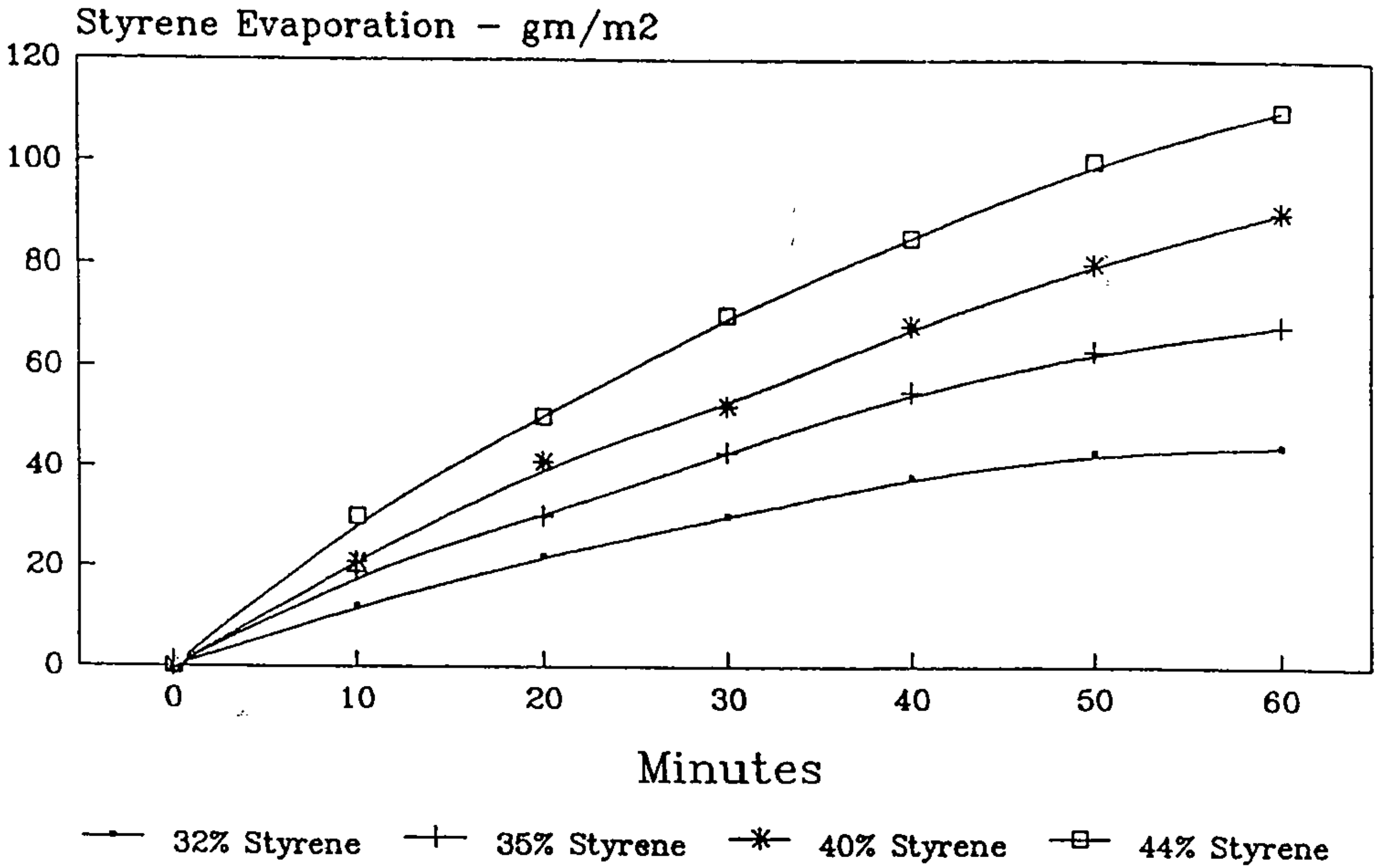
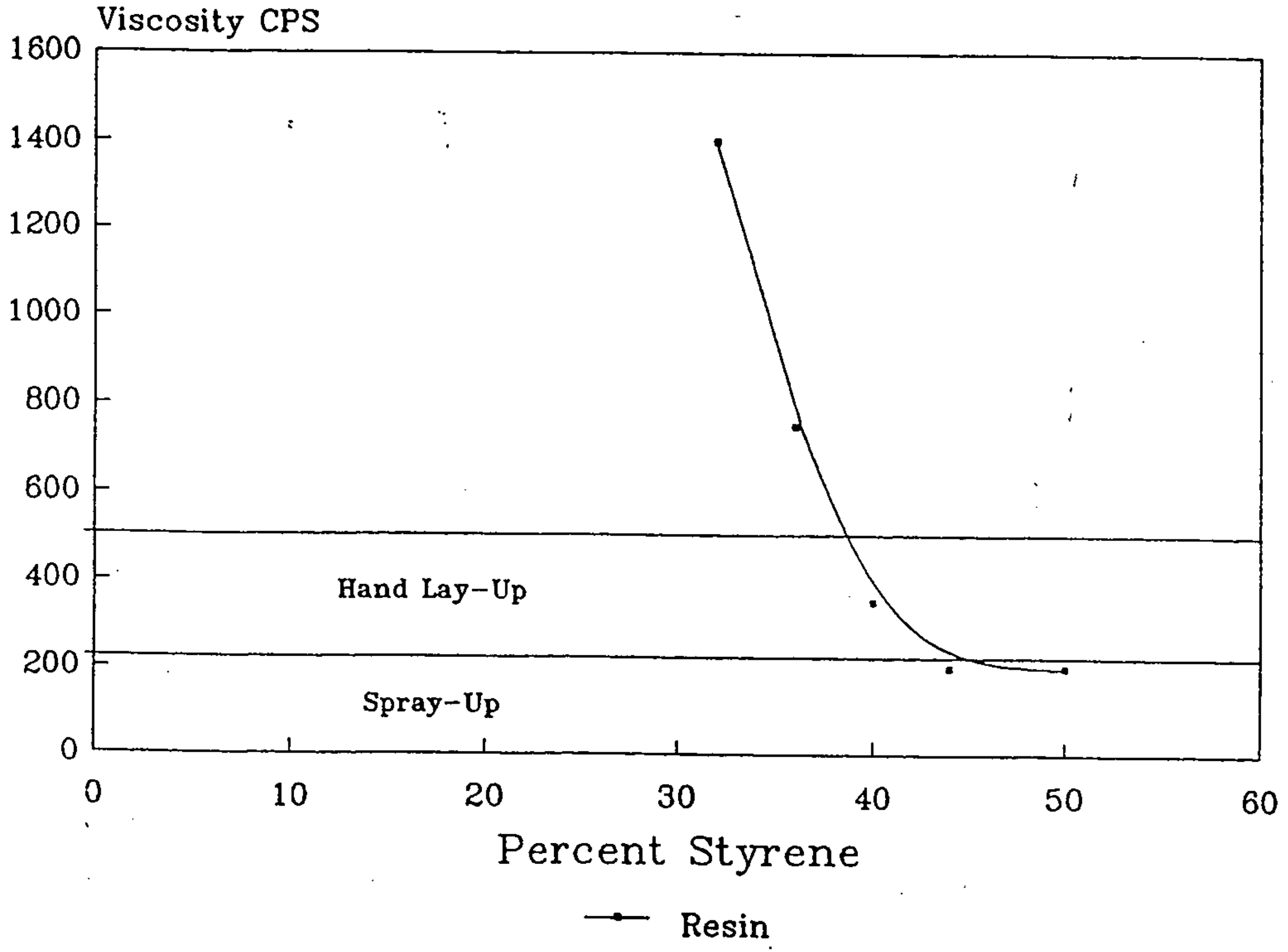


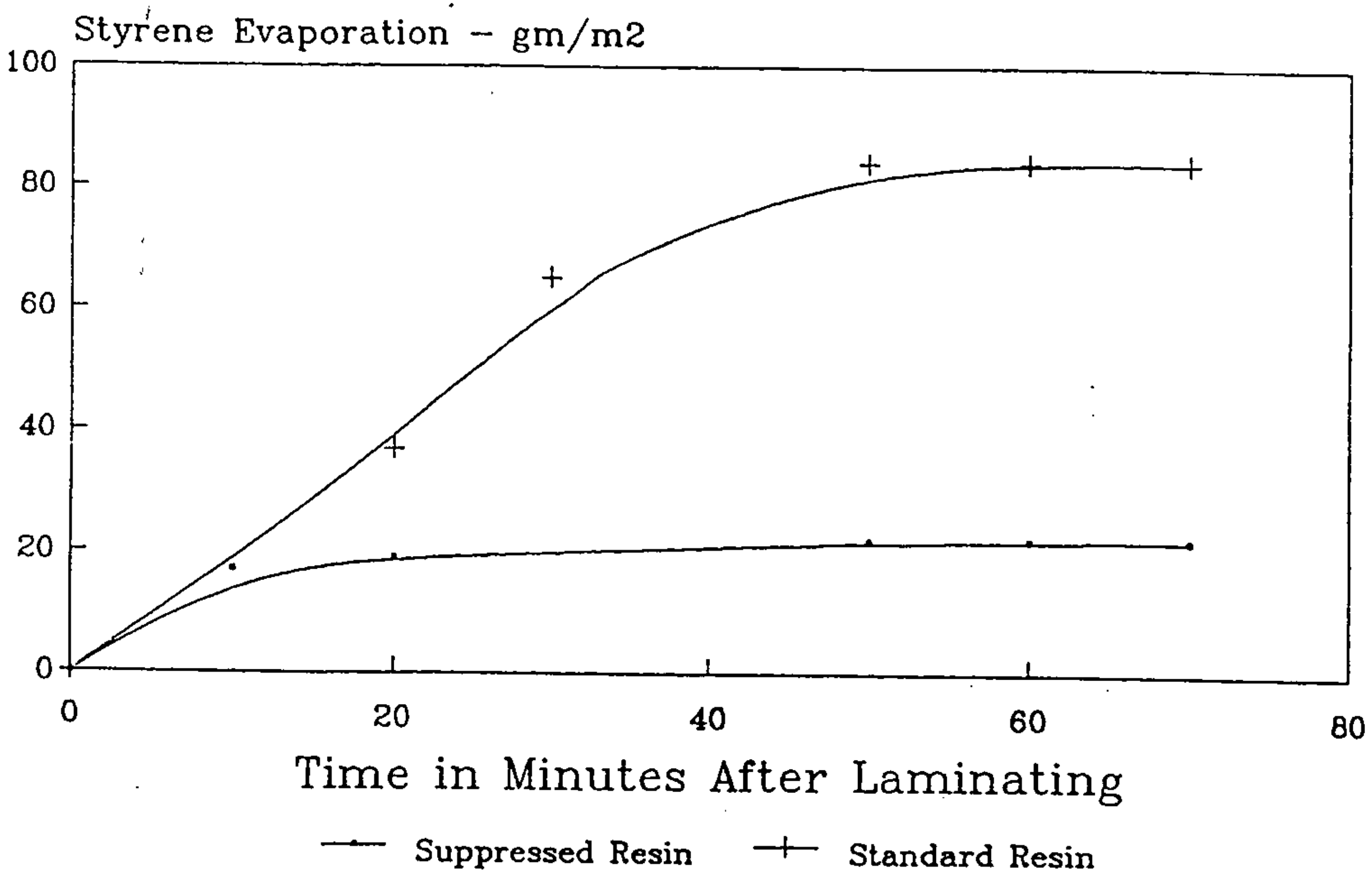
FIGURE 12



Viscosity vs. Percent Styrene (at 20°C)

FIGURE 13

Comparison of Suppressed Resin and Standard Resin



Concentration of Styrene in exhaust air stream.

$$9.07\,\frac{\#}{hr}\cdot\frac{hr}{60\,min}\cdot\frac{min}{100{,}000\,ft^3\,*}\cdot\frac{ft^3}{28.32\,\ell}\cdot\frac{453{,}592.4\,mg}{\#}=0.024\,\frac{mg}{\ell}$$

$$=\underline{5.6\ ppm}$$

Concentration of Acetone in exhaust air stream.

$$3.82\,\frac{\#}{hr}\cdot\frac{hr}{60\,min}\cdot\frac{min}{100{,}000\,ft^3\,*}\cdot\frac{ft^3}{28.32\,\ell}\cdot\frac{453{,}592.4\,mg}{\#}=0.010\,\frac{mg}{\ell}$$

$$=\underline{4.2\ ppm}$$

* 8 - 25,000 cfm fans @ 50% efficiency

Sykes Creek

CONCEPTUAL PLAN AND POTENTIAL COURSE OF ACTION FOR THE FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

PREPARED FOR

SEA RAY BOATS, INC.
MERRITT ISLAND FACILITY

PREPARED BY :

CANTELOU ASSOCIATES
CONSULTING ENGINEERS • PLANNERS
401 Park Avenue SW / P.O. Box 3102 / Aiken, S.C. 29801

AC05-165270

TABLE OF CONTENTS

I. INTRODUCTION. (MERRITT ISLAND).

The purpose of this document is to present background information and data that will support a conceptual plan and potential course of action regarding the reduction or elimination of air emissions from production operations to be considered by Sea Ray Boats, Inc. Implementation of the plan shall demonstrate to the Florida Department of Environmental Regulation that every reasonable effort has been undertaken to assure that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facilities property boundary. [F.A.C. Rules 17-2.200 and 17-2.620 (1) and (2)].

II. Process and Air Emissions. (MERRITT ISLAND).

This chapter will discuss in general the fiberglass reinforced plastic boatbuilding industry and in particular the activities of Sea Ray Boats, Inc. The chapter is divided into three sections. The first will describe the industry in general. The second section will describe the manufacturing process and its emissions, and finally the manufacturing process and VOC/OS emissions at the Sea Ray facility.

Section 1. General.

The fiberglass reinforced plastic boat industry is defined within SIC Code 3732, Boat Building and Repairing. The industry as a whole is comprised of many small businesses with a wide range in the number of employees and size of boats manufactured. The size of fiberglass boats range from about twelve feet to two hundred feet in length. "Large" boats are classified as those greater than thirty feet in length and "small" boats are those less than thirty feet in length. Facilities may produce a range of more than fifty boats per day to less than one boat per month, all depending on boat size and plant capabilities.

Section 2. General - Production Process and Emissions.

There are several methods employed in the production of fiberglass boats. The following discussion, however, is limited to the primary method used within the industry. That process is called "contact open molding". There are air emissions (VOC/OS) associated with that process and they are derived from polyester resin, gel coat resin, paints, carpet glue and cleaning solvents. Various factors and manufacturing techniques influence significantly the quantity of cleaning solvent emissions.

2.1. Production Process for Fiberglass Boats and Methods of Lamination.

The Radian Corporation presented a thorough discussion of the manufacturing process for fiberglass boats and it is reproduced here as follows:

"The contact molding method consists of applying layers of resin impregnated fiberglass reinforcement (laminated) on an open female or male mold. The laminate is built up to the required thickness and then allowed to harden or cure. After the cure is completed, the part is removed and the mold is reused. A male mold is convex leaving a smooth inner surface and a female mold is

concave leaving a smooth outer surface on the product. Since a smooth outer surface is normally desired, female molds are most commonly used in fiberglass boat production.

The primary type of resin used in fiberglass boat production is polyester resin. Polyester resins typically consist of 45 percent styrene monomer and 55 percent polyester solids. Before applying the resin, the necessary catalyst and accelerator are added to initiate curing. During curing, the styrene monomer polymerizes forming a thermo-setting plastic. This is an exothermic process, and because styrene monomer reacts more rapidly at elevated temperatures, the reaction is autocatalytic.

The general production process steps used in the industry for manufacturing fiberglass boats are shown in Exhibit "A". The different parts of the boat (deck, hull, small parts) are fabricated in the molding room. The decks and hulls are fabricated in the main area of the molding room while the small parts are fabricated in the small parts booth. The first step in the production

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process is coating the mold with a releasing agent such as wax. A gel coat is then applied on the mold with a spray gun in a ventilated spray booth. The gel coat is a pigmented polyester resin which forms the outer smooth surface of the molded part. After spraying, the gel coat hardens or cures with a smooth surface against the mold and a tacky outer surface which enhances later bonding of the first layer of laminate.

After the gel coat cures, the first layer of resin and fiberglass laminate is applied using one of the lamination methods described below. The lamination procedure is repeated until the desired thickness is achieved. Structural reinforcements such as wood, plastic, and metal are also added during lamination. Lamination is a batch process with time between laminates dependent on cure time of the resin. After the final lamination has cured, the excess is trimmed from the part and the part is removed from the mold.

After the parts are removed from the mold, they are then taken to the assembly room where they are sanded and the boat is assembled. In addition, carpet and accessories are often installed to produce the finished product.

There are two methods of lamination used in the fiberglass boat manufacturing industry. These are hand lay-up and spray-up. Each method offers advantages and disadvantages over the other and a combination of the two is often used.

In the hand lay-up method, resin is applied with a resin gun or in rare cases with a brush. If a resin gun is used to apply the resin, a brush is usually employed to even out the resin. After a thin coat of resin has been applied to the gel coat or previous layer of laminate, fiberglass reinforcement is placed over the wet resin. The primary fiberglass reinforcements used in hand lay-up are woven roving, cloth, and mat. Squeegees or metal rollers are then used to force the resin up through the reinforcement and remove any entrapped air (wet out). The resin is allowed to gel and the lamination process is repeated until the desired thickness of fiberglass laminate is obtained.

Three types of resin guns may be used in hand lay-up. These are catalyst injection, dual component, and hot pot. The most common type used in the industry are catalyst injection resin guns. Catalyst injection resin guns mix accelerated resin

and the catalyst in the proper proportion inside the gun spray head and then spray the mixture through a single spray nozzle. With dual-component resin guns, two streams of resin are sprayed simultaneously. One stream consists of resin premixed with accelerator and one stream consists of resin premixed with catalyst. The spray nozzles are aimed so the two spray streams mix outside the spray gun and then form a single spray stream. Hot pot resin guns have a pressure pot attached to the gun head. The laminator mixes the resin, accelerator, and catalyst in the pressure pot by hand. All of the resin must be sprayed once it has been mixed in the pot or it will gel inside the spray gun.

The spray-up method is an alternative to hand lay-up for hull and deck fabrication and is the most common method of small parts production. The spray-up method employs a chopper gun to simultaneously apply resin and chopped strands of glass reinforcement. Brushes and rollers are then used to spread the mixture and remove entrapped air. This process is repeated until the desired thickness is obtained.

The spray-up method is restricted to laminates using chopped glass strand as the reinforcement. Due to the type of reinforcement, laminates produced in spray-up have lower glass to resin ratios than the woven roving or cloth laminates produced in hand lay-up. Because the strength to weight ratio is proportional to the glass to resin ratio, laminates produced in spray-up also have lower strength to weight ratios than woven roving or cloth laminates. Laminates produced in hand lay-up with mat reinforcement are similar to those produced in spray-up because mat reinforcement is just chopped strand with a binder.

The advantage of using hand lay-up with woven roving or cloth laminate over spray-up is that a product with a higher strength to weight ratio is produced. However, the fabrication process takes longer when the hand lay-up method is used. A common practice in the industry is to combine these two methods. With this combination, parts of a boat that need to be strongest are fabricated using hand lay-up while parts that do not need as much strength, such as small parts, are fabricated using spray-up. This results in a lightweight boat that is produced in the minimum amount of time."

2.2. Emissions Sources

There are generally two sources of emissions from the fiberglass boat manufacturing processes that produce volatile organic vapors and organic solvent vapors. These originate in the lamination area due to resin application and cleanup operations or the assembly area of the plant due to painting and carpet installation.

Emissions from the lamination process are due to the evaporation or vaporization of the styrene monomer contained within the gel coat and resin applied when the hull, deck, and small parts are manufactured. An additional portion of the styrene monomer contained in resin and gel coat is subject to evaporation after application and before polymerization occurs.

OSHA (Occupational Health and Safety Administration) mandates that worker exposure to styrene concentrations not exceed 25 parts per million. As a result of this requirement, the air contained within the building is vented to the outside and completely replaced by fresh air every ten minutes. In other words, six air changes are required for the total volume of the building every hour.

There are additional exhausts from spray booths to the outside.

The OSHA requirement is the primary factor controlling the rate at which air containing styrene within the lamination building is moved to the outside.

Vapors from clean-up solvents also contribute to the quantity of emissions from the lamination process. Tool and spray gun cleaning is required after each batch of resin is applied. When the spray guns are flushed some of the organic solvent used is vaporized. Also, employees must clean their hands frequently. When tools, spray guns and hands are washed with solvent an amount of solvent is carried from the container on these items and readily evaporates due to the large surface area exposed to air per volume of solvent.

Additional VOC/OS emissions occur in the assembly area during the painting of boat parts and application of glue during carpet installation. The glue solvent evaporates into the room air while vapors from paint application are exhausted to the outside.

2.3. Techniques and Factors Affecting Emissions from Organic Cleaning Solvents.

Cleaning solvent emissions (usually acetone) account for fifty to seventy-five percent of all air emissions from the plant operations. The major factors that influence these emissions are resin gel time, use of covers on storage containers, work habits of the employee, the number of employees, use of hand protection and protective clothing, and air movement within the plant building. Resin gel time affects emissions because it determines the number of times equipment and employees must be cleaned in a specific period of time. Resin gel times may vary from ten to thirty minutes with fifteen minutes being the average desired.

The evaporation of cleaning solvents may be reduced by covering the containers between cleanup operations. Other factors that effect rate of evaporation are the liquid level in the containers, air movement across the containers, and the room temperature. An increase in any of these will increase the evaporation rate.

Work habits of the employee can lower emissions by reducing the amount of resin or other product which must be removed from hands and arms

by cleaning solvents. Some employees are able to stay relatively clean while other employees may get considerably more on themselves. Employee work habits are influenced by training and supervision. The complexity of the mold can also significantly affect the amount of resin which an employee may get on his hands and arms. The more complex the mold, the more difficulty encountered for keeping the employee clean.

The number of employees involved in the lamination process affects emissions because each employee must clean his hands and tools after each operation. Usually, each employee has his own set of solvent containers, this practice increase the volume and surface area exposure to evaporation.

The use of hand protection reduces the number of times and employee must clean his hands. Without protection, cleaning of hands would occur after each resin application or every twenty to thirty minutes. Using gloves may reduce the clean-up of hands to as low as four times a day.

The factors discussed above are generally determined by the amount of organic cleaning solvent issued per employee. The amount of

cleaning solvent issued can be reduced if gloves are required to reduce hand cleaning and covered containers are used to slow evaporation. Room air ventilation reductions are not practical since this would increase worker exposure to the higher concentrations of styrene and other vapors. Temperature for resin curing is determined by the resin chemistry and cannot be changed easily.

Section 3. Sea Ray Boats, Inc. (MERRITT ISLAND) Production Process and Emissions

The production procedure utilized by Sea Ray Boats, Inc. at the Merritt Island Facility are the same as those shown in Production Flow Diagram (Exhibit "A"). The Merritt Island Facility has one gel coat booth and one small parts booth contained in the lamination area. The gel coat used consists of 35 - 40 % styrene monomer, 0 - 5 % methyl methacrylate, and 60 % pigmented solids. Following the gel coat, Sea Ray uses a spray up method with application of woven roving and/or glass cloth hand rolled into place, with additional structural supports and stringers laid into the hull or deck and secured by additional resin and chopped reinforcement. The spray up method is used for small parts.

The Merritt Island Plant utilizes the catalyst injection method of resin application, that is, resin and catalyst are mixed inside the spray gun. The gel time is approximately twenty minutes. The resin used is a general purpose polyester resin containing approximately 40 % styrene and 60 % resin solids.

The VOC/OS emissions at the Merritt Island Facility are shown in Exhibit "B", (Florida Department of Environmental Regulation, Construction Permit for Air Pollution Source and amendments). These emissions result from the evaporation of styrene, acetone, paint and carpet glue solvents. As shown in Exhibit "B", the major sources of VOC/OS emissions are styrene evaporation during hull and deck fabrication, styrene and methyl methacrylate evaporation during gel coat application, and acetone vapors emitted during cleanup. These sources account for over 70% of the emissions so permitted. Emissions from this source according to the construction permit (Exhibit "B") shall not exceed 116.5 tons per year.

Sea Ray's VOC/OS emissions resulting from the cleanup and lamination operations are forced to the atmosphere by exhaust fans in the building sidewalls. The air flow rate of these exhaust fans is estimated at 202,500 cfm. These fans are permitted to operate a maximum of 16 hours a day, five days per week. Concentrations within the air exiting these points have

not been measured. The calculated average concentration based on permitted quantities is 9.3 ppm styrene, 6.3 ppm acetone. Other emissions from this source shall be considered fugitive emissions and cannot be identified with any one point.

The Merritt Island Facility recycles approximately 40 % of the acetone purchased each year. The remaining 60 % represents the emissions of acetone to the air as a result of the production process. The spent acetone is purchased and carried off-site by a licensed carrier to be recycled. Therefore, the volume carried off-site will not contribute to Merritt Island's emissions inventory.

III. Emission Control Techniques.

The discussion that follows in this chapter will cover techniques that may be utilized by the Merritt Island facility to reduce or eliminate VOC emissions from the boat building operations. The first section will discuss process alterations to control acetone emissions, while the second section will consider changes that serve to reduce styrene emissions. Section three will examine add-on controls for exhaust air leaving the facility.

Section 1. General - Acetone Emission Controls.

Acetone emissions may be controlled using three separate approaches. Substitution of non-volatile solvents or emulsifiers, work practice, and spent acetone reclamation.

1.1. Substitution Other Products for Acetone.

There have been products introduced to replace some of the acetone usage. These products vary from strong emulsifiers to non-volatile organic solvents. These emulsifier type products may be used successfully in hand cleaning of tools used in the lamination process. Non-volatile solvents have also seen success in these areas. It should be noted however that the final cleaning of these

tools needs to be accomplished using acetone. Acetone has been found to be the safest product for use in order to remove residue from the initial cleaning operation (i.e. water droplets and other debris). See Exhibit "C", containing manufacturers data on acetone substitutes.

1.2. Work Practice Controls.

The primary work practice controls to reduce acetone emissions in the building of fiberglass boats are as follows:

(a) hand protection,
(b) covered acetone containers,
(c) limiting the issuance of acetone.

1.2.a. Within the boat building facility the resin application methods vary from spray-up to lay-up, the workers are exposed to resin thru handling the tools and overspray from the spray-up. The issuance of gloves, disposable garments and shoe covers eliminates to a great degree the cleaning of hands, other exposed skin areas, and clothing that may come into contact with the resin. This will reduce the amount of acetone to be issued to each employee.

1.2.b. Covering the acetone containers that hold the new acetone as well as the dirty acetone will reduce loss thru evaporation. This provision will also limit the amount of acetone to be required by the employee.

1.2.c. The employer may study each employees use and cleaning techniques and unilaterally reduce the quantity of acetone provided to the employee. The employee recognizing the reduced quantity will be forced into conservation and prudent use of the product.

1.3. Spent Acetone Reclamation.

Emissions can be reduced by recycling the spent acetone. Two options offering economic and environmental benefits exist regarding the disposal of spent acetone. They are on-site recovery or distillation and the delivery of the spent product to a commercial reclaiming facility.

On-site recycling can reduce disposal emission by 90%. The recycling units (stills) are available commercially in various sizes, compatabile with the industrial requirement. Their installation requires electricity and cooling water. A safety hazard also exists with the operation of the still.

As an alternative, there are commercial waste handlers that reclaim spent acetone. The emissions can be eliminated entirely by sending the spent acetone off-site for reclamation. There is an added advantage to the manufacturer in that he also gets rid of the solid waste in the acetone.

Section 2. General - Styrene Emission Control.

Styrene is the cross-linking agent in polyester resins and also it it used as a solvent in the compound that can be used to increase or decrease the viscosity or workability of the resin.

Styrene emissions can be reduced by the manufacturer, if his process will allow him to convert to a new resin designed to limit styrene losses. These new resins may contain a supressant (wax) or may be designed to function with a low-styrene content.

2.1 Supressed Resin.

Supressed resins entrap the styrene monomer that would be emitted as vapor during the exothermal curing of the resin compound. These supressed resins can reduce total styrene emissions by as much as fifty percent. However, a study of manufacturers indicates poor performance of the

finished product. Delamination of the resin has been cited by most as a serious problem. Before a supressed resin could be placed in production, the manufacturer should require extensive testing in the lab and field to determine the products reliability.

2.2. Low Styrene Resin.

Another method of reducing styrene emissions is the conversion by the manufacturer to a low styrene resin. This conversion will reduce emissions because the styrene monomer in the resin can be lowered to as much as thirty-five percent. This can be compared to forty or forty-five percent in conventional resins. Emission reductions during curing due to conversion may be seventeen to thirty percent, this would equate to an overall reduction of ten to twenty percent.

Section 3. Add-On Control.

Add-on controls apply to the boat building industry in the area of exhaust air from the building. The exhaust from spray booths and building ventilation fans can be captured and treated by chemical scrubbing or incineration.

3.1. Chemical Scrubbers.

Chemical scrubbing removes organic vapors from the air by absorbing them into a liquid. The absorbed materials are destroyed by the chemicals in the liquid.

A major problem exist with this approach. Waste stream would be created with the chemical used to absorb air contaminants and the handling of the volume of the chemical waste created by this approach would render the operation impractical.

3.2. Contaminant Incineration.

Two types of incinerators are available, thermal and catalytic. Thermal incineration involves the oxidation of organic vapors to carbon dioxide and water. The solvent laden air is exposed to a high temperature of 1000 to 1500 degrees Farenheit and in some cases a direct flame for a period of 0.3 to 0.6 seconds. Catalytic incinerators use a catalyst bed to oxidize the organic vapors and operate at reduced temperatures of 750 to 1000 degrees Farenheit. Important incineration design factors are residence time, gas stream flow rate, operating temperature, and waste gas heat content.

When collected, most waste gases have low heat contents. This is due in part to OSHA and insurance regulations which limit the maximum concentration of organics to 25 percent of the lower explosive limit (LEL) when no LEL meter is used. If an LEL meter is present to constantly monitor the gas stream then the organic concentration can be as high as 40 percent of LEL. In either case supplemental fuel is needed to raise the off gases to the required operating temperature.

Heat recovery equipment may also be used with incinerators to reduce the amount of supplemental fuel required. It is generally divided into primary and secondary recovery. Primary heat recovery uses heat exchangers to recover heat from the incinerator exhaust gases to heat the incoming air. Secondary heat recovery recovers heat from the exhaust gases for use in plant processes such as ovens, dryers, etc.

The destruction efficiency of both thermal and catalytic incinerators depends on the residence time and temperature. In general these devices can be designed to achieve between 90 and 99+ percent destruction of VOC.

Incinerators have not been demonstrated as VOC control devices in the fiberglass boat manufacturing industry. The main problem results from the low VOC concentrations in the exhausts and high exhaust air flows. Calculated VOC concentrations in the exhaust streams average approximately 9.3 ppm for styrene and 6.3 ppm for acetone. These conditions would result in the exhaust stream having a low heat content thus resulting in high supplemental fuel requirements.

IV. Conclusion - Potential Course of Action.

Sea Ray Boats, Inc., has assessed the technical and economic feasibility of the alternatives presented herein. The potential course of action selected by the Merritt Island Facility and presently being implemented are work practice controls, commercial recycling of acetone, substitution of emulsifiers for acetone where practical and conversion to low styrene resins.

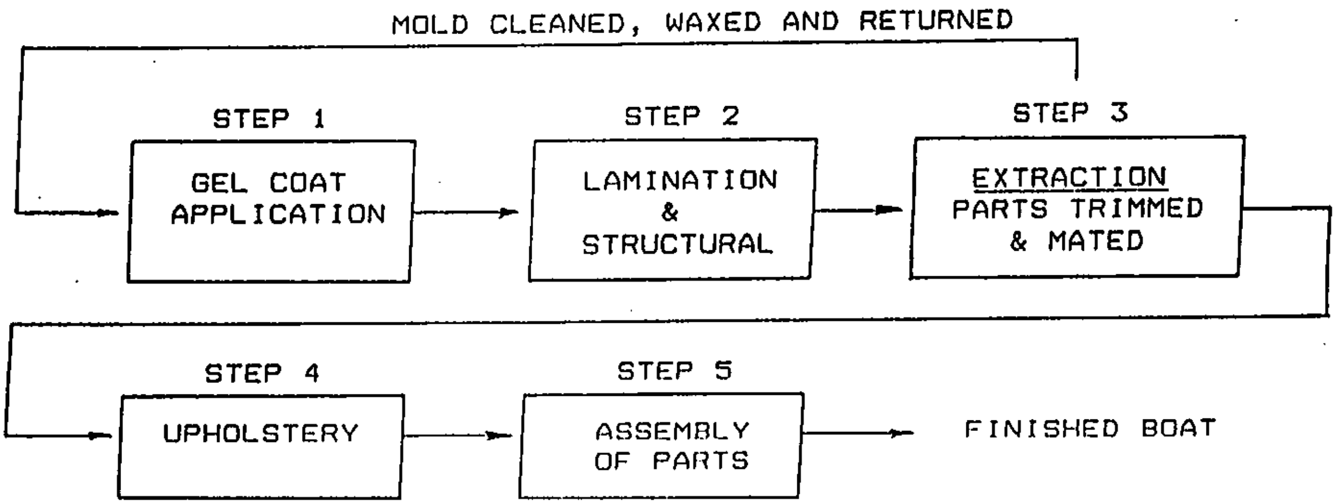
1. Work Practice Controls include the use of hand protection, covered acetone containers, limitation on the issue of acetone to employees and use of Rez-a-way, a commercial product (emulsifier) for cleaning of hands and tools. As discussed in the earlier sections this action should reduce emissions by approximately fifty percent from acetone.
2. The conversion to low styrene resins was selected over use of supressed resins because of the delamination problems experienced by manufacturers using the styrene supressed resin. The fact that the styrene emissions could be reduced using this low styrene resin by at least ten percent was discussed in Section III - 2.2.

Preliminary estimates showed controls by chemical scrubbing and incineration to be so expensive they were

dropped from further consideration. Both of these actions would require an extensive reconstruction of existing facilities, additional capital cost involving the purchase and installation of equipment, and a continuous operation and maintenance expense.

In addition, there would be an impact on waste stream if chemical scrubbing was used and possible risk of water pollution. Incinerators have not been demonstrated as VOC control devices in boat building industry because of low VOC concentration, high exhaust air flows, and the resulting high supplemental fuel requirements because of the low heat content in exhaust air.

PRODUCTION FLOW DIAGRAM



Florida Department of Environmental Regulation
Twin Towers Office Bldg. ● 2600 Blair Stone Road ● Tallahassee, Florida 32399-2400
Bob Martinez, Governor Dale Twachtmann, Secretary John Shearer, Assistant Secretary

PERMITTEE:
Sea Ray Boats, Inc.
Sea Ray Drive
Merritt Island, FL 32953

Permit Number: AC 05-165270
Expiration Date: March 31, 1990
County: Brevard
Latitude/Longitude: 28°24'32"N
80°42'23"W
Project: Fiberglass Boat Plant

This permit is issued under the provisions of Chapter 403, Florida Statutes, and Florida Administrative Code Chapters 17-2 and 17-4. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows:

For the after-the-fact construction of a facility to produce fiberglass boats. This facility is located near the Canaveral Port Authority in Merritt Island, Brevard County, Florida. The UTM coordinates of this site are Zone 17, 529 km E and 3,142 km N.

The source shall be in accordance with the permit application, plans, documents, amendments and drawings, except as otherwise noted in the General and Specific Conditions.

Attachment:

1. Application to Operate/Construct Air Pollution Sources, DER Form 17-202(1), received on May 19, 1989.

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions" and as such are binding upon the permittee and enforceable pursuant to the authority of Sections 403.161, 403.727, or 403.859 through 403.861, Florida Statutes. The permittee is hereby placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of the "Permit Conditions" by the permittee, its agents, employees, servants or representatives.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in Subsections 403.087(6) and 403.722(5), Florida Statutes, the issuance of this permit does not convey any vested rights or any exclusive privileges. Nor does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations. This permit does not constitute a waiver of or approval of any other Department permit that may be required for other aspects of the total project which are not addressed in the permit.

4. This permit conveys no title to land or water, does not constitute state recognition or acknowledgement of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the state. Only the Trustees of the Internal Improvement Trust Fund may express state opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, plant or aquatic life or property and penalties therefore caused by the construction or operation of this permitted source, nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

GENERAL CONDITIONS:

6. The permittee shall at all times properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit, as required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law, access to the premises, at reasonable times, where the permitted activity is located or conducted for the purpose of:

   a. Having access to and copying any records that must be kept under the conditions of the permit;

   b. Inspecting the facility, equipment, practices, or operations regulated or required under this permit; and

   c. Sampling or monitoring any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules.

Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately notify and provide the Department with the following information:

   a. a description of and cause of non-compliance; and

   b. the period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the non-compliance.

GENERAL CONDITIONS:

The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or revocation of this permit.

9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source, which are submitted to the Department, may be used by the Department as evidence in any enforcement case arising under the Florida Statutes or Department rules, except where such use is proscribed by Sections 403.73 and 403.111, Florida Statutes.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance, provided however, the permittee does not waive any other rights granted by Florida Statutes or Department rules.

11. This permit is transferable only upon Department approval in accordance with Florida Administrative Code Rules 17-4.12 and 17-30.30, as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit is required to be kept at the work site of the permitted activity during the entire period of construction or operation.

13. The permittee shall comply with the following monitoring and record keeping requirements:

   a. Upon request, the permittee shall furnish all records and plans required under Department rules. The retention period for all records will be extended automatically, unless otherwise stipulated by the Department, during the course of any unresolved enforcement action.

   b. The permittee shall retain at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation), copies of all reports required by this permit, and records of all data used to complete the application for this permit. The time period of retention shall be at least three years from the date of the sample, measurement, report or application unless otherwise specified by Department rule.

GENERAL CONDITIONS:

c. Records of monitoring information shall include:

- the date, exact place, and time of sampling or measurements;
- the person responsible for performing the sampling or measurements;
- the date(s) analyses were performed;
- the person responsible for performing the analyses;
- the analytical techniques or methods used; and
- the results of such analyses.

14. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be submitted or corrected promptly.

SPECIFIC CONDITIONS:

1. The construction and operation of this source shall be in accordance with the capacities and specifications stated in the application.

2. The plant shall be allowed to operate for up to 3,840 hours per year.

3. Visible emissions from the dust collection system shall not be greater than 5% opacity and compliance shall be demonstrated at 90-100% of permitted capacity using DER Method 9 in accordance with F.A.C. Rule 17-2.700.

4. Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 65.5 lbs/hr, 1048 lbs/day (30 day average), and 125.8 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	272.5	0.06	16.4
Styrene (Gel Coat)	37.7	0.30	11.3
Methyl Methacrylate	125.7	0.05	6.3
Methylene Chloride	2.5	0.30	0.8
Aromatic Hydrocarbon	21.9	0.16	3.5
1,1,1-Trichloroethane	2.5	0.60	1.5
Acetone	24.4	1.00	24.4
Xylene	21.9	0.06	1.3

SPECIFIC CONDITIONS:

5. Nonvolatile acetone substitutes shall be used to the maximum extent practicable to further reduce the quantity of acetone consumed.

6. No air pollutants shall be discharged which cause or contribute to an objectionable odor (F.A.C. Rule 17-2.620(2)).

7. The dust collector compliance test shall be conducted within 90 days after this permit is issued and the results reported to the Department's Central District office before this construction permit expires. The Department shall be notified at least 15 days in advance of the test.

8. VOC compliance shall be demonstrated over a 90-day period and the results reported to the Department's Central District office before this construction permit expires. The Department shall be notified at least 15 days in advance of the commencement of the 90-day compliance demonstration period.

9. Six months from the date of the construction permit, Sea Ray Boats shall submit a conceptual plan and potential course of action that will provide the Department with reasonable assurance that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facility's property boundary or where the public has access, whichever is closest, pursuant to F.A.C. Rules 17-2.200 and 17-2.620(1) and (2). The plan should contain at a minimum, but not be limited to, various control system strategies/options that might be retrofitted/installed to reduce or eventually eliminate emissions of VOC/OS from each type of operation, associated time and cost analyses, and VOC/OS substitutes.

10. The permittee, for good cause, may request that this construction permit be extended. Such a request shall be submitted to the Bureau of Air Regulation prior to 60 days before the expiration of the permit (F.A.C. 17-4.090).

11. An application for an operation permit must be submitted to the Central District office at least 90 days prior to the expiration date of this construction permit or within 45 days after completion of compliance testing, whichever occurs first. To properly apply for an operation permit, the applicant shall submit the appropriate application form, fee, certification that construction was completed noting any deviations from the conditions in the construction permit, and compliance test reports as required by this permit (F.A.C. 17-4.220).

Issued this 7 day
of Sept., 1989

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL REGULATION

Dale Twachtmann

Dale Twachtmann, Secretary

Florida Department of Environmental Regulation

Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400

Bob Martinez, Governor
Dale Twachtmann, Secretary
John Shearer, Assistant Secretary

December 12, 1989

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. John A. Cronkhite
Senior Vice President/General Counsel
Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Dear Mr. Cronkhite:

The Department received your request for an extension of the expiration dates for the construction permits referenced below. The request is acceptable and the following shall be changed:

PROJECT	FROM	TO
AC 05-151435	August 31, 1989	May 31, 1990
AC 05-165270	March 31, 1990	September 30, 1990
AC 05-165271	March 31, 1990	September 30, 1990

Attachment to be Incorporated:

Letter from Sea Ray Boats, Inc. dated November 22, 1989, requesting a change in the expiration dates.

A copy of this letter must be attached to the above construction permits and shall become a part of these permits.

Sincerely,

Dale Twachtmann
Secretary

DT/plm

cc: C. Collins, CF District
G. E. Cantelou, Jr., P.E.

Florida Department of Environmental Regulation

Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400

Bob Martinez, Governor
Dale Twachtmann, Secretary
John Shearer, Assistant Secretary

November 8, 1990

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. John A. Cronkhite
Senior Vice President/General Counsel
Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Dear Mr. Cronkhite:

The Department received your September 13, 1990, request for an extension of the expiration dates and revision of emission limits for the construction permits referenced below. The request is acceptable and the following shall be changed:

PROJECT	FROM	TO
AC 05-165270	September 30, 1990	December 31, 1990
AC 05-165271	September 30, 1990	December 31, 1990

Specific Condition No. 4 (AC 05-165270):

FROM:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 65.5 lbs/hr, 1048 lbs/day (30 day average), and 125.8 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	272.5	0.06	16.4
Styrene (Gel Coat)	37.7	0.30	11.3
Methyl Methacrylate	125.7	0.05	6.3
Methylene Chloride	2.5	0.30	0.8
Aromatic Hydrocarbon	21.9	0.16	3.5
1,1,1-Trichloroethane	2.5	0.60	1.5
Acetone	24.4	1.00	24.4
Xylene	21.9	0.06	1.3

TO:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 60.7 lbs/hr, 971.2 lbs/day (30 day average), and 105.6 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	258.9	0.06	15.5
Styrene (Gel Coat)	49.3	0.30	14.8
Methyl Methacrylate	94.8	0.05	4.7
Toluene	9.5	0.08	0.8
1,1,1-Trichloroethane	9.5	0.68	6.4
Acetone	11.6	1.00	11.6
Paints (Misc.)	16.8	0.41	6.9

Specific Condition No. 4 (AC 05-165271):

FROM:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 26.2 lbs/hr, 420 lbs/day (30 day average), and 50.5 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin-AME)	10.2	0.06	0.6
Styrene (Resin-RCI)	40.8	0.06	2.5
Styrene (Gel coat)	6.4	0.30	1.9
Methyl Methacrylate	18.3	0.05	0.9
1,1,1-Trichloroethane	0.2	0.68	0.1
Acetone	20.1	1.00	20.1
Toluene	0.2	0.08	0.02
Misc.	0.1	1.00	0.1

TO:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 26.2 lbs/hr, 420 lbs/day (30 day average), and 50.5 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin-AME)	10.2	0.06	0.6
Styrene (Resin-RCI)	40.8	0.06	2.5
Styrene (Gel coat)	6.4	0.30	1.9
Methyl Methacrylate	18.3	0.05	0.9
1,1,1-Trichloroethane	0.6	0.68	0.4
Acetone	19.8	1.00	19.8
Toluene	0.6	0.08	0.05
Misc.	0.1	1.00	0.1

Attachment to be Incorporated:

Letters from Sea Ray Boats, Inc. dated September 13, 1990 requesting a change in the expiration dates and emission limits.

A copy of this letter must be attached to the above construction permits and shall become a part of these permits.

Sincerely,

STEVE SMALLWOOD, P.E.
Director
Division of Air Resources
Management

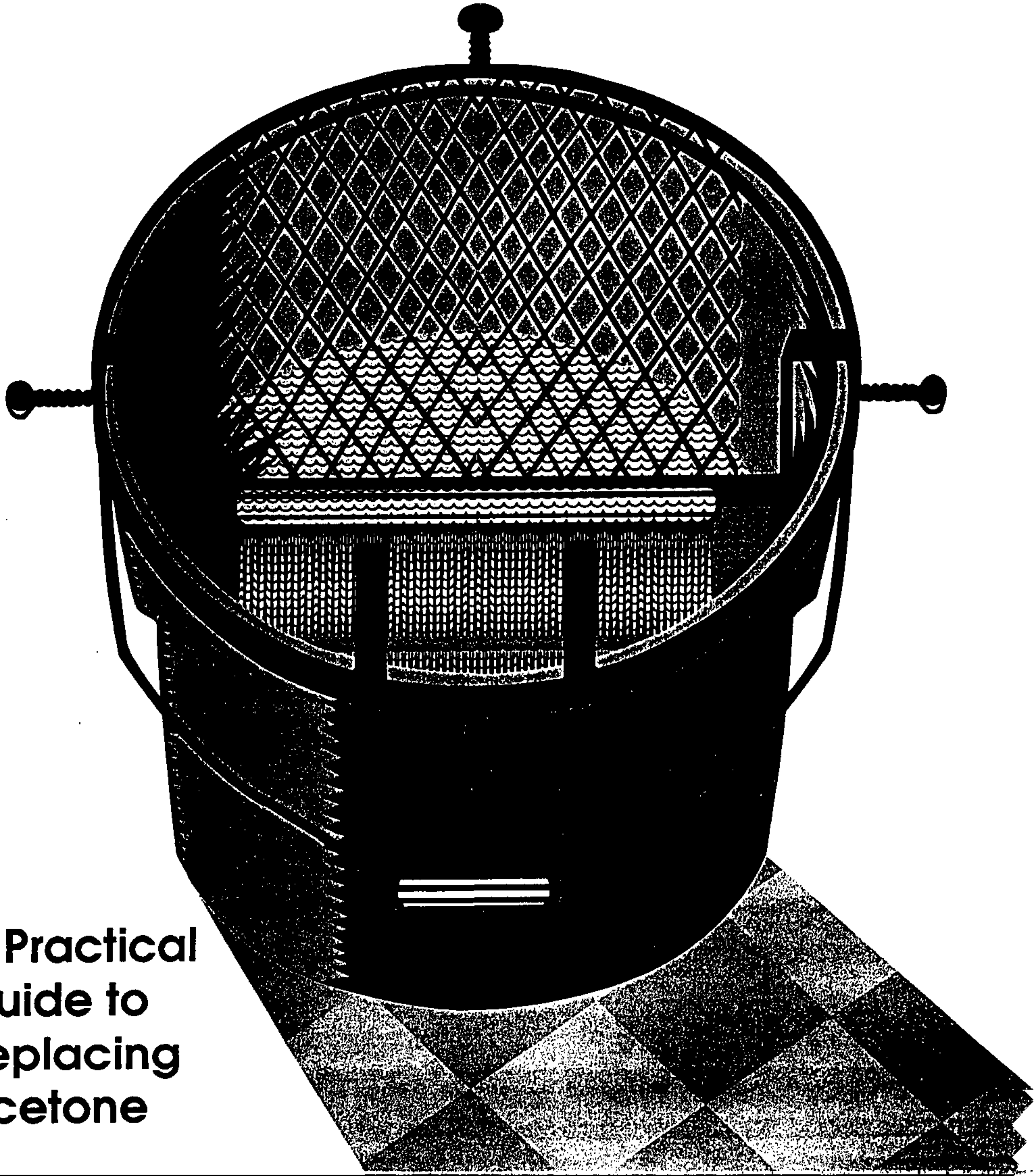
SS/JR/plm

c: C. Collins, Central Dist.
G. E. Cantelou, Jr., P.E.

April 1990

FABRICATION NEWS

OFFICIAL PUBLICATION OF THE FIBERGLASS FABRICATION ASSOCIATION



A Practical Guide to Replacing Acetone

Replace Acetone Successfully –A Practical Guide–

The pace of movement away from acetone as a cleanup solvent has certainly quickened lately. To help you keep up, Dr. Reidar Halle, an acknowledged world-class expert on peroxides, and Joe Brennan have teamed for this very informative and easy-to-follow article.

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feature

Replace Acetone Successfully —A Practical Guide—

By:
Dr. Reidar Halle
Joseph A. Brennan
Managing Directors
Qual Tech Enterprises, Inc.
1485 Bayshore Boulevard
San Francisco, CA 94124
Telephone: 415-467-7887

• Introduction to Emulsifier Technology

• General comments

Like the revolutions in Eastern Europe, the revolution within the FRP Industry away from acetone as a cleanup solvent had a slow, sluggish and hesitant start. Now, the pace of both revolutions is brisk and broadly-based!

FRP laminators have two acetone replacement technologies available: resin emulsifiers and higher boiling point organic solvents. Emulsifier technology costs less than acetone and is significantly safer and more environmentally sound! In addition, emulsifiers, used correctly, actually clean better than acetone. Emulsifiers can easily replace 75-100% of the cleanup acetone in most shops—almost all used for cleaning rollers, brushes and hands. Sometimes, more elaborate techniques are needed to clean internal-mix spray guns and pultrusion dies.

In the past, there was some worker resistance to substitute any product for acetone—the only resin cleaner ever used by most laminators. Today, many FRP shops have implemented acetone replacement systems to comply with health, environmental and fire regulations. Many of these shops, both workers and management, now sing the praises of the safety, ease, efficiency and economy of their new emulsifier systems.

Both emulsifiers and high boiling point solvents reduce VOC (Volatile Organic Compounds) emissions, but the emulsifiers in most cases have the added advantage of not generating hazardous waste. Replacing acetone with high boiling solvents is initially a simpler process; however, the contaminated solvents must be distilled and/or hauled away for waste treatment. Also, solvent still bottoms present disposal problems in more and more states.

Why then does this technology, with its inherent advantages of lower fire, health and environmental dangers, fail to be adopted quickly by every FRP fabricator? The answer to this enigmatic question seems to be a widespread lack of understanding of the new emulsifier technology within the FRP industry. As a result, some FRP shops have neglected to implement an ongoing training programs to teach employees how to use emulsifiers effectively.

Unfortunately, far too many fabricators were presented with a sample of an emulsifier (identified as "an acetone replacement") for evaluation; accompanied only with an MSDS—no demonstrations or detailed instructions were offered! Therefore, in the absence of any other advice, many FRP companies evaluated the emulsifiers in the same manner they used acetone, rather than as a new technology with different techniques. Some laminators complained bitterly to management about the difficulty of cleaning with emulsifiers; and justifiably so, acetone methods don't work with emulsifiers. These complaints frequently led to the abandonment of the acetone replacement project.

On the other hand, if you examine those FRP shops that have successfully implemented emulsifier systems vis-à-vis the unsuccessful shops, you will conclude: The successful shops have the common thread of hands-on management commitment to eliminate hazardous waste generation, close supplier support, and a company-wide training program.

The following is a step-by-step look at the fundamentals of emulsifier technology and the recommendations for FRP shops to choose the correct system to successfully make the transition from acetone to emulsifier technology.

• Emulsifiers versus Solvents

• How does an emulsifier differ from acetone?

Separation versus dissolving: Organic solvents, whether acetone or higher boiling point products, clean the resins by dissolving them homogeneously, creating a dilute solution of the resin—also hazardous waste and varying levels of VOCs. In the process of cleaning resins with acetone, the sticky resin is diluted and spread around, rather then removed from the cleaning solution as with emulsifier technology.

The result is: The efficiency of solvents used for resin cleanup declines rapidly after the first use. Emulsifier cleaning solutions, on the other hand, actually become clearer as the resin settles to the bottom, allowing continued use of the cleaning solution.

The most important differences are:

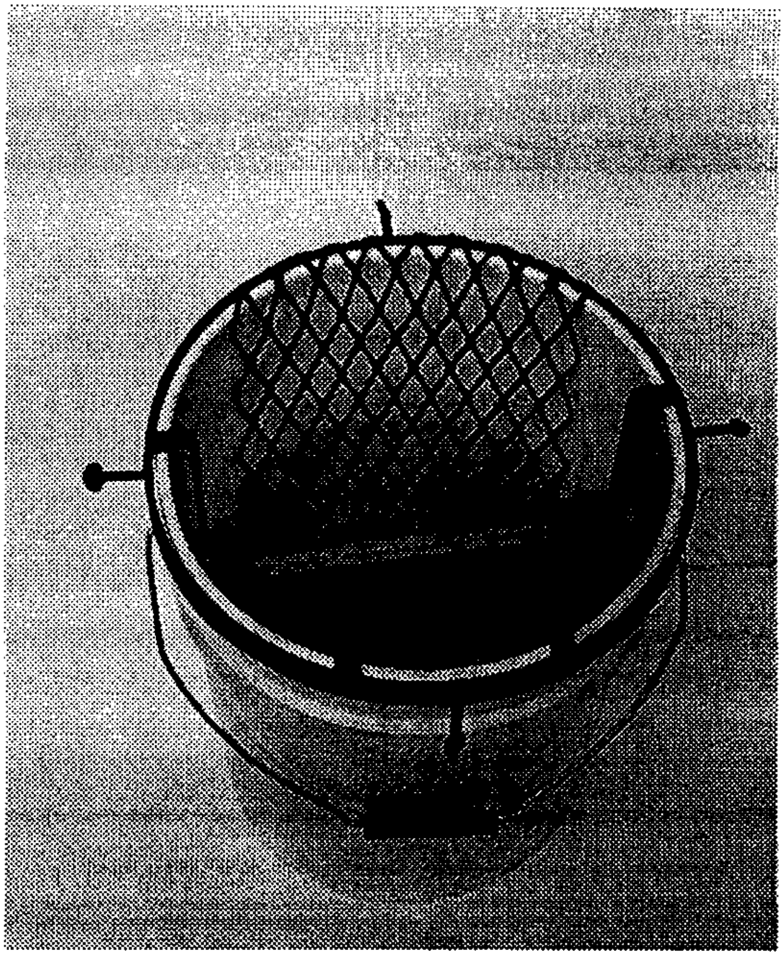
Hazardous Waste Generation: Solvents used for cleaning resins always generate hazardous waste, emulsifiers usually don't.

VOC Emissions: Acetone generates 6,600 pounds of VOCs for each 1,000 gallons consumed in cleaning; typically, 75-100% evaporates. In addition, recycling

Replace Acetone Successfully

solvents, regardless of boiling point, eventually loses all the solvent to evaporation, spillage or still bottoms. A comparable amount of a low-solvent emulsifier cleaner generates only 30-50 pounds of VOCs—a >99% reduction. This point becomes more critical when increased FRP production levels threaten to exceed total plant VOC allowable limits.

Fire & Health Hazards: Emulsifiers are water-based solutions that present no fire danger—preferred by fire marshals and insurance companies. Organic solvents often burn; some, such as acetone, burn vigorously and are red label. Solvents often have workplace air concentration and exposure limits to protect workers; emulsifiers pose no air quality problems.



• How does an emulsifier work?

An emulsifier formulation for resin cleaning is a mixture of surfactants (surface tension modifiers), combined with wetting and complexing agents in water—the system is usually alkaline. Some emulsifier formulations contain excess amounts of solvents; this initially improves the cleaning action of the formulation, but has some serious drawbacks. Solvents dissolve metal salts (Cobalt), styrene, and other organic compounds that can cause disposal problems. In general, a FRP shop manager should check the data sheet and MSDS of the emulsifier product before the evaluation to determine the potential for sewer disposal problems.

An emulsifier surrounds the globules of tacky resin and renders them tack-free by chemical action. These globules, unable to fight gravity by sticking to a surface, fall to the bottom of the cleaning vessel, where they cure, if catalyzed. The emulsified resin in the cleaning vessel should separate to the bottom efficiently to keep the cleaning solution free from resin. Emulsifier products that contain inefficient surfactants, high solvent content, or require heating, can retard this desirable quality of efficient separation. There is a simple resin screening test (covered later in this article) to determine qualitatively the separation capabilities of various emulsifiers.

The emulsifier cleaning solution can continue to be used until the product is depleted—roughly twice as long as solvents—then discharged into the sewer when the proper procedures are followed, and the neccesarry sewer permits are obtained. The cured resin at the bottom of the emulsifier cleaning vessel should be removed, dried and can be discarded with other solid nonhazardous waste.

• Why have acetone-replacement projects failed?

Most FRP shops that have had little or no success switching from acetone to emulsifiers haven't approached the project as an engineered system designed for the plant's unique needs. A system—integrating a basic understanding of the technology in choosing an emulsifier and hardware, a workers' training program, and a disposal method for the spent emulsifier—is essential for the successful conversion from acetone to emulsifier technology.

Typically, companies that failed to make the transition from acetone to emulsifiers on the first attempt did not fully understand that emulsifier cleanup was a different technology involving new strategies and techniques.

Technology Change: Using the long established techniques developed for acetone cleanup will not work with water-based emulsifiers. FRP laminators have to change their work techniques, and sometimes the type of tools and the cleanup systems employed. Actually, acetone replacement is not a direct product replacement, but a technology change.

Laminators can not merely dip-rinse and soak hand tools as with acetone. Tools must be cleaned immediately free of resin.

Instead of simply dissolving resin from the surfaces as solvents do, emulsifiers work best when the liquid bond of the resin to the surface is physically broken by mechanical brushing or swirling. Once the bond is broken, the emulsifier coats the resin, making it nonsticky. The critical step for FRP shops is to select the best mechanical device—brushes in most cases set in place on racks suspended in the emulsifier solution.

Also, there has been some confusion over the technique of cleaning rollers and brushes, as well as dewatering the tools before returning to the laminate. Emulsifier techniques are specific and often re-

quire demonstrations in the plant for workers and management. The new technology is different than the old, but the effort to learn and use it is worth its benefits: Better cleaning, safer handling and reduced costs. Check your supplier for detailed instruction guidelines.

• How to select an emulsifier

Emulsifier products must be chosen for their ability to be discharged into the sewer when spent, as well as their ability to clean. Therefore, the initial pH and the solvent content of the emulsifier concentrate are important.

The pH levels of emulsifier formulations drop during the cleaning of polyester resins (acidic) into an acceptable range to most sewer districts. However, if the pH range is much above 11.5, the product may be a corrosive liquid that doesn't drop enough in pH to meet local sewer requirements. This could require treatment before discharge. The same is true of excess solvent concentrations in emulsifier formulations: Solvents can increase the heavy metal and/or styrene concentrations to unacceptable levels for sewer discharge.

Heating emulsifiers does increase their cleaning efficiency—by lowering the resin viscosity, which speeds up the emulsifying action. But, this can be a drawback to sewer disposal if the warm water dissolves more styrene, etc. In general, heating should be reserved for difficult cleaning tasks and flushing some internal resin transfer systems in order to minimize the chance of sewer disposal problems.

• Resin Screening

The Replacetone Separation/Capacity Screening Test

A standard test developed to quickly screen various emulsifiers and dilution ratios to determine the optimum cleaning, separation efficiency and settling rates. Test procedure: Pour approximately 1-inch of resin into a 12-ounce clear soda bottle and fill the bottle to 75% of its capacity with the diluted emulsifier solution. Cap securely. Then shake vigorously to remove the resin from the sides of the bottle and to intimately mix the resin and emulsifier.

Allow the sealed bottle to stand undisturbed; check after 15 minutes, 1 hour and 24 hours for completeness of separation. Repeat for various resins and dilution ratios and compare the cleaning and settling rates, and the emulsifier capacity.

Emulsifier capacity, the quantitative ability to continue cleaning resins, can be checked by successively using the effluent from the previous Replacetone Screening Test for additional tests until the emulsifier loses its cleaning ability.

• What is the pH?

Most emulsifiers are alkaline to varying degrees. Higher pH improves the efficiency of the formulation, but also introduces a possible cause of skin and eye irritation and burning: Caustic, silicates, phosphates, amines, carbonates, etc., added to raise the pH. As mentioned earlier, high pH can cause sewer disposal problems, as well as tool corrosion problems.

Also, silicates and phosphates, known complexing agents and solubilizers of heavy metals, can prevent discharge of spent emulsifier into the sewer treatment plant. Low molecular weight amines can also solubilize heavy metals, as well as cause dermatitis.

• What is the Flash Point?

A high solvent content in an emulsifier formulation can lower the Flash Point of emulsifiers. Check the emulsifier MSDS. Emulsifier formulations with low solvent content do not burn because of the water content.

High boiling solvents, even with flash points exceeding 200° F, usually burn if ignited. Acetone, most FRP resins containing styrene or other monomers, and MEK are flammable liquids.

• What is the effect on health?

Water-based emulsifiers can contain many different kinds of chemicals—too many to generalize about health precautions. Even though some of these chemical ingredients are not required to be listed on the MSDS, they can have an adverse effect eyes and skin. Be certain to obtain information (other than the obvious "other than gloves are recommended") from the manufacturer on the product's effect on health.

• Does it contain restricted chemicals?

Phosphate disposal into sewers is being banned in many states. Check the emulsifier MSDS and data sheet. All formulations contain some quantities of low molecular weight chemicals that serve as wetting agents or cleaning enhancers. The emulsifier MSDS should be checked for ingredients that are restricted or suspected chemicals.

• How is the material stored?

Emulsifiers usually range in pH from 10-11.5, which allows storage with labeled materials. A pH of more than 12.5 makes the emulsifier a corrosive liquid, restricting its flexibility in handling, shipping and storage.

Most emulsifier concentrates have pHs above the norm permitted by water treatment plants. Therefore, concentrates should have secondary containment storage, when possible, to prevent leaks into the environment. Local storage regulations must be checked and observed.

• How to choose the emulsifier dilution ratio

An emulsifier dilution ratio varies with type and grade of resin, and what is being cleaned: Tools, hands, spray guns, or light-wipe cleaning.

• Type of resin

Emulsifiers behave differently with resins types, fillers and additives—both type of resin and dilution ratio with water are critical to effective cleaning. Below is a list of many of the resins that can be cleaned with emulsifier formulations and a general guideline to dilution ratios with water. These recommendations are based on our experience with a low-solvent emulsifier concentrate.

Polyester
    General Purpose— 1:15
    Vinyl ester— 1:5
    Cultured Marble— 1:10
    Gel Coat— 1:5
    Fire Retardant— 1:5
    Highly-filled Resins— 1:5
Epoxy
    Room Temperature cured— 1:10
    Elevated Temperature cured— 1:5
Polyurethane
    Rigid— 1:5
    Flexible— 1:15

• Laminating Tools (Rollers, brushes, etc.)

The use of water-based emulsifiers to clean rollers and brushes requires some brushing action (fixed or rotary) to remove the resin from the surface and to intimately surround the resin with the emulsifier. This renders the resin non-sticky for easy removal. A Jiffy-Cleaner, a five gallon pail with scrub brushes in-

quire demonstrations in the plant for workers and management. The new technology is different than the old, but the effort to learn and use it is worth its benefits: Better cleaning, safer handling and reduced costs. Check your supplier for detailed instruction guidelines.

• How to select an emulsifier

Emulsifier products must be chosen for their ability to be discharged into the sewer when spent, as well as their ability to clean. Therefore, the initial pH and the solvent content of the emulsifier concentrate are important.

The pH levels of emulsifier formulations drop during the cleaning of polyester resins (acidic) into an acceptable range to most sewer districts. However, if the pH range is much above 11.5, the product may be a corrosive liquid that doesn't drop enough in pH to meet local sewer requirements. This could require treatment before discharge. The same is true of excess solvent concentrations in emulsifier formulations: Solvents can increase the heavy metal and/or styrene concentrations to unacceptable levels for sewer discharge.

Heating emulsifiers does increase their cleaning efficiency—by lowering the resin viscosity, which speeds up the emulsifying action. But, this can be a drawback to sewer disposal if the warm water dissolves more styrene, etc. In general, heating should be reserved for difficult cleaning tasks and flushing some internal resin transfer systems in order to minimize the chance of sewer disposal problems.

• Resin Screening

<u>The Replacetone Separation/Capacity Screening Test</u>

A standard test developed to quickly screen various emulsifiers and dilution ratios to determine the optimum cleaning, separation efficiency and settling rates. Test procedure: Pour approximately 1-inch of resin into a 12-ounce clear soda bottle and fill the bottle to 75% of its capacity with the diluted emulsifier solution. Cap securely. Then shake vigorously to remove the resin from the sides of the bottle and to intimately mix the resin and emulsifier.

Allow the sealed bottle to stand undisturbed; check after 15 minutes, 1 hour and 24 hours for completeness of separation. Repeat for various resins and dilution ratios and compare the cleaning and settling rates, and the emulsifier capacity.

Emulsifier capacity, the quantitative ability to continue cleaning resins, can be checked by successively using the effluent from the previous Replacetone Screening Test for additional tests until the emulsifier loses its cleaning ability.

• What is the pH?

Most emulsifiers are alkaline to varying degrees. Higher pH improves the efficiency of the formulation, but also introduces a possible cause of skin and eye irritation and burning: Caustic, silicates, phosphates, amines, carbonates, etc., added to raise the pH. As mentioned earlier, high pH can cause sewer disposal problems, as well as tool corrosion problems.

Also, silicates and phosphates, known complexing agents and solubilizers of heavy metals, can prevent discharge of spent emulsifier into the sewer treatment plant. Low molecular weight amines can also solubilize heavy metals, as well as cause dermatitis.

• What is the Flash Point?

A high solvent content in an emulsifier formulation can lower the Flash Point of emulsifiers. Check the emulsifier MSDS. Emulsifier formulations with low solvent content do not burn because of the water content.

High boiling solvents, even with flash points exceeding 200° F, usually burn if ignited. Acetone, most FRP resins containing styrene or other monomers, and MEK are flammable liquids.

• What is the effect on health?

Water-based emulsifiers can contain many different kinds of chemicals—too many to generalize about health precautions. Even though some of these chemical ingredients are not required to be listed on the MSDS, they can have an adverse effect eyes and skin. Be certain to obtain information (other than the obvious "other than gloves are recommended") from the manufacturer on the product's effect on health.

• Does it contain restricted chemicals?

Phosphate disposal into sewers is being banned in many states. Check the emulsifier MSDS and data sheet. All formulations contain some quantities of low molecular weight chemicals that serve as wetting agents or cleaning enhancers. The emulsifier MSDS should be checked for ingredients that are restricted or suspected chemicals.

• How is the material stored?

Emulsifiers usually range in pH from 10-11.5, which allows storage with labeled materials. A pH of more than 12.5 makes the emulsifier a corrosive liquid, restricting its flexibility in handling, shipping and storage.

Most emulsifier concentrates have pHs above the norm permitted by water treatment plants. Therefore, concentrates should have secondary containment storage, when possible, to prevent leaks into the environment. Local storage regulations must be checked and observed.

• How to choose the emulsifier dilution ratio

An emulsifier dilution ratio varies with type and grade of resin, and what is being cleaned: Tools, hands, spray guns, or light-wipe cleaning.

• Type of resin

Emulsifiers behave differently with resins types, fillers and additives—both type of resin and dilution ratio with water are critical to effective cleaning. Below is a list of many of the resins that can be cleaned with emulsifier formulations and a general guideline to dilution ratios with water. These recommendations are based on our experience with a low-solvent emulsifier concentrate.

Polyester
    General Purpose— 1:15
    Vinyl ester— 1:5
    Cultured Marble— 1:10
    Gel Coat— 1:5
    Fire Retardant— 1:5
    Highly-filled Resins— 1:5
Epoxy
    Room Temperature cured— 1:10
    Elevated Temperature cured— 1:5
Polyurethane
    Rigid— 1:5
    Flexible— 1:15

• Laminating Tools (Rollers, brushes, etc.)

The use of water-based emulsifiers to clean rollers and brushes requires some brushing action (fixed or rotary) to remove the resin from the surface and to intimately surround the resin with the emulsifier. This renders the resin nonsticky for easy removal. A Jiffy-Cleaner, a five gallon pail with scrub brushes in-

quire demonstrations in the plant for workers and management. The new technology is different than the old, but the effort to learn and use it is worth its benefits: Better cleaning, safer handling and reduced costs. Check your supplier for detailed instruction guidelines.

• How to select an emulsifier

Emulsifier products must be chosen for their ability to be discharged into the sewer when spent, as well as their ability to clean. Therefore, the initial pH and the solvent content of the emulsifier concentrate are important.

The pH levels of emulsifier formulations drop during the cleaning of polyester resins (acidic) into an acceptable range to most sewer districts. However, if the pH range is much above 11.5, the product may be a corrosive liquid that doesn't drop enough in pH to meet local sewer requirements. This could require treatment before discharge. The same is true of excess solvent concentrations in emulsifier formulations: Solvents can increase the heavy metal and/or styrene concentrations to unacceptable levels for sewer discharge.

Heating emulsifiers does increase their cleaning efficiency—by lowering the resin viscosity, which speeds up the emulsifying action. But, this can be a drawback to sewer disposal if the warm water dissolves more styrene, etc. In general, heating should be reserved for difficult cleaning tasks and flushing some internal resin transfer systems in order to minimize the chance of sewer disposal problems.

• Resin Screening

The Replacetone Separation/Capacity Screening Test

A standard test developed to quickly screen various emulsifiers and dilution ratios to determine the optimum cleaning, separation efficiency and settling rates. Test procedure: Pour approximately 1-inch of resin into a 12-ounce clear soda bottle and fill the bottle to 75% of its capacity with the diluted emulsifier solution. Cap securely. Then shake vigorously to remove the resin from the sides of the bottle and to intimately mix the resin and emulsifier.

Allow the sealed bottle to stand undisturbed; check after 15 minutes, 1 hour and 24 hours for completeness of separation. Repeat for various resins and dilution ratios and compare the cleaning and settling rates, and the emulsifier capacity.

Emulsifier capacity, the quantitative ability to continue cleaning resins, can be checked by successively using the effluent from the previous Replacetone Screening Test for additional tests until the emulsifier loses its cleaning ability.

• What is the pH?

Most emulsifiers are alkaline to varying degrees. Higher pH improves the efficiency of the formulation, but also introduces a possible cause of skin and eye irritation and burning: Caustic, silicates, phosphates, amines, carbonates, etc., added to raise the pH. As mentioned earlier, high pH can cause sewer disposal problems, as well as tool corrosion problems.

Also, silicates and phosphates, known complexing agents and solubilizers of heavy metals, can prevent discharge of spent emulsifier into the sewer treatment plant. Low molecular weight amines can also solubilize heavy metals, as well as cause dermatitis.

• What is the Flash Point?

A high solvent content in an emulsifier formulation can lower the Flash Point of emulsifiers. Check the emulsifier MSDS. Emulsifier formulations with low solvent content do not burn because of the water content.

High boiling solvents, even with flash points exceeding 200° F, usually burn if ignited. Acetone, most FRP resins containing styrene or other monomers, and MEK are flammable liquids.

• What is the effect on health?

Water-based emulsifiers can contain many different kinds of chemicals—too many to generalize about health precautions. Even though some of these chemical ingredients are not required to be listed on the MSDS, they can have an adverse effect eyes and skin. Be certain to obtain information (other than the obvious "other than gloves are recommended") from the manufacturer on the product's effect on health.

• Does it contain restricted chemicals?

Phosphate disposal into sewers is being banned in many states. Check the emulsifier MSDS and data sheet. All formulations contain some quantities of low molecular weight chemicals that serve as wetting agents or cleaning enhancers. The emulsifier MSDS should be checked for ingredients that are restricted or suspected chemicals.

• How is the material stored?

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Replace Acetone Successfully

serted, is the best solution to this problem. Mechanical devices in combination with emulsifiers clean efficiently and allow higher dilution ratios and better cost effectiveness.

• Spray guns

Spray guns, both internal and external-mix, are cleaned with a 1:5 dilution ratio.

• Hand & light-wipe cleaning

Simple hand cleaning and wiping down a cured FRP part requires a dilution of 1:15 to 1:20 in most cases. A hands-only type of Jiffy-Cleaner (with softer brushes) is recommended for best results. Hands must be rinsed in clear water to remove the residual emulsifier to prevent skin irritation or rash.

Using spray bottles of emulsifier diluted 1:20 in water is the best approach to wiping off cured gel coat surfaces and laminates. This minimizes the fire and air pollution dangers posed by acetone cleaning.

• Dilution methods

Management should determine a standard method of emulsifier dilution and appoint an employee to be responsible for preparing the emulsifier solution. This step avoids inconsistent results (over dilution) and waste (under dilution). Either batch mixing or the use of a proportioning hose connection gives satisfactory results.

• How to clean with emulsifiers

• Roller & paint brushes

The following are directions for cleaning rollers and brushes in a Jiffy-Cleaner—the most popular and versatile cleaning tool:

Fill a diluted emulsifier solution into a Jiffy-Cleaner to a level of 1" above the top of the brushes. Fill a second pail with clean water to approximately three-quarters full; change the rinse water periodically as needed.

Insert rollers soiled with resin between the Jiffy-Cleaner scrub brushes and plunge the rollers three or more times between the brushes. The bottom bracket of the Jiffy-Cleaner is elevated several inches from the bottom of the bucket so the rollers do not touch the curing resin collected there.

Shake off excess emulsifier and suds and briefly dip the rollers in the clear water pail. Give three to four sharp snaps of the wrist to dispel water from the surface of the rollers. In most cases the rollers are now dry enough to return to the laminate. If not, hang the rollers to dry for several minutes. All tools must be cleaned immediately in order to avoid the resin curing on parts. This is important: Soaking tools before cleaning is unnecessary—and a problem, if the resin is allowed to cure on the tools. Rollers cleaned with emulsifiers are nonsticky and noticeably cleaner than those cleaned with organic solvents.

A small number of FRP shops use the larger felt paint-type of rollers to apply resin uniformly to the laminates. These rollers clean well in a 1-inch or 2-inch Jiffy-Cleaner. After the felt cover is cleaned and rinsed in clear water, it should be wrung by hand and hung on a peg to dry. The removable felt cover should have a plastic core, not paper or cardboard. The roller holder can be cleaner in the Jiffy-Cleaner and dried before another felt roller cover is attached.

For brushes, the technique is important:

Insert the paint brushes in the Jiffy-Cleaner by pressing the bristles against the top of the Jiffy-Cleaner brushes on one side. Move the handle of the paint brush downward along the open space between brushes to scrub the interior paint brush bristles clean. The bristles should be pointing upward and be spread out like a bird's tail. Pull up. Turn the paint brush over and repeat. Depending upon the size of the brush, repeat this technique several times until the paint brush is free from resin. Squeeze the bristles to expel the excess emulsifier and suds.

Rinse the paint brush in clear water by forcing the bristles against the side of the pail beneath the water. Wring the bristles and hit them against the top of the bucket rapidly several times to dispel water droplets from the brush. Hang brush to dry if still moist, or use dry air.

Use splash goggles to prevent emulsifier solution from getting into the eyes. Read MSDS and product data sheets before use.

• What system tools are required?

Fixed Brushes

A Jiffy-Cleaner was invented to aid in the cleaning of the tools using emulsifiers. The Jiffy-Cleaner, with fixed brushes on a rack, is widely used to clean rollers and brushes. It is a versatile tool that is available in various container sizes (5, 15 & 55-gallon) and brush configurations.

Air-driven brushes

Air-driven brushes, despite their lack of versatility and mobility, are well suited for some specialty cleaning: Very large or odd-sized tools and rollers; intricate parts and dies. Air-driven brush machines cause a powerful churning action that finely disperses the emulsified resin in suspension for a considerably longer time. This vortex flow also stirs up the resin collecting at the bottom of the cleaning reservoir—this tends to decrease the efficiency of the emulsifier solution and possibly poses a sewer disposal problem. For this reason, air-driven brush systems should have deep reservoirs equipped with baffles.

Heated Baths

Heated reservoirs are not widely used, but do have specific applications (e.g., intricate parts, pipes, dies). They suffer from the same lack of versatility and mobility as air-driven brush machines. Hot water baths do improve cleaning somewhat by reducing the resin viscosity and improving the emulsifying action. However, heated baths increase the levels of styrene, cobalt salts, MEKP, etc. in the emulsifier solution, and can cause sewer disposal problems.

• Hands

Hands are cleaned best in a dedicated hand Jiffy-Cleaner, followed by a clear water rinse to remove residual emulsifier. Soft sponges and hand brushes also clean well. Hands may be dried with towels or air. Insufficient rinsing and drying of hands, or a combination of emulsifier residue with solvents and resins can cause skin irritation.

• Spray & gel coat guns

Due to wide variations in emulsifier effectiveness with various resins and fillers, it is difficult to give specific cleaning instructions for internal-mix and gel coat spray guns. Spray gun manufacturers and emulsifier suppliers should be consulted. External-mix guns can be cleaned with an emulsifier spray bottle and small brush, and dried with clean cloths similar to solvent cleaning.

• Dies and molds

This normally involves heavily-filled resins with specialty additives that even make acetone cleanup difficult due to stickiness. An emulsifier system, with air-driven brushes and heated reservoir, can do a

more effective job than solvents. Almost every system is unique, but all are based on the basic principles of emulsifier technology: Use of mechanical energy to break the resin liquid bond with the surface; emulsification and separation of the resin; clear water rinse and drying.

• Wipe off of cured FRP parts

Emulsifiers diluted to 1:20 in spray bottles can be used with clean cloth wipes to clean oil, dirt or liquid resin from cured resin parts. This type of cleaning is similar to acetone cleaning. However, acetone spreads a portion of the diluted residue over the entire surface; emulsifiers remove the resin, oil or dirt from the surface.

• Cured resin

Cleaning cured resin is a problem for emulsifiers as well as acetone. Methylene Chloride is somewhat effective, but is being restricted as a resin cleanup solvent. Most solvents that remove cured resins also carry health and environmental warnings. Preventive maintenance is essential to minimize this problem by dealing with the resin waste before it cures.

• How to solve cleaning problems

• Introduction

If possible, FRP managers should get an in-plant demonstration from their emulsifier supplier. This allows management and production personnel to see the proper techniques and procedures to clean their currently used resins from their own tools first hand from experienced professionals. If demonstrations are not possible, complete "How to Use..." and "How to Dispose of..." instruction guides are available from suppliers. Finally, follow-up training is necessary to ensure that proper procedures are maintained.

• Cleaning efficiency

Cleaning efficiency with emulsifiers is dependent on the speed of separation of the emulsified resin to the bottom of the cleaning vessel. Even if the chemical separation is good, if the vessel is shallow (especially critical with air-driven brushes), the curing resin is stirred up into the cleaning zone, causing inefficient cleaning. Therefore, it is important to use deep containers (5-gallon minimum) with fixed brushes that are at least two inches off the bottom; air-driven brushes should be considerably higher because of the churning action caused by the rotating brushes. If more than 4-5 laminators are cleaning tools, additional cleaning buckets should be set up. Regular changing of the emulsifier cleaning solution is best—daily changing, if that works in your operation.

• Possible pitfalls

Below is a summary of the typical problems with the use of emulsifiers if the proper procedures are not performed. All of the pitfalls associated with rollers, brushes and hands can be avoided by using the proper hardware tools and techniques to clean, rinse and dewater the rollers.

• Rollers

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and correct technique.

Water in barrel

Remedy: Learn technique of snapping wrist to force water from rollers.

Barrel freeze

Remedy: Use Jiffy-Cleaner and learn technique to rinse and dewater. Also, use quick-release rollers to minimize barrel freeze.

• Brushes

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and learn the technique of cleaning the interior bristles of the paint brush, and use the proper dewatering method.

Water in handle

Remedy: Punch holes in the ferrule on the handle to allow excess water to drain; hang up to dry with bristle toward the ceiling to minimize the drying time.

Moisture

Remedy: Brushes may be air dried or forced dried with compressed air.

• Hands

Inadequate cleaning

Remedy: For inadequate cleaning—sticky hands—use a hand brush or soft-brush Jiffy-Cleaner to remove the resin before rinsing. Hand rinsing with clear water is essential to prevent skin rash or discomfort. Hand cleaner systems should be placed at or close to waist level for the best results.

Moisture on hands

Remedy: Supply soft clean towels or air driers near the hand cleaning station.

• Spray guns

Cleaning spray guns, especially internal-mix and gel coat guns, is not a simple task. It will probably involve the technical assistance of your emulsifier supplier and your gun manufacturer. Certain resin types, fillers and pigments can cause inefficient cleaning and excessive plugging of guns if the proper emulsifier is not used. It is strongly suggested that this conversion be made last after the replacement of the open acetone containers used for cleaning rollers, brushes and hands. It is essential for each plant to establish and follow a standard procedure for cleaning spray guns.

• Training

Almost all pitfalls outlined above can be avoided or minimized by good training, follow-up programs and the help of your suppliers. An in-plant demonstration is worth thousands of words. Call your supplier.

• How to handle your spent cleaning solution

Liquid solution

Filter the solid resin from the emulsifier cleaning solution at the end of each day. The cleaning solution can continue to be used until it is completely spent. When the cleaning solution is no longer effective, allow at least 24 hours settling time before the final filtering. Then, the spent emulsifier liquid can be discharged into the sewer if permits have been obtained.

Resin sediment

The wet resin sediment, separated from the liquid portion of the spent solution, must be dried before disposal. Spread the wet solid for ease of drying. The dried, cured resin can be disposed of as solid nonhazardous waste along with the hardened resin and trim. Note: Only catalyzed resins cure to a solid.

★• How to dispose of the waste

Liquid effluent

The spent emulsifier solution can be discharged into the sewer if the Federal, State and Local regulations have been met. However, navigating the maze of regulations necessary to obtain a sewer disposal permit is difficult, detailed and time-consuming. Contact your emulsifier supplier for assistance and guidance.

Normally, spent emulsifier solutions from plant operations would not be classified as a hazardous waste. However, any

feature

Replace Acetone Successfully

mixture with a hazardous waste listed in 40 CFR Part 261 Subpart D, Proposition 65, or similar state regulations, etc., would make the resultant waste stream hazardous.

In addition, if a waste stream generated from the use of an emulsifier exhibits one or more of the characteristics of hazardous waste (Corrosivity, EP toxicity, reactivity, or ignitability), it likewise would be subject to the hazardous waste regulations. If in doubt, have your waste stream analyzed.

Use splash goggles to prevent eye injuries when handling.

Septic systems

Septic systems are local issues, and it may not be possible to dispose of the effluent into leaching fields. Consult your emulsifier supplier.

Evaporation

Evaporation by heating of the water phase of the spent emulsifier solution is possible, but it is energy-intensive and expensive.

Cleaning water for recycling

This a costly affair, but it might be of interest to large companies that already have recycling/treatment plants.

Dried cured resin residue

The generated solid cured resin, when dried, may be able to be disposed of as nonhazardous waste. If the residual resin is not completely cured, add a small amount of catalyzed resin to complete the cure before disposal.

Cost comparison with solvents

The purchase price of cleanup solvents—without disposal costs included—are from $2+ per gallon for acetone to 3-4 times as much for higher boiling solvents.

Diluted emulsifier solutions typically cost $1.00 per gallon and last at least twice as long as solvents. The cost effectiveness of emulsifiers versus solvents is substantial, even if the solvents are recycled—only 50-60% of all cleanup solvents are reclaimed. Emulsifiers offer considerable cost advantages even before the additional hidden costs of solvent recycling losses and disposal are factored into the comparison.

• Summary

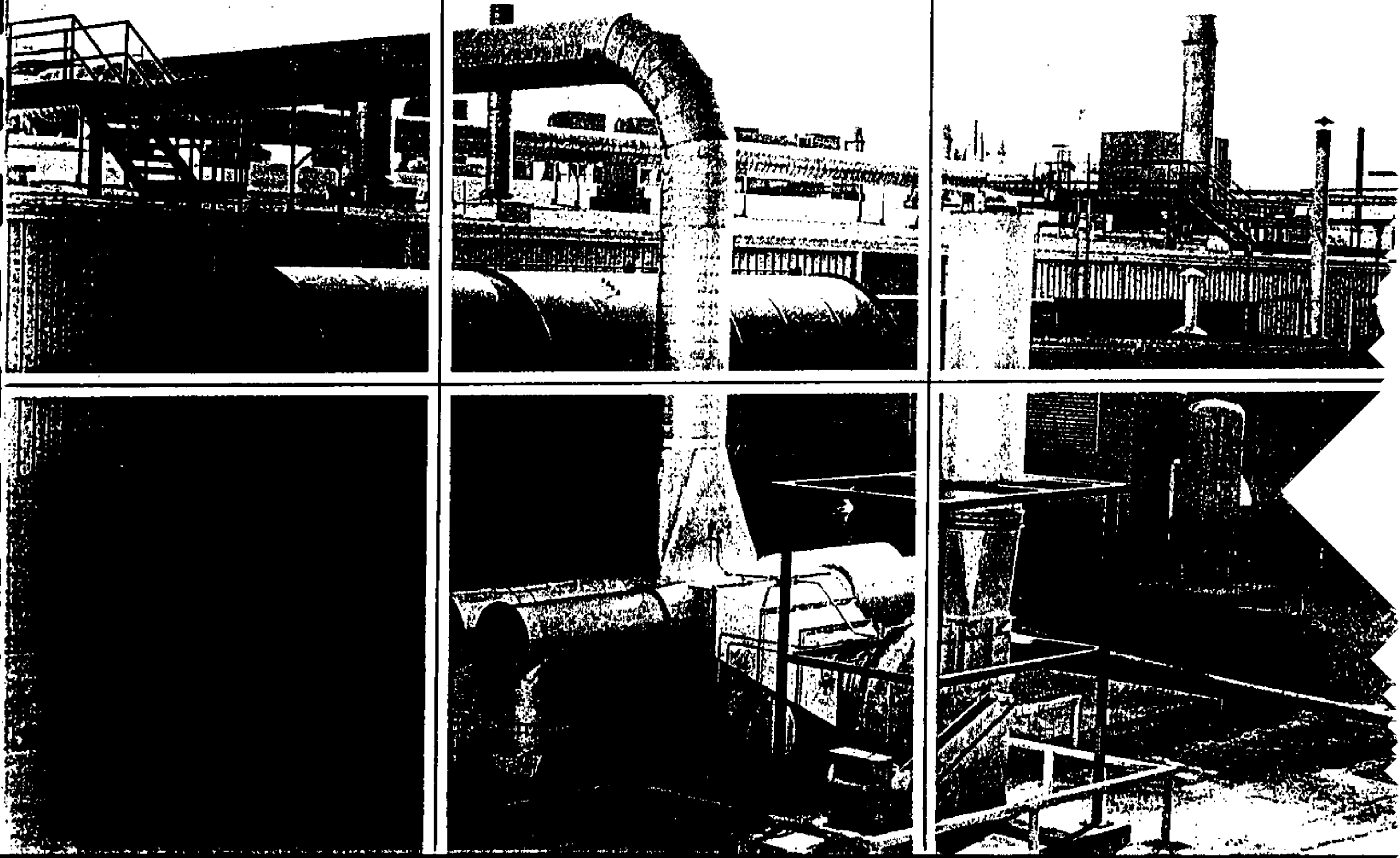
Replacing acetone with emulsifiers is a technology change. At least 75% of all acetone used for cleanup can be replaced easily by emulsifiers, but most FRP shops initially require the close involvement of their emulsifier supplier to accomplish this.

FRP shops should begin by replacing the solvents used for cleaning tools and hands first; this switch is the easiest and represents the biggest cost reduction and environmental benefits. The remaining areas, such as spray gun cleaning, require a more detailed and systematic approach.

The bottom line is: The choice of emulsifier suppliers is critical because the FRP fabricator often must rely on his supplier for his resin-cleaning systems for the 1990s, worker training, disposal methods and a sewer discharge permit.

HES HUNTINGTON ENERGY SYSTEMS, INC.

Huntington Energy Systems designs and installs the most thermally efficient fume oxidation systems available in industry today.



HUNTINGTON ENERGY SYSTEMS

Preserving the environment and meeting EPA standards in a cost efficient manner requires state-of-the-art engineering. HES engineers, manufacture and installs the most technologically advanced and thermally efficient fume oxidation systems available to industry today, through its patented designs. With a staff of experienced engineering and sales professionals, supported by advanced Computer Aided Design (CAD) equipment, HES has delivered systems to customers and industries ranging from local printers to major manufacturers. Over the years, HES has developed a reputation for high quality, reliability and low maintenance life cycle costs.

System Operation—The HES Regenerative Fume Oxidation system destroys noxious fumes containing organic solvents, hydrocarbons and odors by oxidation at temperatures in the realm of 1500 degrees Fahrenheit. The fumes are converted to harmless water vapor and carbon dioxide. The regenerative cycle stores combustion heat energy for reuse to preheat process emissions prior to oxidation, providing the most thermodynamically efficient system of fume oxidation. It is, therefore, the most cost effective means available for compliance with government requirements for pollution control.

System Simplicity—The concept of the HES design is simplicity. The patented single valve drive shaft minimizes operation and maintenance problems. All other systems utilize multiple electric operators or complicated hydraulics. This also substantially reduces the amount of field wiring required.

System Performance—The HES Regenerative Fume Oxidation System incorporates the latest fume oxidation technology. Its patented design destroys the pollutants in contaminated exhaust streams while recovering up to 95% of the input heat energy for preheating the process emissions. The requirement for auxiliary fuel is thereby minimized to the lowest possible level. The system will meet and/or exceed the current VOC destruction requirements mandated by local and federal Environmental Protection Agencies.

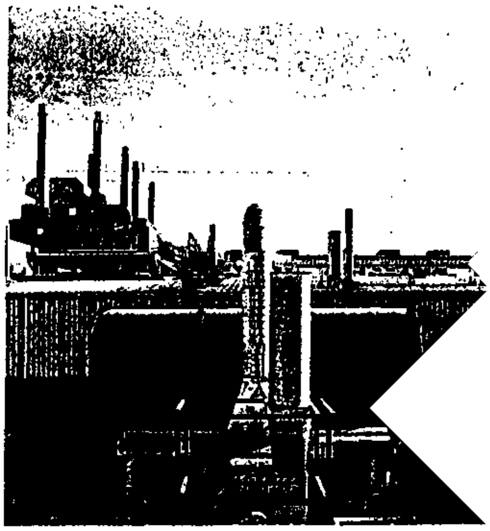
Total System Responsibility—HES takes full responsibility for the installation and start-up of its systems on a turnkey contract basis, including the design and modification of connected processes, e.g. air-volume reduction.

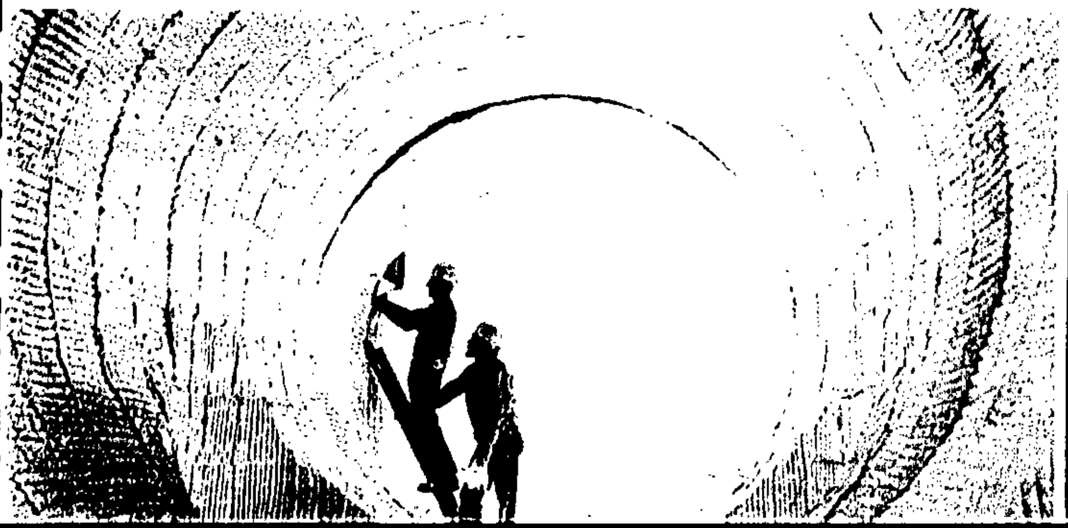
System Economy—"Life-Cycle Cost" ...the cost of owning and operating capital equipment is the total of its capital cost, its operating cost and the cost of maintaining the equipment over the period of its anticipated useful life. The life-cycle cost of HES's Regenerative Fume Oxidation system is substantially lower than that of alternate systems.

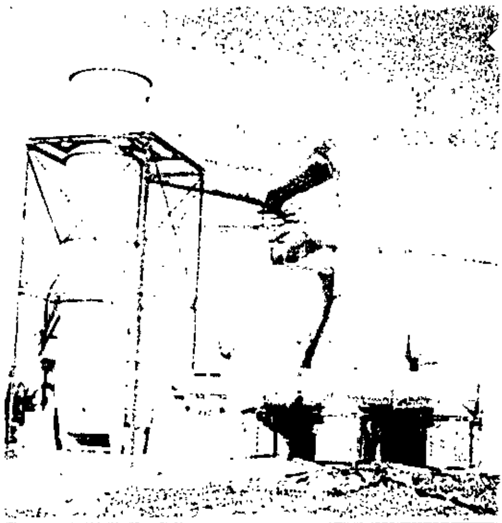
Who Is HES? HES is a wholly owned subsidiary of JWP, INC., a NYSE corporation with annual sales well in excess of a billion dollars. HES customers can expect systems to reflect dedication to quality performance.

Application: A major manufacturer of military tract vehicles such as tanks, troop carriers and construction vehicles. The final stage of manufacturing requires painting of the vehicle with solvent-based coatings. The HES System destroys air pollutants emitted from the paint spraying and drying processes. (Size: 20,000 SCFM)

Application: A residential wood cabinet manufacturer which coats the wood with stain, antiquing, sealants, and other finishes. Prior to discharge into the atmosphere, these predominantly solvent-based coatings are oxidized by the HES System, allowing the manufacturer to meet EPA standards in a cost efficient manner. (Size = 75,000 SCFM).







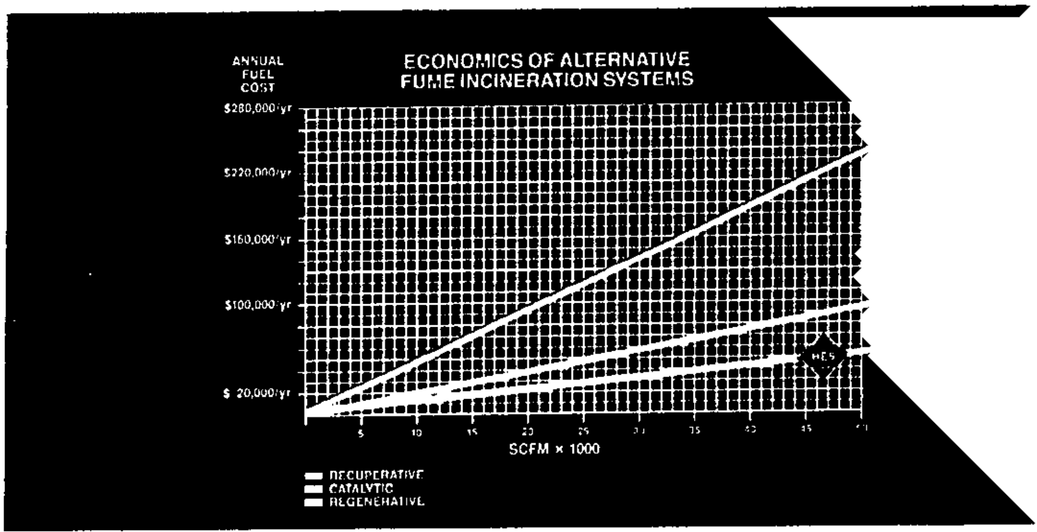
"MINIMIZING THE COST OF FUME EMISSIONS CONTROL"

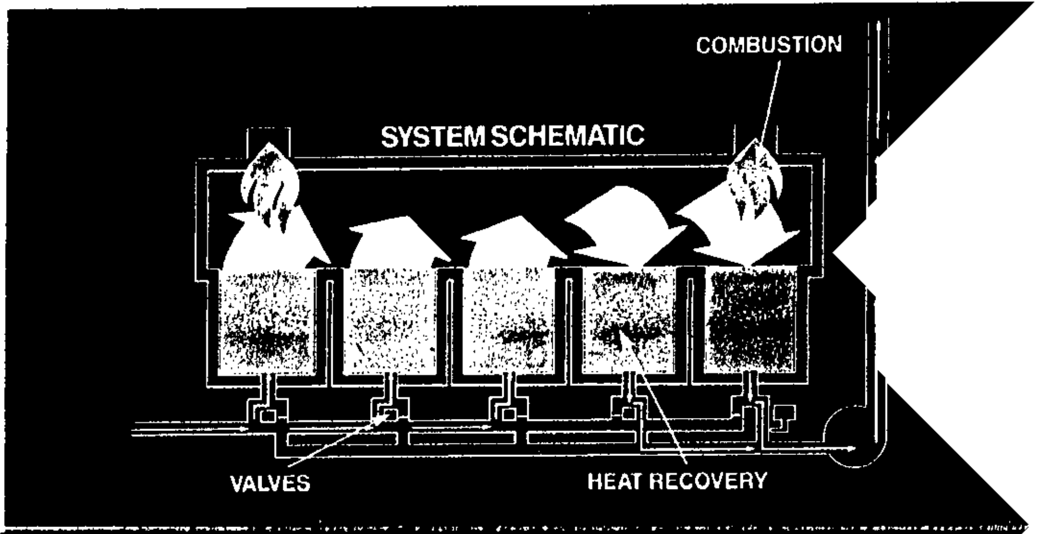
Application: a major vinyl floor covering manufacturer, which was required to meet the new clean air standards. Its problem was dealing with the VOCs released during the printing of resilient vinyl sheet flooring. By installing an HES regenerative fume oxidation system specifically designed for its needs, the firm has been able to heat the plant with recycled air resulting in a substantial fuel cost savings. This processor is also realizing additional savings on natural gas. (Size = 36,000 SCFM)

Not every system can have substantial savings designed into it because of the many variables involved, but we analyze every system for potential savings as well as for changes required to meet state and federal EPA requirements.

STANDARD FEATURES

- Single operator valve drive system
- Independent control and gas pipe trains for each burner
- Machined cast steel valves
- 1/4" ASTM A 36 steel housing
- Stainless steel ceramic support grids
- IRI/FM burner system
- 2400° soft ceramic insulation
- Programmable logic controller
- Expansion capabilities
- Prewired & Tested control panel





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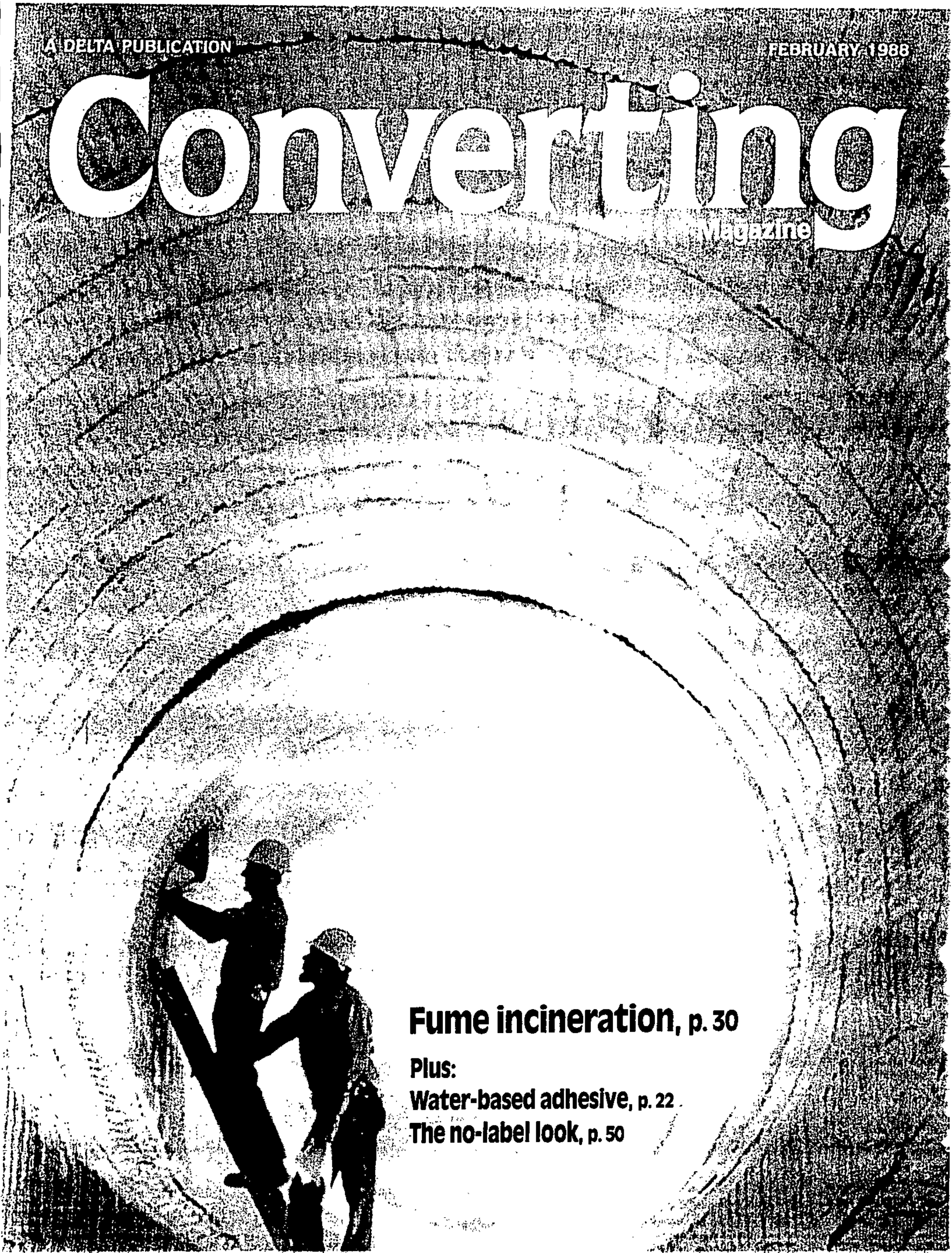


A DELTA PUBLICATION

FEBRUARY 1988

Converting Magazine

Fume incineration, p. 30

Plus:

Water-based adhesive, p. 22

The no-label look, p. 50

Shopping for FUME INCINERATION

The purchase of an incineration system will impact not only on the state of EPA compliance, but can affect total operations in the long run. Knowing what to look for will greatly increase the chances of a successful selection. . . . by **Richard J. Greco**, vice president of engineering, Huntington Energy Systems

In order to meet the stringent clean-air standards set by the Environmental Protection Agency, a substantial segment of American industry is choosing to install fume incineration systems as the method of compliance.

The choice of the proper system can mean much more than just meeting EPA requirements. It can mean a significant impact on profit. In fact, the proper system can actually pay for itself within a few years and lower manufacturing costs thereafter.

Fume incineration systems incorporate thermal oxidizers that destroy volatile organic compounds (VOCs) by high-temperature conversion of hydrocarbon-laden fumes to simple, harmless water vapor and carbon dioxide. While the various types of systems have acceptable clean-up efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks.

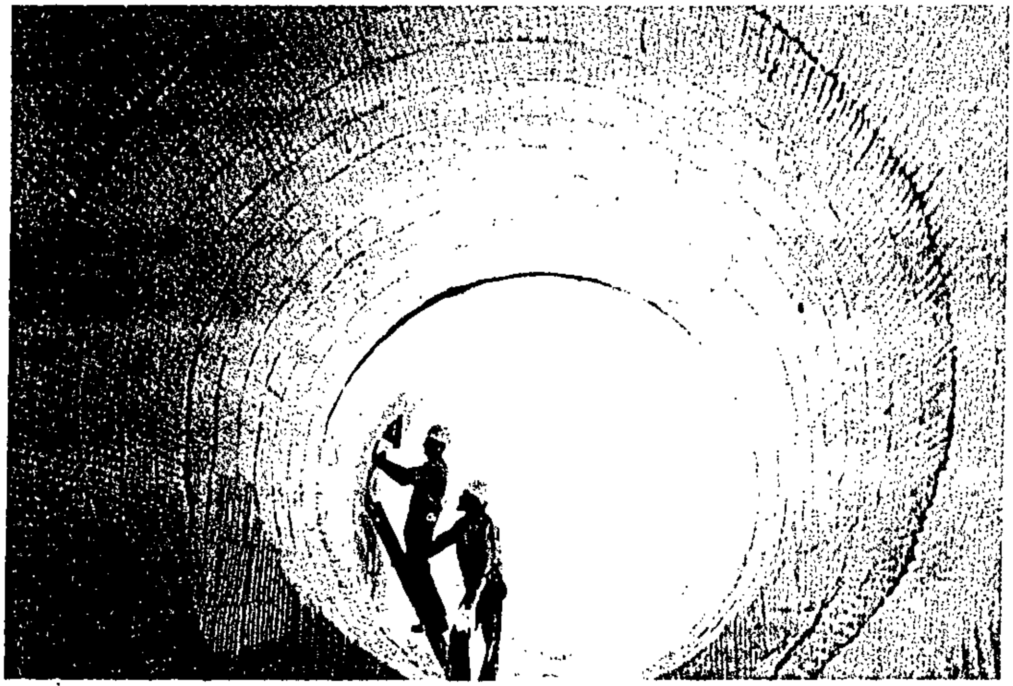
There are four types of fume incineration systems: common afterburner; catalytic converter; recuperative thermal oxidizer; and regenerative thermal oxidizer.

- *Common afterburner* (see Figure 1):

Function: Raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually ¼ sec at 1,400 deg F.

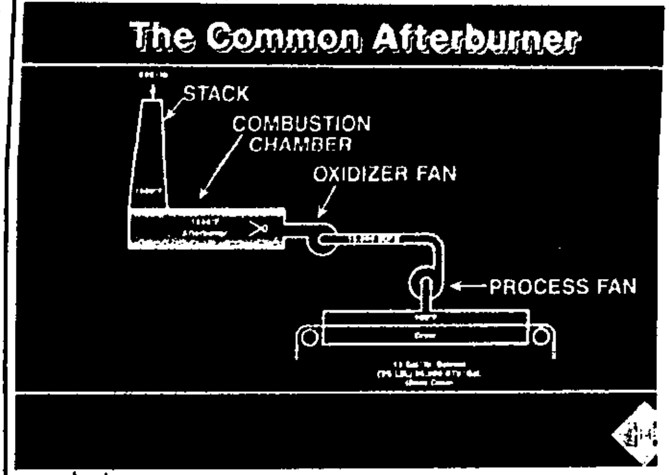
Benefits: The afterburner is relatively inexpensive to manufacture and install.

Drawbacks: It is not designed for efficient use of



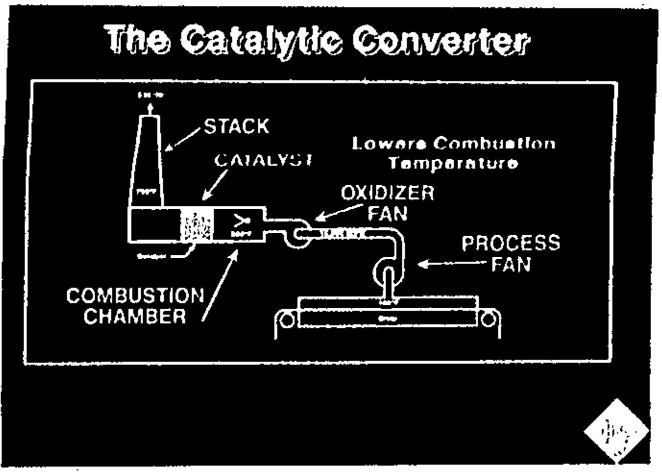
Workmen put the finishing touches on the interior of a Huntington Energy Systems regenerative fume incinerator. The system is typical of those Huntington installs at converting operations. The incinerator is lined with Manville Z-Blok® refractory ceramic fiber modules to withstand temperatures up to 2,300 deg F and 1,000 AFPM air flow velocity.

FIGURE 1



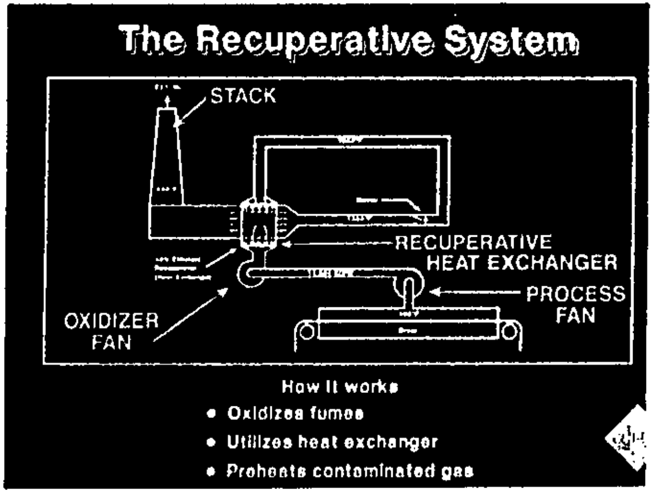
The Common Afterburner

FIGURE 2



The Catalytic Converter

FIGURE 3

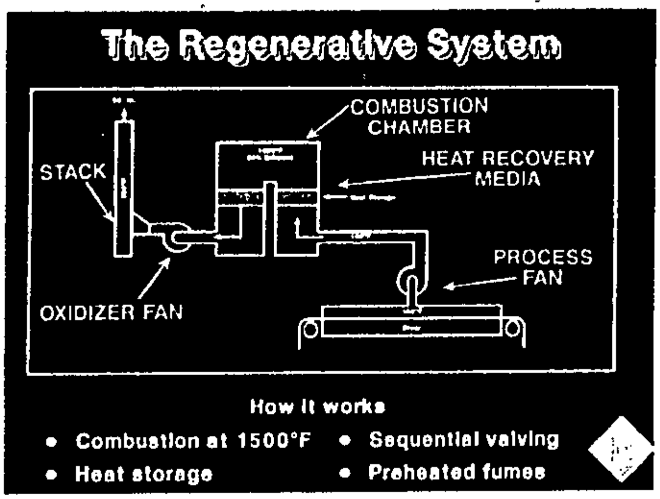


The Recuperative System

How it works

- Oxidizes fumes
- Utilizes heat exchanger
- Preheats contaminated gas

FIGURE 4



The Regenerative System

How it works

- Combustion at 1500°F
- Heat storage
- Sequential valving
- Preheated fumes

fuel and typically consumes 2,000 percent more fuel than other systems.

Industries/processes for which suitable: Small processes of 500 SCFM (Standard Cubic Feet Per Minute) or less.

Cost: Installed cost of equipment only is under $150,000 for a 500 SCFM unit. The cost to operate is approximately $10,000 for 2,000 hrs/yr, or about $20/SCFM year.

- ***Catalytic converter*** (see Figure 2):

Function: Hydrocarbon-laden fumes are pushed by a fan through a preheat section wherein the temperature of the fumes is raised to a maximum of 700 deg F. The fumes then pass through another section of the system containing the catalyst, which reduces the oxidation temperature to 700 deg F, at which the hydrocarbons are thermally oxidized.

Benefits: The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams).

Drawbacks: It performs poorly with fumes contaminated with ash, paper, dust, resin, heavy metals or silicone—commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also reduces flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation. Ultimately, the catalyst becomes useless and the system becomes clogged, forcing the catalytic converter to function in the same way as a common, fuel-intensive afterburner.

Industries/processes for which suitable: clean ink processes; no silicone.

Cost: Costs to install depend on type of catalyst used. For a 10,000 SCFM unit, approximate cost to

Richard J. Greco is vice president of engineering for Huntington Energy Systems, Inc., a [illegible] subsidiary. He has been a mechanical engineer in the field of pollution control and combustion since 1965 and has designed and managed the installation of approximately 30 fume incinerator systems throughout the United States.

operate is $13,000 for 2,000 hrs/yr, or $1.30/SCFM year.

- ***Recuperative thermal oxidizer*** (see Figure 3):

Function: This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1,500 deg F gas by passing it through the low-temperature inlet gas stream via an indirect shell and tube heat exchange—thus preheating the incoming contaminated gas to within 65 percent (maximum of 80 percent) of oxidation temperature.

Benefits: The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to overcome the fuel required for combustion. The 20 to 35 percent of the heat lost during incineration can be reused for indirect building heat or steam, or it can be returned to the process.

Drawbacks: Auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as size, heat transfer coefficients and stress limit the system's preheat efficiency. Reusing the 20 to 35 percent lost heat requires an additional investment for heat transfer equipment and its maintenance.

Industries/processes for which suitable: High solvent concentrations above 25 percent LEL (lower explosive limit), coil coating and gravure printing.

Cost: No fuel usage when LEL is above 25 percent.

- ***Regenerative thermal oxidizer*** (see Figure 4):

Function: Oxidized gases exit the combustion chamber, passing through a porous heat-transfer section, storing by conduction 95 percent of its heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where, by conduction, fumes are preheated to within five percent of oxidation temperature by the already-stored heat on its way up to the combustion chamber. There is a continuous cycle of storing and releasing heat alternately within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

Benefits: The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5 percent of normally-required fuel is needed for oxidation. In many cases, just a burner pilot is sufficient when coupled with the 95 percent preheat efficiency.

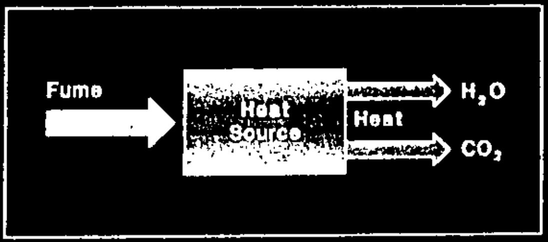
Drawbacks: Most available systems are maintenance-intensive because they use hydraulic or electric drive valving components. However, there are systems available that alleviate most of the maintenance because they utilize a single speed-reducer mechanical valving system.

Industries/processes for which suitable: Recommended for larger process flows with lower solvent concentrations because the high primary heat recovery will reduce operating fuel costs. Five percent LEL or greater will result in almost no fuel usage.

Cost: Cost of equipment and system is approximately $45/SCFM.

(Note: The difference between a 95-percent-efficient regenerative unit and a 65-percent-efficient recuperative unit in terms of fuel use may *not* be 30 percent, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel use difference could be as high as 40 percent.)

How Does Fume Incineration Work?



System converts hydrocarbon laden fumes to simple, harmless water vapor and carbon dioxide by high temperature incineration

The following checklist covers the many factors to take into account when considering installation of a fume incineration system.

1. **Operating characteristics of process:**
   - Type of process
   - Emission exhaust volume (SCFM). Are there multiple sources, and what are the maximum and minimum exhaust volumes? At what flow rate is the system operating the majority of the time?
   - Hood exhaust volume (SCFM)
   - Oven exhaust temperature (deg F)
   - Oven temperature (deg F)
   - Process temperature of the stream going to the oxidizer (deg F)
   - Fuel used in process (oil, natural gas)

---

*Twenty-five percent LEL equals 10,000 SCFM/1 GPM (gal/min) air solven ratio.

- Cost of fuel ($/Million BTUs)
- Type of solvent used in process
- Gallons/hour of solvent used on product
- Solvent load at various flow conditions (lb/hr)
- Percent of each constituent in solvent
- Hours/day of process operation
- Days/week of process operation
- Hours/year of process operation
- Percent downtime (flow going to oxidizer without solvent)
- Number of startups/year. (Is unit down every weekend?)
- Contaminants in the stream that could cause problems, e.g., silicone, heavy metals, chlorides, particulates. If no contaminants now, might there be some in the future?

2. Regulatory requirements:

- What level of hydrocarbon destruction must be obtained? (Typically, an overall destruction level is established, which is a combination of collection efficiency at the process and destruction by the oxidizer.)
- What is the schedule? When must the oxidizer be installed and operational?
- What method of test will be required by the regulatory agency? (Various methods are accepted by different states and regions, e.g., flame ionization, gas chromatograph, etc.)
- Must the oxidizer include instrumentation to continuously monitor inlet/outlet temperature, inlet/outlet hydrocarbon concentrations or other constituents in the exhaust, such as CO and NOX?

3. Insurance factors:

- Are there specific insurance approval requirements, such as Factory Mutual (FM) or Industrial Risk Insurers (IRI)?
- Upon system startup, will the process be purged through the oxidizer or indirectly to the atmosphere? (Insurance requirements will dictate that both the process and the oxidizer must be purged with clean air before any burners can be lit, to ensure there are no dangerous concentrations of hydrocarbons built up that may cause an explosion.)

4. Return on Investment:

If you want the system to give you a return on your investment, such as using recycled air to heat or cool the building, you must know the following:

- Type of building heating system
- Square footage of building being heated
- Type of installed air conditioning
- Tons of air conditioning
- Capacities of individual air conditioners (tons).

5. Operating costs:

- What are the comparative utility costs, e.g., natural gas and electricity?

6. Ease of maintenance of system:

- Need for adequate maintenance staff to handle technical aspects of the different systems.

7. Expandability of system:

- Does the equipment lend itself to future expansion, should production schedules dictate?

8. Location of system:

- Will the oxidizer be located outdoors, indoors, at grade, on roof?
- What is the availability of utilities, e.g., natural gas, oil, propane?
- What is the electrical service available, and is there sufficient capacity?
- Is noise pollution a consideration? (Is there housing nearby?)
- Are soil conditions adequate for the foundation?
- Is there sufficient access for construction equipment?
- Is the site selected clear of any underground obstructions, such as drain sewers, tanks, etc?
- Where is the control panel to be located?

9. Bid evaluation:

- Is this to be a turnkey project? Many companies prefer a single-source, including installation.
- Are you comparing equivalent bids? Has each of the vendors included all of the necessary equipment and services? Has a bidder left something out in order to better his price position? (Compare your bids to each other, and to all the guidelines enumerated here, to avoid accepting an incomplete bid.)
- Has each vendor supplied the proper performance guarantees and equipment warranties?
- Are the terms of payment acceptable?
- Has freight been included in the price?
- Does the vendor have proven operating field installations?
- Can the vendor meet the necessary schedules?
- Carefully evaluate the following for quality of workmanship: construction materials and thicknesses; equipment suppliers for controls, fans, etc; methods of assembly.
- What happens to the oxidizer in the event of excessive solvent loads? Will it over-temperature and cause problems?
- Have the proper safeguards been incorporated in the control scheme, e.g., high-temperature shutdown, audible alarms in the event of shutdown?

Summary

The above information should serve to guide you in evaluating which fume incineration system would be best for your business. It should also help you to initiate meaningful discussions with equipment suppliers and/or independent environmental consultants, and to analyze vendor bids.

In the end, EPA regulations will do more than create a cleaner environment for all of us; they will force us to take a hard look at our manufacturing processes, very possibly resulting in lower production costs in the long run. #

Reprinted from CONVERTING MAGAZINE February 1988

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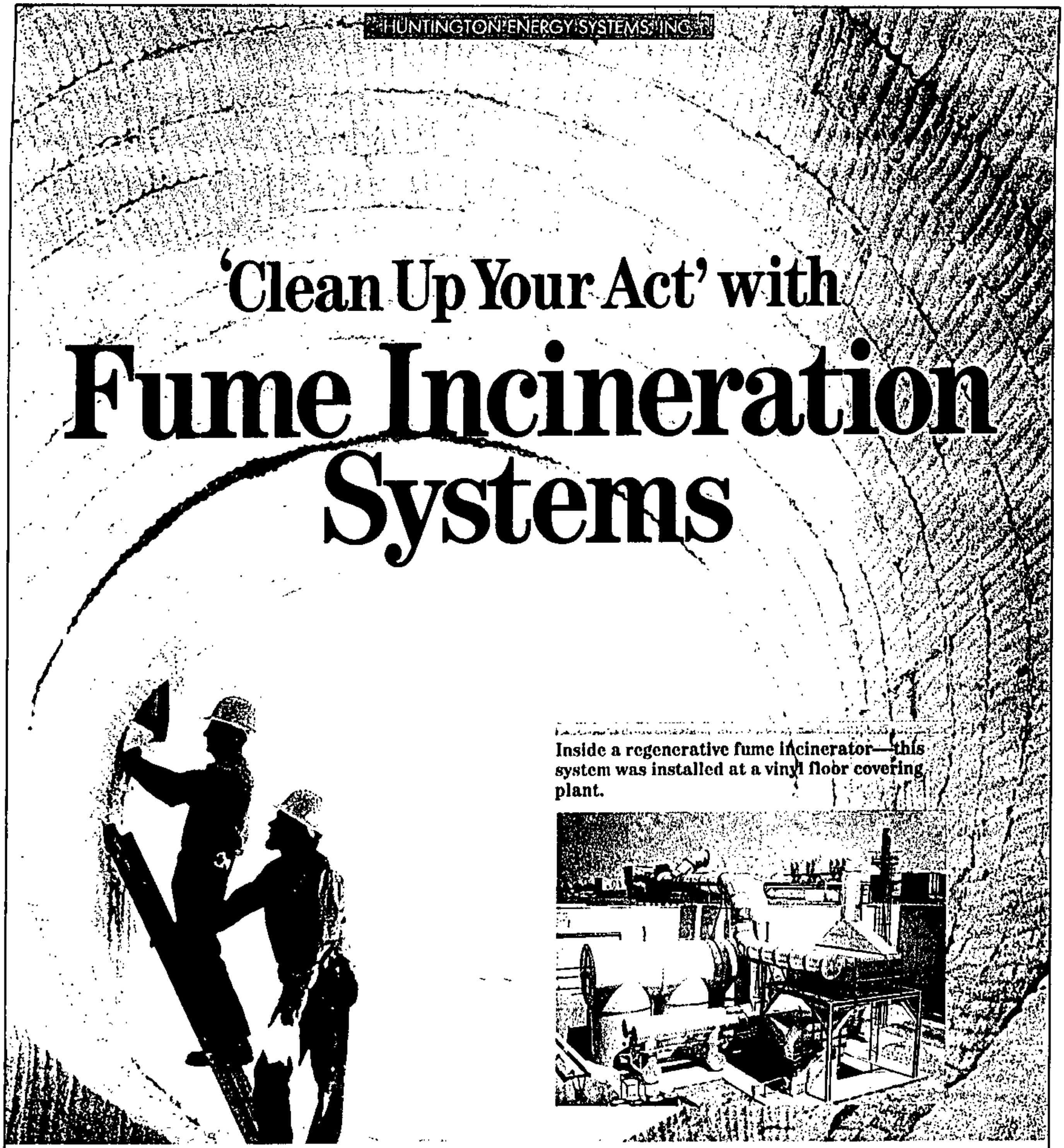
'Clean Up Your Act' with Fume Incineration Systems



Inside a regenerative fume incinerator—this system was installed at a vinyl floor covering plant.

To avoid an expected EPA crackdown on VOC emissions, fume incineration may be your best bet. Here's a look at available equipment.

Many plastics processors, along with a substantial segment of the rest of American industry, will soon be forced to install fume incineration systems in order to meet existing EPA clean-air standards, and provisions of possible amendments to the Clean Air Act, or even entirely new environmental bills which Congress may pass. The Federal Environmental Protection Agency has already designated localities that are currently not meeting minimum requirements for the control of volatile organic compound (VOC) emissions, and agency spokesmen have said recently that they will be cracking down on manufacturers located in "nonattainment" areas. There have even been new rules instituted recently that are aimed specifically at application of coatings to plastic business-machine housings (see *PT, March '88, p. 113*).

Plastics processors within these areas that use solvent-based paints,

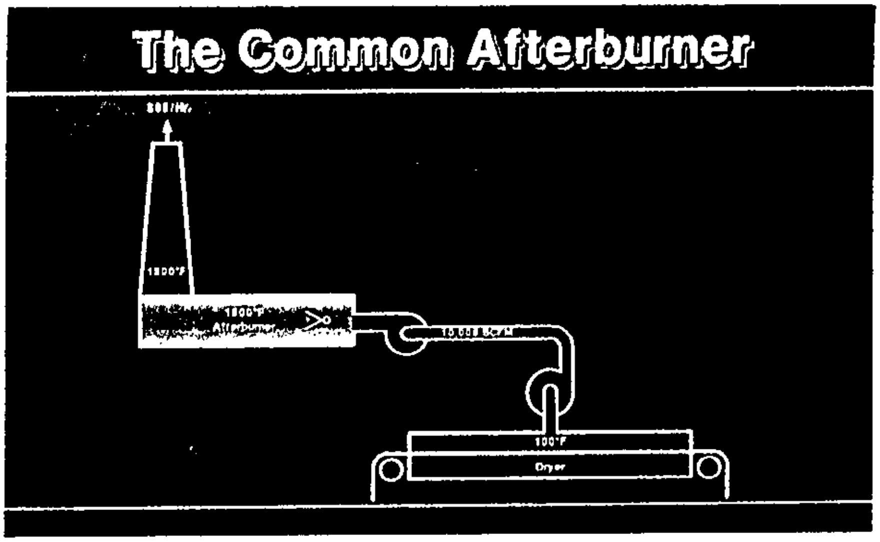
Reprinted from PLASTICS TECHNOLOGY July 1988

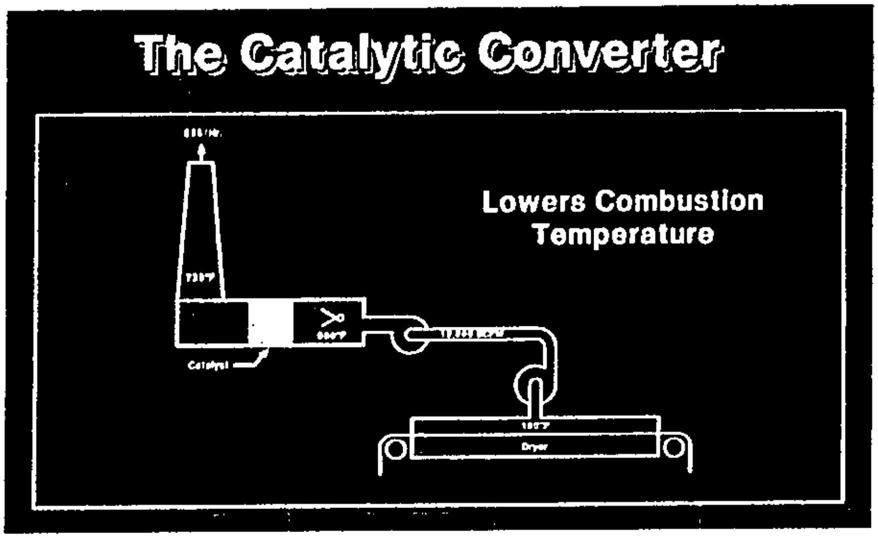
inks, or other coatings will be required by law to measure VOC emissions at their own facilities. The burden of proof will be on them to show compliance, and their testing procedures will also be regulated by the EPA. Specific rules and regulations for compliance will vary between different EPA jurisdictions, but penalties for noncompliance can include fines, annual production limitations, or even plant shutdowns.

The present Clean Air Act had scheduled the deadline for compliance for December 31, 1987, but that deadline was extended by Congress to mid-1988. The lawmakers may choose to extend it again or, more likely, take an even tougher stance on pollution emissions, while giving businesses a longer time to comply. There were still 76 nonattainment areas at the end of 1987, and it's not likely these areas will be within compliance soon.

Fume cleanup is needed to eliminate air contamination by hydrocarbons, such as MEK (methyl ethylketone), MIBK (methyl isobutylketone), toluene and alcohols. These are typically produced in the plastics coating and printing operations.

In addition, many processes that generate VOC and objectionable odors, such as plasticizers from flexible PVC calendering and plastisol processing, and styrene monomer from FRP fabricating, are coming under scrutiny. Whether or not the odor-producing volatile emissions must be cleaned up depends upon specific EPA regulations, as well as on the plant location. And, in addition to Federal EPA restrictions, local environmental regulations on VOC's—such as in Southern California—can also have major impact on plastics operations.


The Common Afterburner


The Catalytic Converter

FOUR TYPES OF SYSTEMS

Unlike the problem of dealing with particulate-laden emissions—a relatively simple process utilizing familiar equipment, with minimal operating cost—meeting EPA standards for fume cleanup involves more sophisticated options. Most of these require major investment and operating costs. Therefore, the choice of the proper fume incineration system can have a significant impact on profit. The proper system can actually pay for itself within a few years, and lower manufacturing costs thereafter, in contrast with less efficient systems available.

There are basically four types of fume incineration systems, all of which incorporate thermal oxidizers that destroy VOC's by high-temperature conversion of hydrocarbon-laden fumes to harmless water vapor and carbon dioxide.

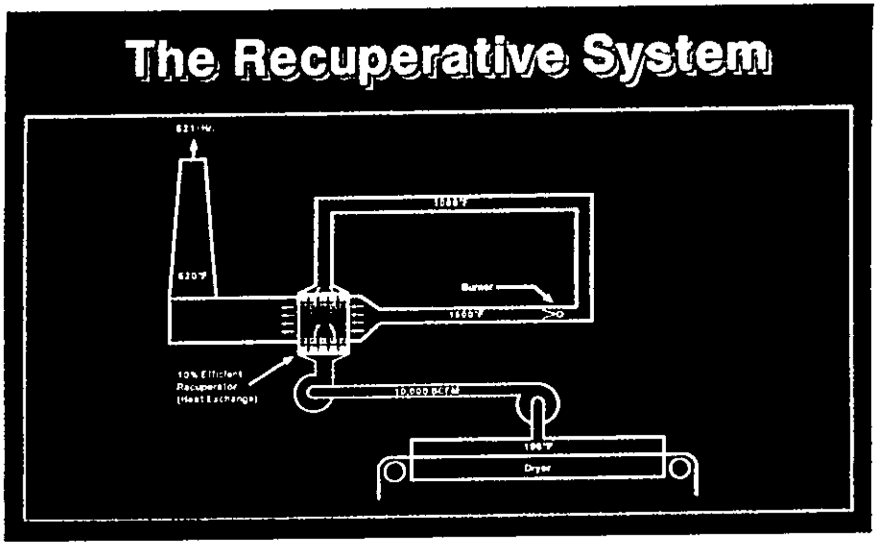
While all the various types of systems have acceptable cleanup efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks. The purpose of this article is to illustrate the differences between incineration systems, and to provide examples of current installations.

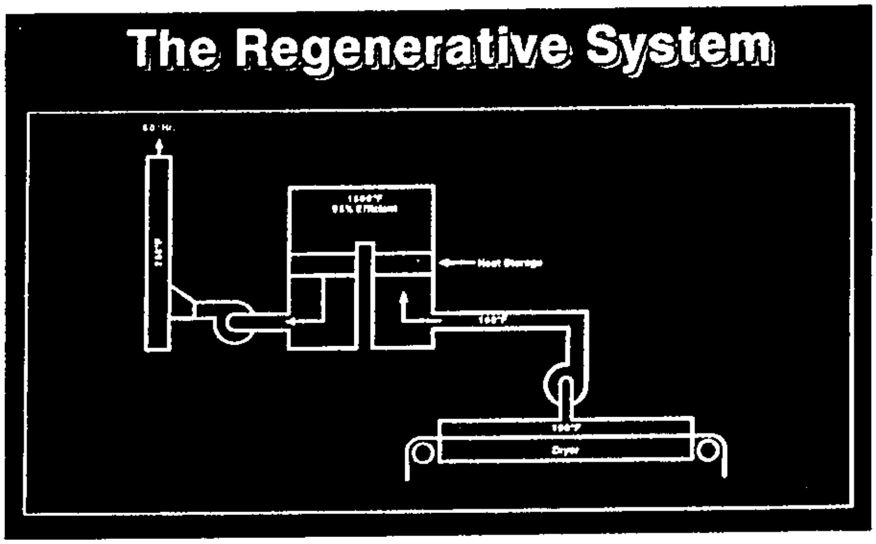
All costs discussed here are based on a 10,000-scfm (standard cubic foot per meter) system, operating at 2000 hr/yr, maintaining exhaust fume temperatures of 100 F, with fuel costs of $6/million Btu. For a physical description of each system, consult the accompanying diagrams.

▶ **Common afterburner:** This system raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually 0.5 sec at 1400 F.

The afterburner is relatively inexpensive to buy and install. However, it is not designed for efficient use of fuel and, typically, consumes 2000% more fuel than other systems.

It is typically suitable for low-throughput applications, which require processing contaminated air at rates of





500 scfm or less. Capital investment can be around $70,000, with annual operating costs around $170,000. Installation costs can be $30,000-50,000.

▶ **Catalytic converter:** Hydrocarbon-laden fumes are pushed by a fan through a preheat section, wherein the temperature of the fumes is raised to a maximum of 700 F. The fumes then pass through another section of the system containing the catalyst, which is able to thermally oxidize the hydrocarbons at the reduced temperature of 700 F.

The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams). It performs poorly with fumes contaminated with particulates, resin, heavy metals or silicone — commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated or poisoned with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also may reduce flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation.

Catalytic converters are best suited for clean ink processes that involve no silicone. Typical equipment costs for a catalytic converter would run around $230,000, with annual operating costs around $24,000. Equipment installation costs of approximately $100,000 can be expected.

▶ **Recuperative thermal oxidizer:** This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1500 F gas by passing it through the low-temperature inlet gas stream via an indirect shell-and-tube heat exchanger, thus preheating the incoming contaminated gas to within 65-80% of oxidation temperature.

The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to replace the fuel required for combustion. The 20-35% of the heat lost during incineration can be reused for indirect building heat or generating steam, or be returned to the process. However, auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as equipment size, heat-transfer coefficients and stress, limit the system's preheat efficiency. Reusing the 20-35% lost heat requires an additional investment for heat-transfer equipment and its maintenance.

The recuperative thermal oxidizer is suitable for processes that need to incinerate fumes with a high solvent content—typically fumes with an air-to-solids ratio above 25% LEL (10,000 scfm/gpm [gal/min]). Capital equipment costs for these systems run around $200,000, with annual operating costs of around $50,000. Installment costs are estimated at $100,000.

▶ **Regenerative thermal oxidizer:** In this system, oxidized gases from the combustion chamber pass through a porous heat-transfer section, storing by conduction 95% of the heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where the fumes are preheated by conduction of the stored heat to within 5% of oxidation temperature on their way to the combustion chamber. There is a continuous cycle of alternately storing and releasing heat within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5% of normally required fuel is needed for oxi-

FUME INCINERATION SYSTEM COSTS*

Type of System	% Heat Recovery	Capital Cost, $/scfm	Operating Cost, $/scfm/year
Afterburner	0	7.00	17.55
Catalytic Converter	70	23.00	2.43
Recuperative Thermal Oxidizer	70	20.00	5.27
Regenerative Thermal Oxidizer	95	28.00	0.96

*Costs based on 10,000 scfm; operating 2000 hr/yr; process exhaust fume temperature of 100 F; fuel cost of $6/million Btu. Installation costs for afterburner approx. $30,000-60,000 additional; for the other three, approx. $100,000 additional.

dation. In many cases, just a pilot burner is sufficient, when coupled with the 95% preheat efficiency. Up to now, most available systems have been maintenance-intensive, because they use hydraulic or electric valving. However, the newest systems eliminate most of the maintenance because they utilize a single-speed-reducer mechanical valving system.

Regenerative thermal oxidizers are recommended for larger process flows with lower solvent concentrations, because the high primary heat recovery will reduce operating fuel costs. A 5% LEL or greater will result in almost no fuel usage. Investment costs are typically around $280,000, with annual operating costs around $9,300.

RECUPERATIVE VS. REGENERATIVE

The difference between a 95%-efficient regenerative unit and a 65%-efficient recuperative unit, in terms of fuel use, may not be 30%; it may be higher, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel-use difference could be as high as 40%.

As for operating costs, the actual fuel-cost saving for a 10,000-scfm unit could be over $50,000/yr for the regenerative system, with no solvent present, compared with a typical recuperative system.

To further enhance the economics of regenerative thermal oxidation, the spent fumes, now slightly elevated in temperature, can be reintroduced into the process from which they came or, by use of a heat exchanger, used as building heat. What was once an undesirable pollutant becomes a desirable energy source, replacing up to 60% of the fuel used to heat the process.

A typical regenerative system receiving fumes at 200 F would return the clean air back to the process at 265 F, at 95% preheat efficiency.

CASE HISTORIES IN PLASTICS

As was stated at the beginning of this article, the choice of proper fume incineration system can mean not only that EPA requirements are met, but also that the system could pay for itself and, eventually, lower your cost of manufacturing. A recent example is a major vinyl floor-covering manufacturer, which now meets the new clean-air standards with a regenerative fume incineration system. This firm managed to turn a potentially unprofitable situation into a profitable one.

Its problem was dealing with the VOC's released during the printing of resilient vinyl sheet flooring. By installing a regenerative fume incineration system specifically designed for its needs, the firm has been able to heat the plant with recycled air, resulting in a savings of $58,000/yr in fuel costs.

This processor is realizing additional savings of $200,000/yr in natural gas by using this system, instead of a less-efficient system with a conventional air-to-air exchanger. Thus, payback in cost of fuel alone will come in about four years.

Not every incineration system can have such substantial payback designed into it, because of the many variables involved. But every process must be analyzed not only for potential savings, but also for any changes that may be required in order to meet state and federal codes.

Regenerative incineration systems can save up to 40% in fuel consumption compared with other incineration alternatives, and operating costs can be $50,000/yr lower.

That's because it is no longer sufficient merely to destroy 95% of a facility's emissions. You are also now required to capture a specified quantity of hydrocarbons being generated within your facility, to yield an overall rate of capture/destroy efficiency. This rate depends on a number of variables, such as the nature of the process, type of VOC's emitted, annual production, and geographic location.

In the state of Connecticut, for example, plants doing flexographic printing on vinyl film must achieve a fume capture/destroy efficiency of 60-75%. This percentage may be different for other manufacturers within the state, or for the same sort of operation in other states. To determine what the regulations are for their specific process, manufacturers must check with their regional office of the state air-quality board.

A recent case in point is a firm doing printing on vinyl film. In order to meet local codes, it required a process modification whereby a "loop" was designed between the print stations and the dryer, which previously had been exhausted individually, as well as more efficient collection exhaust hooding. This hooding and recirculating loop lowered the total exhaust volume, while also making incineration more efficient by increasing solvent concentrations.

This new focus on higher fume collection and destruction efficiencies will obviously require higher capital equipment expenditures. Thus, the more efficient and simple the emission-control device, the lower the annual operating expense to offset ever-increasing capital expense. □□

R.J. Renko is technical sales manager of Huntington Energy Systems, Mountainside, N.J., which supplies incineration systems.

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JWP INC.
A JWP COMPANY

INTER/PORT

News and Views for the Recreational Boating Industry

Edited and produced in Chicago, Wednesday, December 12, 1990

HAPPY HOLIDAYS!

NMMA directors and staff wish you a Merry Christmas and a Happy New Year. *INTER/PORT* will not be published during Christmas week, so look for the next issue on or about January 2.

EPA GIVES STYRENE CLEAN BILL OF HEALTH

In a major development for fiberglass boatbuilders and other industries relying on molding processes, the Environmental Protection Agency has decided not to classify styrene as a carcinogen. The decision from EPA's Office of Drinking Water (ODW) comes after review of all existing evidence and the recommendations of its own Science Advisory Board. Comprised of many of the country's top scientists having expertise in this area, the EPA Science Advisory Board went on record as saying that there was no scientific justification for classifying styrene as a "probable human carcinogen."

The decision is particularly significant to boat manufacturers in light of measures included in the recently passed Clean Air Bill that provide for separate consideration of boat building in the development of styrene emission standards. Under the legislation, determination of emission standards must weigh specific capabilities of manufacturers to meet the standards, including economic costs and technical feasibility of proposed pollution control technology -- determinations which rest with the EPA. The ODW did say that it will set a maximum contaminant level for styrene in drinking water, as required by law for other chemicals, but these levels are not anticipated to pose any serious compliance problems for industry.

EPA's new stance on styrene is due in large part to the efforts of the Styrene Information and Research Center (SIRC), an organization which receives substantial funding from NMMA, and has worked closely with association staff and member firms over the past two years to fend off stringent styrene legislation at both state and federal levels. SIRC chairman Ken Harman was encouraged by EPA's decision. "It is consistent with earlier decisions by OSHA and the National Institute of Occupational Safety and Health (NIOSH) and also with the views of the leading scientific panel of the European Community," he said. "All have now agreed that the facts simply are not there to classify, regulate or label styrene as a carcinogen."

The "facts" that Harman refers to are part of a large body of evidence collected and compiled by SIRC over several years and recently presented at the group's annual meeting by Geoffrey Granville of Shell Canada, chairman of SIRC's

continued

FIGURE 8

Influence of Gel Time
on
Styrene Emissions

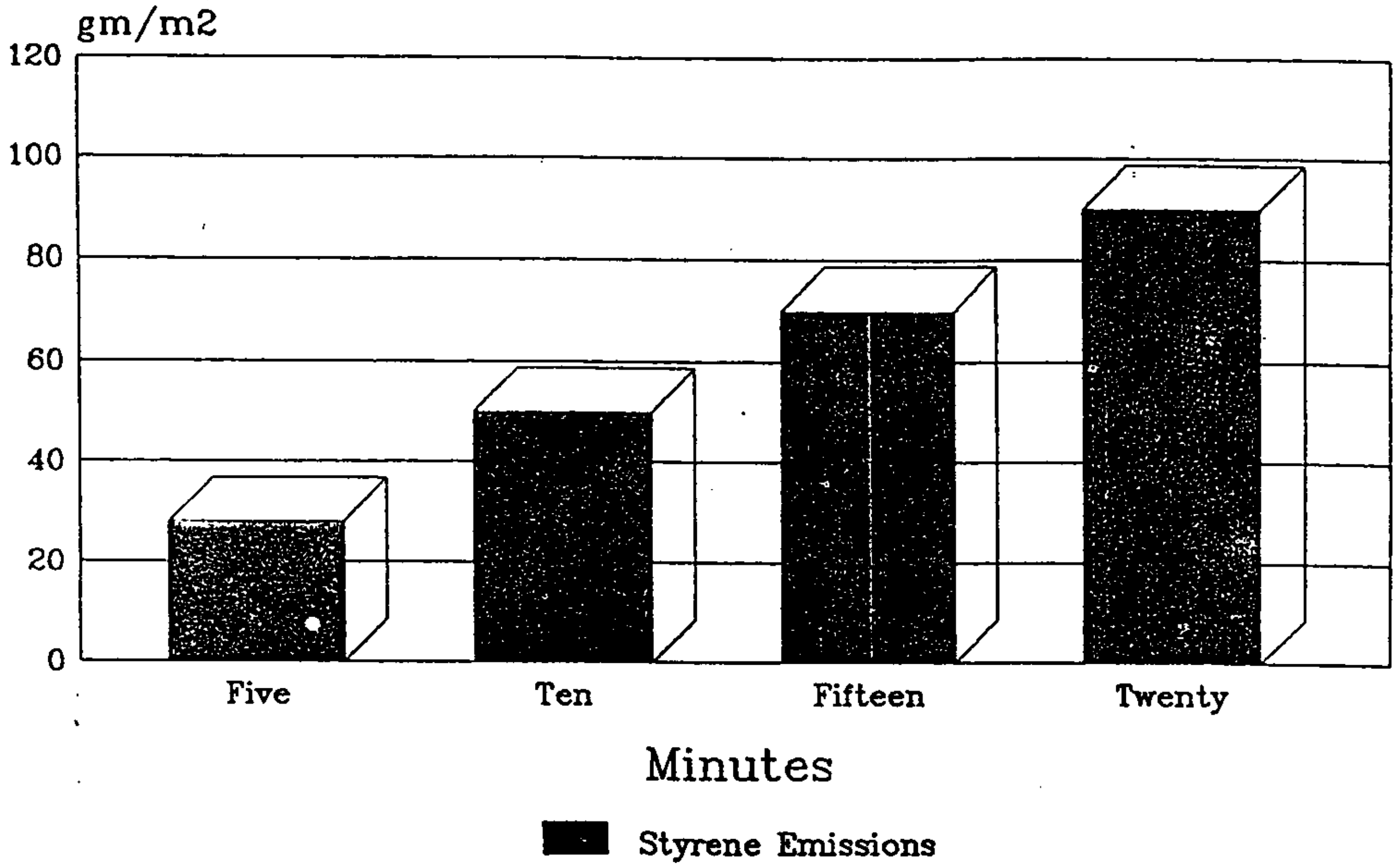


FIGURE 9

Influence of Temperature on Styrene Emissions

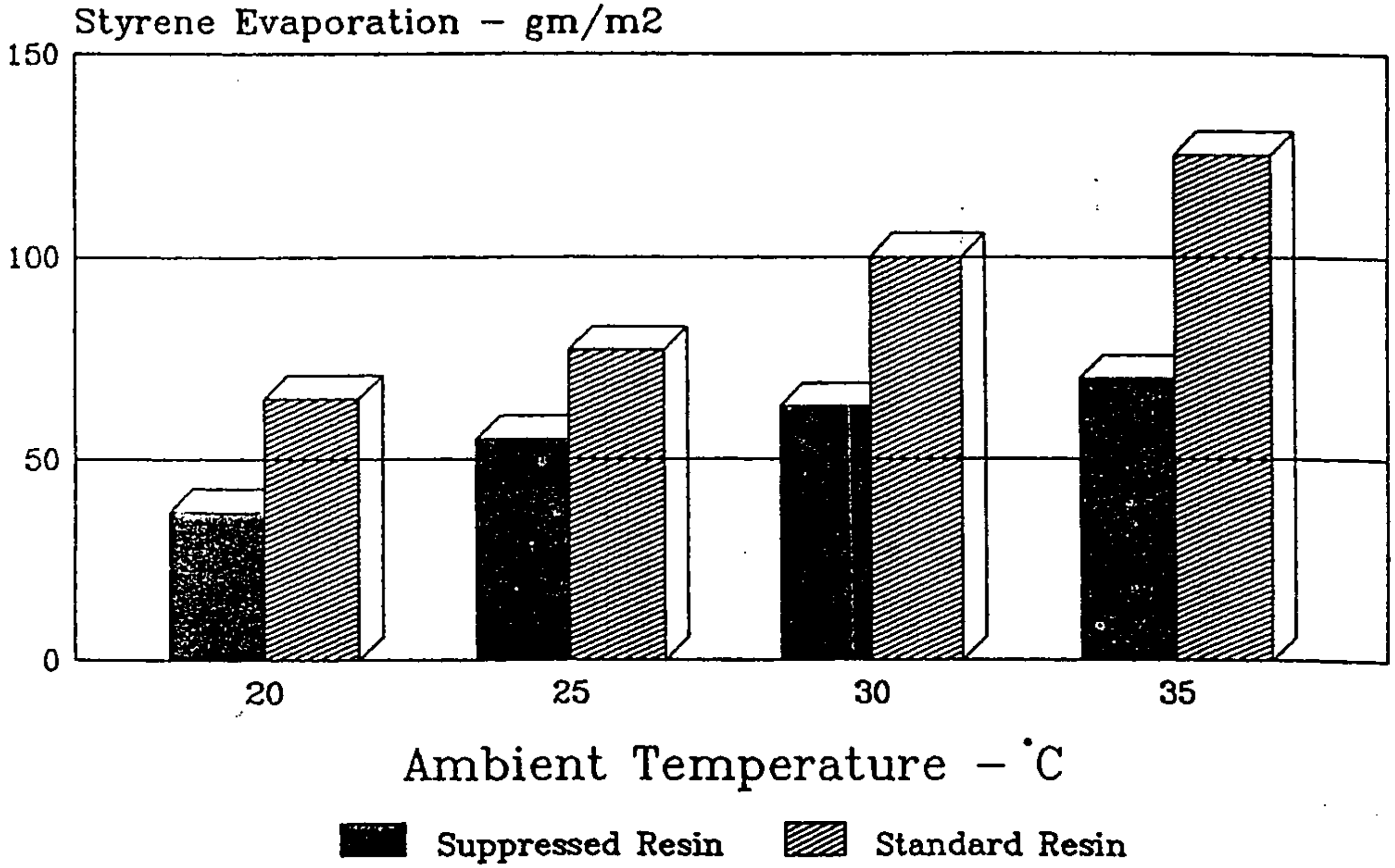


FIGURE 10

Influence of Air Flow Rate
on
Styrene Emissions

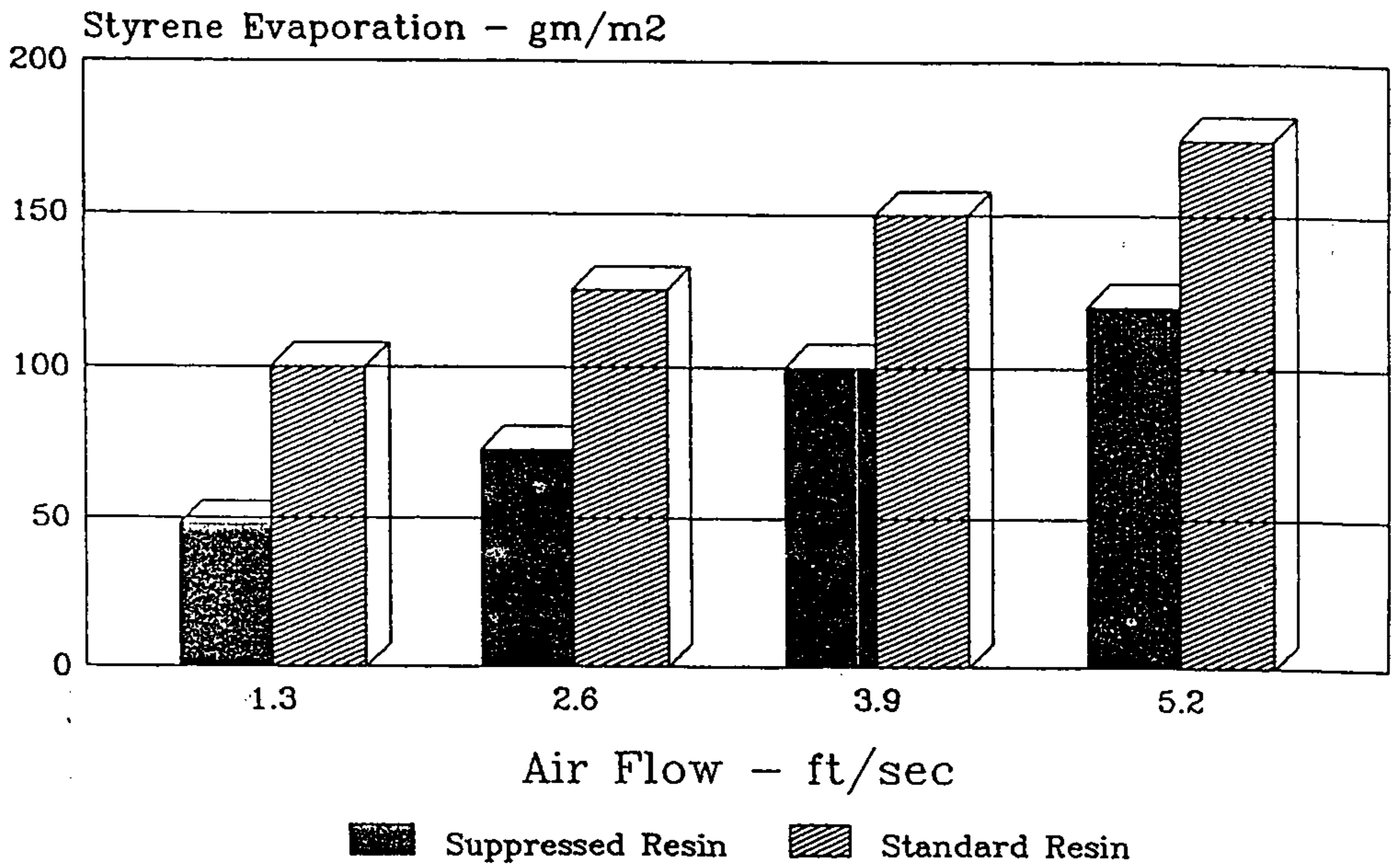


FIGURE 11

Influence of Styrene Content on Styrene Emissions

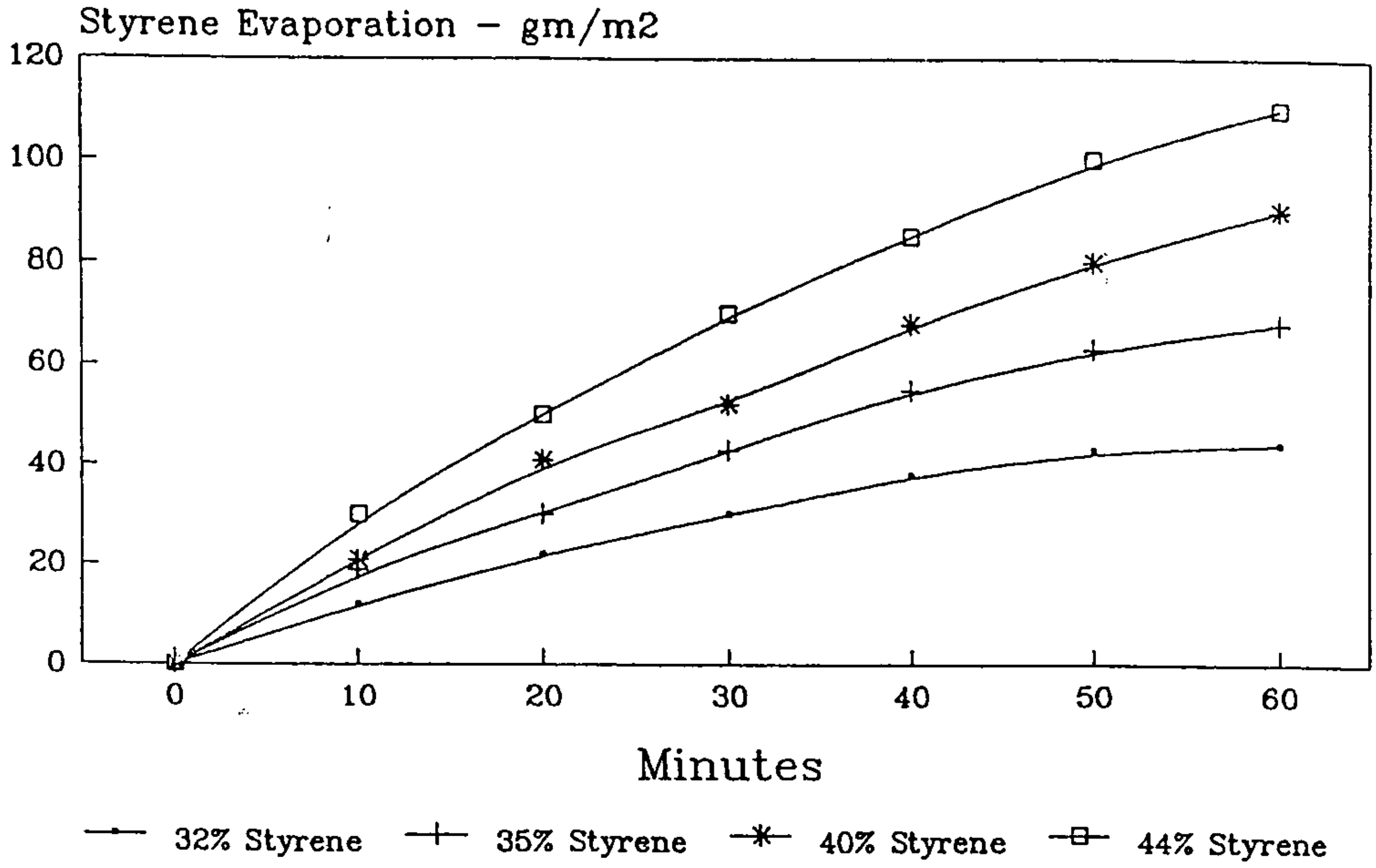


FIGURE 12

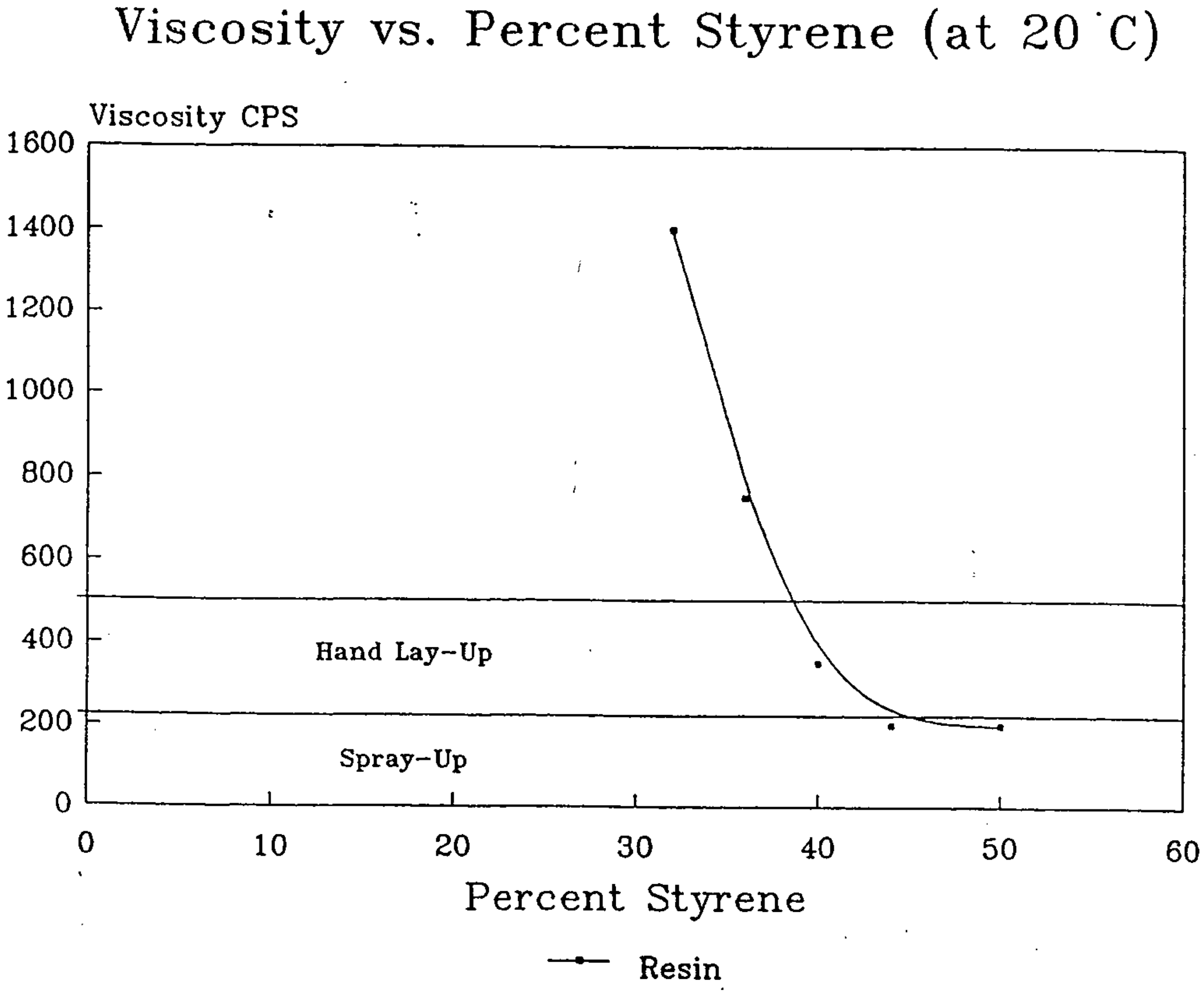
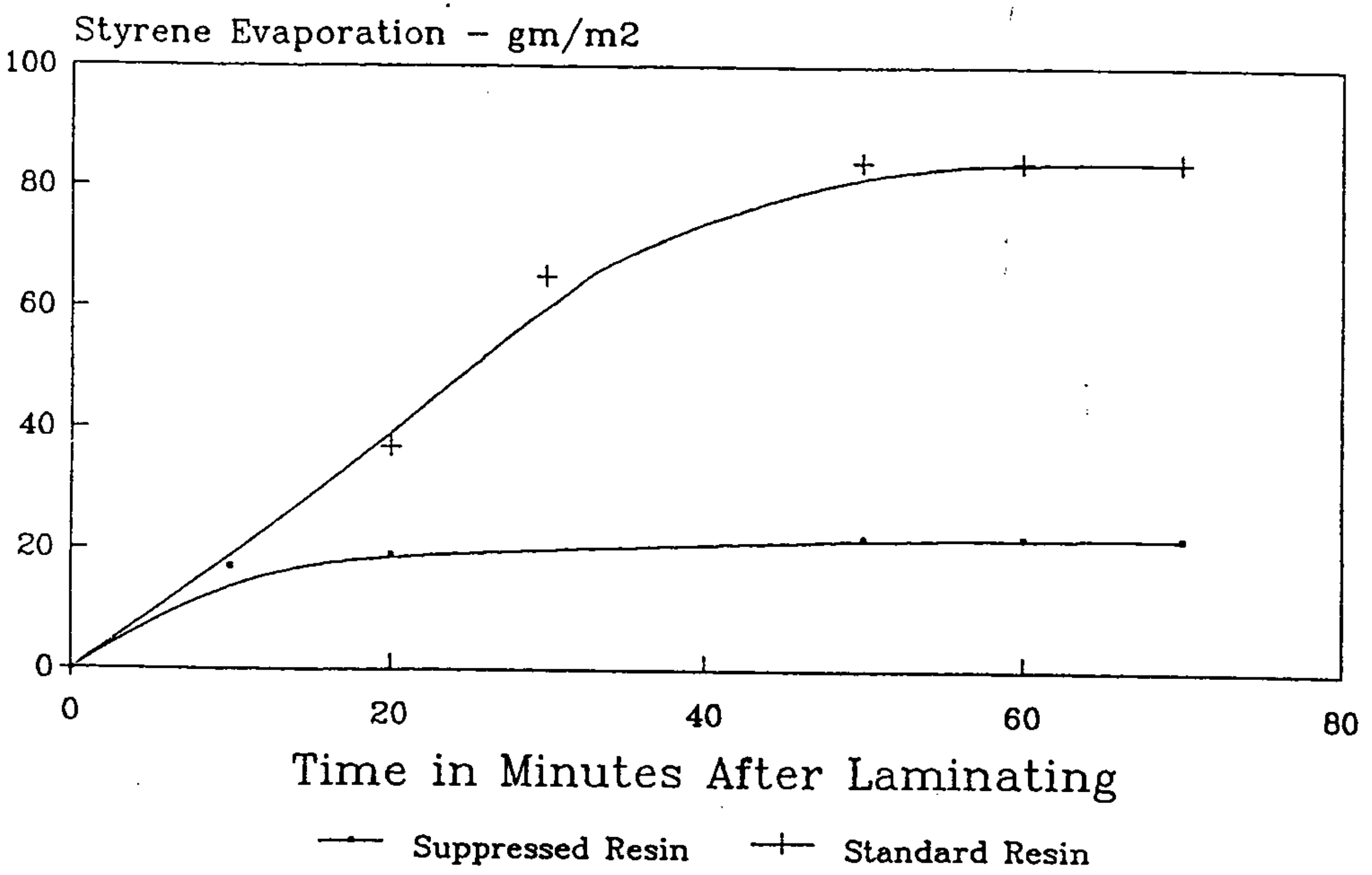

Viscosity vs. Percent Styrene (at 20 °C)
Viscosity CPS
1600
1400
1200
1000
800
600
400
200
0
Hand Lay-Up
Spray-Up
0
10
20
30
40
50
60
Percent Styrene
Resin

FIGURE 13

Comparison of Suppressed Resin and Standard Resin



Concentration of Styrene in exhaust air stream.

$$30.3\,\frac{\#}{hr}\cdot\frac{hr}{60\,min}\cdot\frac{min}{202{,}500\,ft^3 *}\cdot\frac{ft^3}{28.32\,l}\cdot\frac{453{,}592.4\,mg}{\#}=0.04\,\frac{mg}{l}$$

$$=\underline{\underline{9.3\ ppm}}$$

Concentration of Acetone in exhaust air stream.

$$11.6\,\frac{\#}{hr}\cdot\frac{hr}{60\,min}\cdot\frac{min}{202{,}500\,ft^3 *}\cdot\frac{ft^3}{28.32\,l}\cdot\frac{453{,}592.4\,mg}{\#}=0.015\,\frac{mg}{l}$$

$$=\underline{\underline{6.3\ ppm}}$$

* 27 fans estimated @ 7,500 cfm

Merritt Island

CONCEPTUAL PLAN AND POTENTIAL COURSE OF ACTION
FOR THE

FLORIDA DEPARTMENT OF ENVIRONMENTAL REGULATION

PREPARED FOR

SEA RAY BOATS, INC.
PRODUCT DEVELOPMENT & ENGINEERING

PREPARED BY :

CANTELOU ASSOCIATES
CONSULTING ENGINEERS • PLANNERS
401 Park Avenue SW / P.O. Box 3102 / Aiken, S.C. 29801

I. INTRODUCTION. (P. D. & E.).

The purpose of this document is to present background information and data that will support a conceptual plan and potential course of action regarding the reduction or elimination of air emissions from production operations to be considered by Sea Ray Boats, Inc. Implementation of the plan shall demonstrate to the Florida Department of Environmental Regulation that every reasonable effort has been undertaken to assure that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facilities property boundary. [F.A.C. Rules 17-2.200 and 17-2.620 (1) and (2)].

II. Process and Air Emissions. (P. D. & E.).

This chapter will discuss in general the fiberglass reinforced plastic boatbuilding industry and in particular the activities of Sea Ray Boats, Inc. The chapter is divided into three sections. The first will describe the industry in general. The second section will describe the manufacturing process and its emissions, and finally the manufacturing process and VOC/OS emissions at the Sea Ray facility.

Section 1. General.

The fiberglass reinforced plastic boat industry is defined within SIC Code 3732, Boat Building and Repairing. The industry as a whole is comprised of many small businesses with a wide range in the number of employees and size of boats manufactured. The size of fiberglass boats range from about twelve feet to two hundred feet in length. "Large" boats are classified as those greater than thirty feet in length and "small" boats are those less than thirty feet in length. Facilities may produce a range of more than fifty boats per day to less than one boat per month, all depending on boat size and plant capabilities.

Section 2. General - Production Process and Emissions.

There are several methods employed in the production of fiberglass boats. The following discussion, however, is limited to the primary method used within the industry. That process is called "contact open molding". There are air emissions (VOC/OS) associated with that process and they are derived from polyester resin, gel coat resin, paints, carpet glue and cleaning solvents. Various factors and manufacturing techniques influence significantly the quantity of cleaning solvent emissions.

2.1. Production Process for Fiberglass Boats and Methods of Lamination

The Radian Corporation presented a thorough discussion of the manufacturing process for fiberglass boats and it is reproduced here as follows:

"The contact molding method consists of applying layers of resin impregnated fiberglass reinforcement (laminated) on an open female or male mold. The laminate is built up to the required thickness and then allowed to harden or cure. After the cure is completed, the part is removed and the mold is reused. A male mold is convex leaving a smooth inner surface and a female mold is

concave leaving a smooth outer surface on the product. Since a smooth outer surface is normally desired, female molds are most commonly used in fiberglass boat production.

The primary type of resin used in fiberglass boat production is polyester resin. Polyester resins typically consist of 45 percent styrene monomer and 55 percent polyester solids. Before applying the resin, the necessary catalyst and accelerator are added to initiate curing. During curing, the styrene monomer polymerizes forming a thermo-setting plastic. This is an exothermic process, and because styrene monomer reacts more rapidly at elevated temperatures, the reaction is autocatalytic.

The general production process steps used in the industry for manufacturing fiberglass boats are shown in Exhibit "A". The different parts of the boat (deck, hull, small parts) are fabricated in the molding room. The decks and hulls are fabricated in the main area of the molding room while the small parts are fabricated in the small parts booth. The first step in the production

process is coating the mold with a releasing agent such as wax. A gel coat is then applied on the mold with a spray gun in a ventilated spray booth. The gel coat is a pigmented polyester resin which forms the outer smooth surface of the molded part. After spraying, the gel coat hardens or cures with a smooth surface against the mold and a tacky outer surface which enhances later bonding of the first layer of laminate.

After the gel coat cures, the first layer of resin and fiberglass laminate is applied using one of the lamination methods described below. The lamination procedure is repeated until the desired thickness is achieved. Structural reinforcements such as wood, plastic, and metal are also added during lamination. Lamination is a batch process with time between laminates dependent on cure time of the resin. After the final lamination has cured, the excess is trimmed from the part and the part is removed from the mold.

After the parts are removed from the mold, they are then taken to the assembly room where they are sanded and the boat is assembled. In addition, carpet and accessories are often installed to produce the finished product.

There are two methods of lamination used in the fiberglass boat manufacturing industry. These are hand lay-up and spray-up. Each method offers advantages and disadvantages over the other and a combination of the two is often used.

In the hand lay-up method, resin is applied with a resin gun or in rare cases with a brush. If a resin gun is used to apply the resin, a brush is usually employed to even out the resin. After a thin coat of resin has been applied to the gel coat or previous layer of laminate, fiberglass reinforcement is placed over the wet resin. The primary fiberglass reinforcements used in hand lay-up are woven roving, cloth, and mat. Squeegees or metal rollers are then used to force the resin up through the reinforcement and remove any entrapped air (wet out). The resin is allowed to gel and the lamination process is repeated until the desired thickness of fiberglass laminate is obtained.

Three types of resin guns may be used in hand lay-up. These are catalyst injection, dual component, and hot pot. The most common type used in the industry are catalyst injection resin guns. Catalyst injection resin guns mix accelerated resin

and the catalyst in the proper proportion inside the gun spray head and then spray the mixture through a single spray nozzle. With dual-component resin guns, two streams of resin are sprayed simultaneously. One stream consists of resin premixed with accelerator and one stream consists of resin premixed with catalyst. The spray nozzles are aimed so the two spray streams mix outside the spray gun and then form a single spray stream. Hot pot resin guns have a pressure pot attached to the gun head. The laminator mixes the resin, accelerator, and catalyst in the pressure pot by hand. All of the resin must be sprayed once it has been mixed in the pot or it will gel inside the spray gun.

The spray-up method is an alternative to hand lay-up for hull and deck fabrication and is the most common method of small parts production. The spray-up method employs a chopper gun to simultaneously apply resin and chopped strands of glass reinforcement. Brushes and rollers are then used to spread the mixture and remove entrapped air. This process is repeated until the desired thickness is obtained.

The spray-up method is restricted to laminates using chopped glass strand as the reinforcement. Due to the type of reinforcement, laminates produced in spray-up have lower glass to resin ratios than the woven roving or cloth laminates produced in hand lay-up. Because the strength to weight ratio is proportional to the glass to resin ratio, laminates produced in spray-up also have lower strength to weight ratios than woven roving or cloth laminates. Laminates produced in hand lay-up with mat reinforcement are similar to those produced in spray-up because mat reinforcement is just chopped strand with a binder.

The advantage of using hand lay-up with woven roving or cloth laminate over spray-up is that a product with a higher strength to weight ratio is produced. However, the fabrication process takes longer when the hand lay-up method is used. A common practice in the industry is to combine these two methods. With this combination, parts of a boat that need to be strongest are fabricated using hand lay-up while parts that do not need as much strength, such as small parts, are fabricated using spray-up. This results in a lightweight boat that is produced in the minimum amount of time."

2.2. Emissions Sources

There are generally two sources of emissions from the fiberglass boat manufacturing processes that produce volatile organic vapors and organic solvent vapors. These originate in the lamination area due to resin application and cleanup operations or the assembly area of the plant due to painting and carpet installation.

Emissions from the lamination process are due to the evaporation or vaporization of the styrene monomer contained within the gel coat and resin applied when the hull, deck, and small parts are manufactured. An additional portion of the styrene monomer contained in resin and gel coat is subject to evaporation after application and before polymerization occurs.

OSHA (Occupational Health and Safety Administration) mandates that worker exposure to styrene concentrations not exceed 25 parts per million. As a result of this requirement, the air contained within the building is vented to the outside and completely replaced by fresh air every ten minutes. In other words, six air changes are required for the total volume of the building every hour.

There are additional exhausts from spray booths to the outside.

The OSHA requirement is the primary factor controlling the rate at which air containing styrene within the lamination building is moved to the outside.

Vapors from clean-up solvents also contribute to the quantity of emissions from the lamination process. Tool and spray gun cleaning is required after each batch of resin is applied. When the spray guns are flushed some of the organic solvent used is vaporized. Also, employees must clean their hands frequently. When tools, spray guns and hands are washed with solvent an amount of solvent is carried from the container on these items and readily evaporates due to the large surface area exposed to air per volume of solvent.

Additional VOC/OS emissions occur in the assembly area during the painting of boat parts and application of glue during carpet installation. The glue solvent evaporates into the room air while vapors from paint application are exhausted to the outside.

2.3. Techniques and Factors Affecting Emissions from Organic Cleaning Solvents.

Cleaning solvent emissions (usually acetone) account for fifty to seventy-five percent of all air emissions from the plant operations. The major factors that influence these emissions are resin gel time, use of covers on storage containers, work habits of the employee, the number of employees, use of hand protection and protective clothing, and air movement within the plant building. Resin gel time affects emissions because it determines the number of times equipment and employees must be cleaned in a specific period of time. Resin gel times may vary from ten to thirty minutes with fifteen minutes being the average desired.

The evaporation of cleaning solvents may be reduced by covering the containers between cleanup operations. Other factors that effect rate of evaporation are the liquid level in the containers, air movement across the containers, and the room temperature. An increase in any of these will increase the evaporation rate.

Work habits of the employee can lower emissions by reducing the amount of resin or other product which must be removed from hands and arms

by cleaning solvents. Some employees are able to stay relatively clean while other employees may get considerably more on themselves. Employee work habits are influenced by training and supervision. The complexity of the mold can also significantly affect the amount of resin which an employee may get on his hands and arms. The more complex the mold, the more difficulty encountered for keeping the employee clean.

The number of employees involved in the lamination process affects emissions because each employee must clean his hands and tools after each operation. Usually, each employee has his own set of solvent containers, this practice increase the volume and surface area exposure to evaporation.

The use of hand protection reduces the number of times and employee must clean his hands. Without protection, cleaning of hands would occur after each resin application or every twenty to thirty minutes. Using gloves may reduce the clean-up of hands to as low as four times a day.

The factors discussed above are generally determined by the amount of organic cleaning solvent issued per employee. The amount of

cleaning solvent issued can be reduced if gloves are required to reduce hand cleaning and covered containers are used to slow evaporation. Room air ventilation reductions are not practical since this would increase worker exposure to the higher concentrations of styrene and other vapors. Temperature for resin curing is determined by the resin chemistry and cannot be changed easily.

Section 3. Sea Ray Boats, Inc. (P. D. & E.) Production Process and Emissions

The production procedure utilized by Sea Ray Boats, Inc. at the Product Development and Engineering are the same as those shown in Production Flow Diagram (Exhibit "A"). The P. D. & E. Facility has one gel coat booth and one small parts booth contained in the lamination area. The gel coat used consists of 35% styrene monomer, 5 % methyl methacrylate, and 60 % pigmented solids. Following the gel coat, Sea Ray uses a spray up method with application of woven roving and/or glass cloth hand rolled into place, with additional structural supports and stringers laid into the hull or deck and secured by additional resin and chopped reinforcement. The spray up method is used for small parts.

The P. D. & E. Facility utilizes the catalyst injection method of resin application, that is the resin and catalyst are mixed inside the spray gun. The gel time is approximately twenty minutes. The resin used is a general purpose polyester resin containing approximately 37 - 50 % styrene and 50 - 63 % resin solids.

The VOC/OS emissions at the P. D. & E. Facility are shown in Exhibit "B", (Florida Department of Environmental Regulation, Construction Permit for Air Pollution Source and amendments). These emissions result from the evaporation of styrene, acetone, paint and carpet glue solvents. As shown in Exhibit "B", the major sources of VOC/OS emissions are styrene evaporation during hull and deck fabrication, styrene and methyl methacrylate evaporation during gel coat application, and acetone vapors emitted during cleanup. These sources account for over 70% of the emissions so permitted. Emissions from this source according to the construction permit (Exhibit "B") shall not exceed 50.5 tons per year.

Sea Ray's VOC/OS emissions resulting from the cleanup and lamination operations are forced to the atmosphere by exhaust fans in the building sidewalls. The air flow rate of these exhaust fans is rated at 114,150 cfm. These fans are permitted to operate a maximum of 16 hours a day, five days per week. Concentrations within the air exiting these points have

not been measured. The calculated average concentration based on permitted quantities is 5.3 ppm styrene, 38.75 ppm acetone. Other emissions from this source shall be considered fugitive emissions and cannot be identified with any one point.

The P. D. & E. Facility purchases approximately 14,744 gallons of acetone each year and produces 6,215 gallons of spent acetone per year. This difference represents the emissions of acetone to the air as a result of the production process. The spent acetone is purchased and carried off-site by a licensed carrier to be recycled. Therefore, the volume carried off-site will not contribute to the P. D. & E.'s emissions inventory.

III. Emission Control Techniques.

The discussion that follows in this chapter will cover techniques that may be utilized by the P. D. & E. facility to reduce or eliminate VOC emissions from the boat building operations. The first section will discuss process alterations to control acetone emissions, while the second section will consider changes that serve to reduce styrene emissions. Section three will examine add-on controls for exhaust air leaving the facility.

Section 1. General - Acetone Emission Controls.

Acetone emissions may be controlled using three separate approaches. Substitution of non-volatile solvents or emulsifiers, work practice, and spent acetone reclamation.

1.1. Substitution Other Products for Acetone.

There have been products introduced to replace some of the acetone usage. These products vary from strong emulsifiers to non-volatile organic solvents. These emulsifier type products may be used successfully in hand cleaning of tools used in the lamination process. Non-volatile solvents have also seen success in these areas. It should be noted however that the final cleaning of these

tools needs to be accomplished using acetone. Acetone has been found to be the safest product for use in order to remove residue from the initial cleaning operation (i.e. water droplets and other debris). See Exhibit "C", containing manufacturers data on acetone substitutes.

1.2. Work Practice Controls.

The primary work practice controls to reduce acetone emissions in the building of fiberglass boats are as follows:

(a) hand protection,
(b) covered acetone containers,
(c) limiting the issuance of acetone.

1.2.a. Within the boat building facility the resin application methods vary from spray-up to lay-up, the workers are exposed to resin thru handling the tools and overspray from the spray-up. The issuance of gloves, disposable garments and shoe covers eliminates to a great degree the cleaning of hands, other exposed skin areas, and clothing that may come into contact with the resin. This will reduce the amount of acetone to be issued to each employee.

1.2.b. Covering the acetone containers that hold the new acetone as well as the dirty acetone will reduce loss thru evaporation. This provision will also limit the amount of acetone to be required by the employee.

1.2.c. The employer may study each employees use and cleaning techniques and unilaterally reduce the quantity of acetone provided to the employee. The employee recognizing the reduced quantity will be forced into conservation and prudent use of the product.

1.3. Spent Acetone Reclamation.

Emissions can be reduced by recycling the spent acetone. Two options offering economic and environmental benefits exist regarding the disposal of spent acetone. They are on-site recovery or distillation and the delivery of the spent product to a commercial reclaiming facility.

On-site recycling can reduce disposal emission by 90%. The recycling units (stills) are available commercially in various sizes, compatabile with the industrial requirement. Their installation requires electricity and cooling water. A safety hazard also exists with the operation of the still.

As an alternative, there are commercial waste handlers that reclaim spent acetone. The emissions can be eliminated entirely by sending the spent acetone off-site for reclamation. There is an added advantage to the manufacturer in that he also gets rid of the solid waste in the acetone.

Section 2. General - Styrene Emission Control.

Styrene is the cross-linking agent in polyester resins and also it it used as a solvent in the compound that can be used to increase or decrease the viscosity or workability of the resin.

Styrene emissions can be reduced by the manufacturer, if his process will allow him to convert to a new resin designed to limit styrene losses. These new resins may contain a supressant (wax) or may be designed to function with a low-styrene content.

2.1 Supressed Resin.

Supressed resins entrap the styrene monomer that would be emitted as vapor during the exothermal curing of the resin compound. These supressed resins can reduce total styrene emissions by as much as fifty percent. However, a study of manufacturers indicates poor performance of the

finished product. Delamination of the resin has been cited by most as a serious problem. Before a supressed resin could be placed in production, the manufacturer should require extensive testing in the lab and field to determine the products reliability.

2.2. Low Styrene Resin.

Another method of reducing styrene emissions is the conversion by the manufacturer to a low styrene resin. This conversion will reduce emissions because the styrene monomer in the resin can be lowered to as much as thirty-five percent. This can be compared to forty or forty-five percent in conventional resins. Emission reductions during curing due to conversion may be seventeen to thirty percent, this would equate to an overall reduction of ten to twenty percent.

Section 3. Add-On Control.

Add-on controls apply to the boat building industry in the area of exhaust air from the building. The exhaust from spray booths and building ventilation fans can be captured and treated by chemical scrubbing or incineration.

3.1. Chemical Scrubbers.

Chemical scrubbing removes organic vapors from the air by absorbing them into a liquid. The absorbed materials are destroyed by the chemicals in the liquid.

A major problem exist with this approach. Waste stream would be created with the chemical used to absorb air contaminants and the handling of the volume of the chemical waste created by this approach would render the operation impractical.

3.2. Contaminant Incineration.

Two types of incinerators are available, thermal and catalytic. Thermal incineration involves the oxidation of organic vapors to carbon dioxide and water. The solvent laden air is exposed to a high temperature of 1000 to 1500 degrees Farenheit and in some cases a direct flame for a period of 0.3 to 0.6 seconds. Catalytic incinerators use a catalyst bed to oxidize the organic vapors and operate at reduced temperatures of 750 to 1000 degrees Farenheit. Important incineration design factors are residence time, gas stream flow rate, operating temperature, and waste gas heat content.

When collected, most waste gases have low heat contents. This is due in part to OSHA and insurance regulations which limit the maximum concentration of organics to 25 percent of the lower explosive limit (LEL) when no LEL meter is used. If an LEL meter is present to constantly monitor the gas stream then the organic concentration can be as high as 40 percent of LEL. In either case supplemental fuel is needed to raise the off gases to the required operating temperature.

Heat recovery equipment may also be used with incinerators to reduce the amount of supplemental fuel required. It is generally divided into primary and secondary recovery. Primary heat recovery uses heat exchangers to recover heat from the incinerator exhaust gases to heat the incoming air. Secondary heat recovery recovers heat from the exhaust gases for use in plant processes such as ovens, dryers, etc.

The destruction efficiency of both thermal and catalytic incinerators depends on the residence time and temperature. In general these devices can be designed to achieve between 90 and 99+ percent destruction of VOC.

Incinerators have not been demonstrated as VOC control devices in the fiberglass boat manufacturing industry. The main problem results from the low VOC concentrations in the exhausts and high exhaust air flows. Calculated VOC concentrations in the exhaust streams average approximately 5.3 ppm for styrene and 38.75 ppm for acetone. These conditions would result in the exhaust stream having a low heat content thus resulting in high supplemental fuel requirements.

IV. Conclusion - Potential Course of Action.

Sea Ray Boats, Inc., has assessed the technical and economic feasibility of the alternatives presented herein. The potential course of action selected by the P. D. & E. Facility and presently being implemented are work practice controls, commercial recycling of acetone, substitution of emulsifiers for acetone where practical and conversion to low styrene resins.

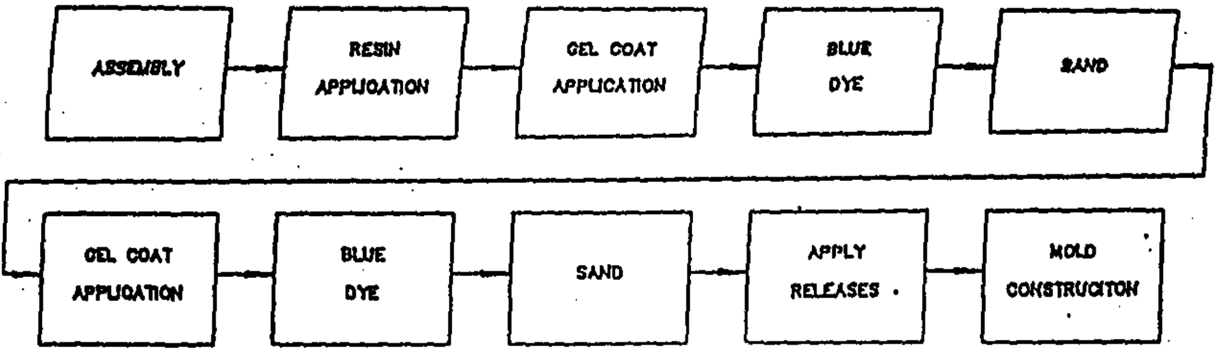
1. Work Practice Controls include the use of hand protection, covered acetone containers, limitation on the issue of acetone to employees and use of Rez-a-way, a commercial product (emulsifier) for cleaning of hands and tools. As discussed in the earlier sections this action should reduce emissions by approximately fifty percent from acetone.
2. The conversion to low styrene resins was selected over use of supressed resins because of the delamination problems experienced by manufacturers using the styrene supressed resin. The fact that the styrene emissions could be reduced using this low styrene resin by at least ten percent was discussed in Section III - 2.2.

Preliminary estimates showed controls by chemical scrubbing and incineration to be so expensive they were

dropped from further consideration. Both of these actions would require an extensive reconstruction of existing facilities, additional capital cost involving the purchase and installation of equipment, and a continuous operation and maintenance expense.

In addition, there would be an impact on waste stream if chemical scrubbing was used and possible risk of water pollution. Incinerators have not been demonstrated as VOC control devices in boat building industry because of low VOC concentration, high exhaust air flows, and the resulting high supplemental fuel requirements because of the low heat content in exhaust air.

MASTERS



Step 1 Masters

a. Master is assembled per drawing by Master Design and delivered to Product Tooling.

b. Resin coat to seal - sprayed on in gel coat booth.

c. Apply sanding gel coat to specification - sprayed on in gel coat booth.

d. Blue dye completely - by hand outside.

e. Ruff block (dry) - by hand outside.

f. Apply production gel coat to specification - sprayed on in gel coat booth.

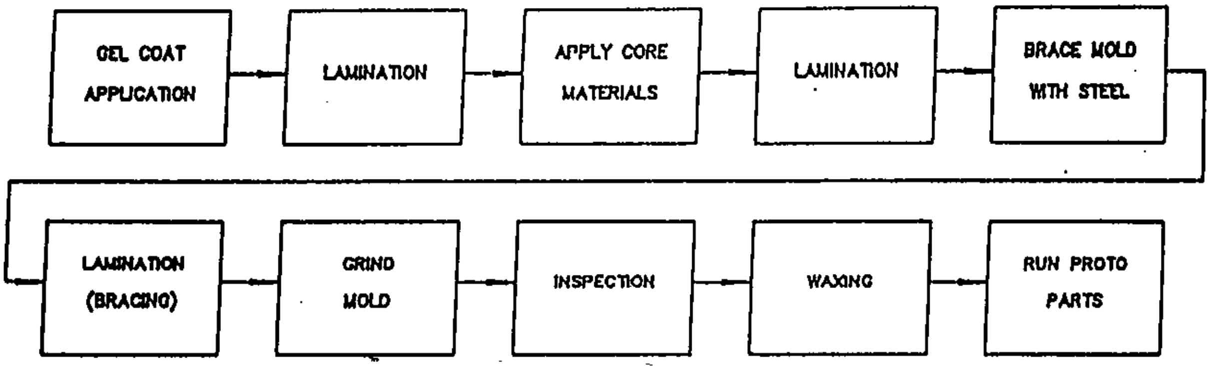
g. Blue dye completely - by hand outside.

h. Fine block (wet) - by hand outside.

i. Apply releases - by machine and hand inside.

j. Master is ready for mold construction.

MOLDS



Step 2 Molds

a. Apply lead-free tooling gel coat to specification - sprayed on in gel coat booth.

b. Apply laminates to specification - by hand on lamination floor.

c. Apply core materials - by hand on lamination floor.

d. Apply laminates to specification - by chop gun on lamination floor.

e. Brace mold with steel - by hand on welding floor.

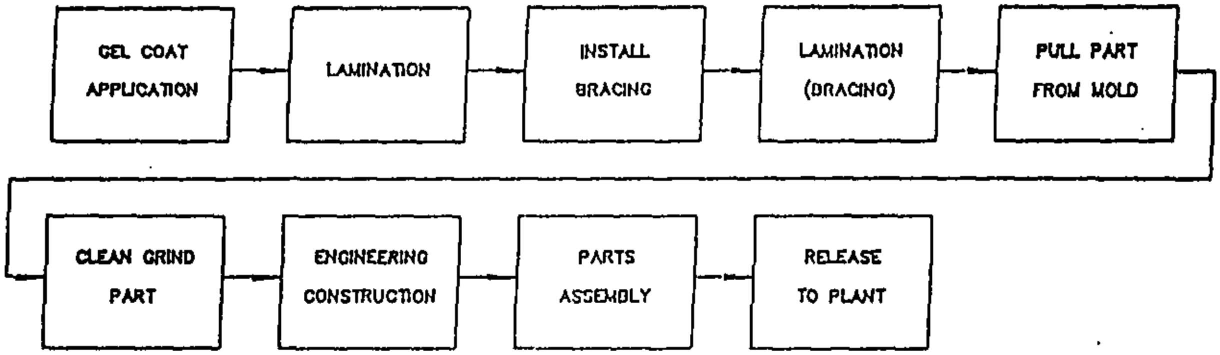
f. Apply laminates to bracing - by hand and gun on lamination floor.

g. Grind mold to pull - by machine outside.

h. Pull mold and inspect - pulling area inside.

i. Mold is ready to be waxed and run for proto part.

PARTS



Step 3 Parts

a. Apply production gel coat to specification - sprayed on in gel coat booth.

b. Apply laminates to specification - by hand and gun on lamination floor.

c. Install bracing into part to specification - by hand on lamination floor.

d. Apply laminates over bracing to specification - by hand and gun on lamination floor.

e. Pull part from mold - with hoists in pulling area.

f. Clean grind part - by machine outside.

g. Part is ready for engineering construction.

Step 4 Assembly of Proto-Type

a. Fiberglass parts are delivered to assembly groups for completion of proto-type. Documentation is prepared, then the molds, proto-type boat and documentation is released to manufacturing plant designated to build.

Florida Department of Environmental Regulation
Twin Towers Office Bldg. ● 2600 Blair Stone Road ● Tallahassee, Florida 32399-2400
Bob Martinez, Governor | Dale Twachtmann, Secretary | John Shearer, Assistant Secretary

PERMITTEE:
Sea Ray Boats, Inc.
Sea Ray Drive
Merritt Island, FL 32953

Permit Number: AC 05-165271
Expiration Date: March 31, 1990
County: Brevard
Latitude/Longitude: 28°24'22"N
80°42'08"W
Project: Development Facility

This permit is issued under the provisions of Chapter 403, Florida Statutes, and Florida Administrative Code Chapters 17-2 and 17-4. The above named permittee is hereby authorized to perform the work or operate the facility shown on the application and approved drawing(s), plans, and other documents attached hereto or on file with the Department and made a part hereof and specifically described as follows:

For the after-the-fact construction of a facility to develop prototypes for new fiberglass boats. This facility is located near the Canaveral Port Authority in Merritt Island, Brevard County, Florida. The UTM coordinates of this site are Zone 17, 529 km E and 3,142.3 km N.

The source shall be in accordance with the permit application, plans, documents, amendments and drawings, except as otherwise noted in the General and Specific Conditions.

Attachment:

1. Application to Operate/Construct Air Pollution Sources, DER Form 17-202(1), received on May 19, 1989.

DDE

GENERAL CONDITIONS:

1. The terms, conditions, requirements, limitations, and restrictions set forth herein are "Permit Conditions" and as such are binding upon the permittee and enforceable pursuant to the authority of Sections 403.161, 403.727, or 403.859 through 403.861, Florida Statutes. The permittee is hereby placed on notice that the Department will review this permit periodically and may initiate enforcement action for any violation of the "Permit Conditions" by the permittee, its agents, employees, servants or representatives.

2. This permit is valid only for the specific processes and operations applied for and indicated in the approved drawings or exhibits. Any unauthorized deviation from the approved drawings, exhibits, specifications, or conditions of this permit may constitute grounds for revocation and enforcement action by the Department.

3. As provided in Subsections 403.087(6) and 403.722(5), Florida Statutes, the issuance of this permit does not convey any vested rights or any exclusive privileges. Nor does it authorize any injury to public or private property or any invasion of personal rights, nor any infringement of federal, state or local laws or regulations. This permit does not constitute a waiver of or approval of any other Department permit that may be required for other aspects of the total project which are not addressed in the permit.

4. This permit conveys no title to land or water, does not constitute state recognition or acknowledgement of title, and does not constitute authority for the use of submerged lands unless herein provided and the necessary title or leasehold interests have been obtained from the state. Only the Trustees of the Internal Improvement Trust Fund may express state opinion as to title.

5. This permit does not relieve the permittee from liability for harm or injury to human health or welfare, animal, plant or aquatic life or property and penalties therefore caused by the construction or operation of this permitted source, nor does it allow the permittee to cause pollution in contravention of Florida Statutes and Department rules, unless specifically authorized by an order from the Department.

GENERAL CONDITIONS:

6. The permittee shall at all times properly operate and maintain the facility and systems of treatment and control (and related appurtenances) that are installed or used by the permittee to achieve compliance with the conditions of this permit, as required by Department rules. This provision includes the operation of backup or auxiliary facilities or similar systems when necessary to achieve compliance with the conditions of the permit and when required by Department rules.

7. The permittee, by accepting this permit, specifically agrees to allow authorized Department personnel, upon presentation of credentials or other documents as may be required by law, access to the premises, at reasonable times, where the permitted activity is located or conducted for the purpose of:

   a. Having access to and copying any records that must be kept under the conditions of the permit;

   b. Inspecting the facility, equipment, practices, or operations regulated or required under this permit; and

   c. Sampling or monitoring any substances or parameters at any location reasonably necessary to assure compliance with this permit or Department rules.

Reasonable time may depend on the nature of the concern being investigated.

8. If, for any reason, the permittee does not comply with or will be unable to comply with any condition or limitation specified in this permit, the permittee shall immediately notify and provide the Department with the following information:

   a. a description of and cause of non-compliance; and

   b. the period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the non-compliance is expected to continue, and steps being taken to reduce, eliminate, and prevent recurrence of the non-compliance.

GENERAL CONDITIONS:

The permittee shall be responsible for any and all damages which may result and may be subject to enforcement action by the Department for penalties or revocation of this permit.

9. In accepting this permit, the permittee understands and agrees that all records, notes, monitoring data and other information relating to the construction or operation of this permitted source, which are submitted to the Department, may be used by the Department as evidence in any enforcement case arising under the Florida Statutes or Department rules, except where such use is proscribed by Sections 403.73 and 403.111, Florida Statutes.

10. The permittee agrees to comply with changes in Department rules and Florida Statutes after a reasonable time for compliance, provided however, the permittee does not waive any other rights granted by Florida Statutes or Department rules.

11. This permit is transferable only upon Department approval in accordance with Florida Administrative Code Rules 17-4.12 and 17-30.30, as applicable. The permittee shall be liable for any non-compliance of the permitted activity until the transfer is approved by the Department.

12. This permit is required to be kept at the work site of the permitted activity during the entire period of construction or operation.

13. The permittee shall comply with the following monitoring and record keeping requirements:

   a. Upon request, the permittee shall furnish all records and plans required under Department rules. The retention period for all records will be extended automatically, unless otherwise stipulated by the Department, during the course of any unresolved enforcement action.

   b. The permittee shall retain at the facility or other location designated by this permit records of all monitoring information (including all calibration and maintenance records and all original strip chart recordings for continuous monitoring instrumentation), copies of all reports required by this permit, and records of all data used to complete the application for this permit. The time period of retention shall be at least three years from the date of the sample, measurement, report or application unless otherwise specified by Department rule.

GENERAL CONDITIONS:

c. Records of monitoring information shall include:

- the date, exact place, and time of sampling or measurements;
- the person responsible for performing the sampling or measurements;
- the date(s) analyses were performed;
- the person responsible for performing the analyses;
- the analytical techniques or methods used; and
- the results of such analyses.

14. When requested by the Department, the permittee shall within a reasonable time furnish any information required by law which is needed to determine compliance with the permit. If the permittee becomes aware that relevant facts were not submitted or were incorrect in the permit application or in any report to the Department, such facts or information shall be submitted or corrected promptly.

SPECIFIC CONDITIONS:

1. The construction and operation of this source shall be in accordance with the capacities and specifications stated in the application.

2. The plant shall be allowed to operate for up to 3,840 hours per year.

3. Visible emissions from the dust collection system shall not be greater than 5% opacity and compliance shall be demonstrated at 90-100% of permitted capacity using DER Method 9 in accordance with F.A.C. Rule 17-2.700.

4. Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 26.2 lbs/hr, 420 lbs/day (30 day average), and 50.5 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin-AME)	10.2	0.06	0.6
Styrene (Resin-RCI)	40.8	0.06	2.5
Styrene (Gel coat)	6.4	0.30	1.9
Methyl Methacrylate	18.3	0.05	0.9
1,1,1-Trichloroethane	0.2	0.68	0.1
Acetone	20.1	1.00	20.1
Toluene	0.2	0.08	0.02
Misc.	0.1	1.00	0.1

SPECIFIC CONDITIONS:

5. Nonvolatile acetone substitutes shall be used to the maximum extent practicable to further reduce the quantity of acetone consumed.

6. No air pollutants shall be discharged which cause or contribute to an objectionable odor (F.A.C. Rule 17-2.620(2)).

7. VOC Compliance shall be demonstrated over a 90-day period and the results reported to the Department's Central District office before this construction permit expires. The Department shall be notified at least 15 days in advance of the commencement of the 90 day compliance demonstration period.

8. The dust collector compliance test shall be conducted within 90 days after this permit is issued and the results reported to the Department's Central District office before this construction permit expires. The Department shall be notified at least 15 days in advance of the test.

9. Six months from the date of the construction permit, Sea Ray Boats shall submit a conceptual plan and potential course of action that will provide the Department with reasonable assurance that objectionable odors and toxic air pollutants in quantities that could exceed acceptable ambient concentrations will not be discharged off of the facility's property boundary or where the public has access, whichever is closest, pursuant to F.A.C. Rules 17-2.200 and 17-2.620(1) and (2). The plan should contain at a minimum, but not be limited to, various control system strategies/options that might be retrofitted/installed to reduce or eventually eliminate emissions of VOC/OS from each type of operation, associated time and cost analyses, and VOC/OS substitutes.

10. The permittee, for good cause, may request that this construction permit be extended. Such a request shall be submitted to the Bureau of Air Regulation prior to 60 days before the expiration of the permit (F.A.C. Rule 17-4.090).

11. An application for an operation permit must be submitted to the Central District office at least 90 days prior to the expiration date of this construction permit or within 45 days after completion of compliance testing, whichever occurs first. To properly apply for an operation permit, the applicant shall submit the appropriate application form, fee, certification that construction was completed noting any deviations from the conditions in the construction permit, and compliance test reports as required by this permit (F.A.C. 17-4.220).

Issued this 7 day
of Sept., 1989

STATE OF FLORIDA DEPARTMENT
OF ENVIRONMENTAL REGULATION

Dale Twachtmann

Dale Twachtmann, Secretary

Florida Department of Environmental Regulation
Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400
Bob Martinez, Governor   Dale Twachtmann, Secretary   John Shearer, Assistant Secretary

December 12, 1989

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. John A. Cronkhite
Senior Vice President/General Counsel
Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Dear Mr. Cronkhite:

The Department received your request for an extension of the expiration dates for the construction permits referenced below. The request is acceptable and the following shall be changed:

PROJECT	FROM	TO
AC 05-151435	August 31, 1989	May 31, 1990
AC 05-165270	March 31, 1990	September 30, 1990
AC 05-165271	March 31, 1990	September 30, 1990

<u>Attachment to be Incorporated</u>:

Letter from Sea Ray Boats, Inc. dated November 22, 1989, requesting a change in the expiration dates.

A copy of this letter must be attached to the above construction permits and shall become a part of these permits.

Sincerely,

Dale Twachtmann
Secretary

DT/plm

cc: C. Collins, CF District
G. E. Cantelou, Jr., P.E.✓

Florida Department of Environmental Regulation

Twin Towers Office Bldg. • 2600 Blair Stone Road • Tallahassee, Florida 32399-2400

Bob Martinez, Governor
Dale Twachtmann, Secretary
John Shearer, Assistant Secretary

November 8, 1990

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Mr. John A. Cronkhite
Senior Vice President/General Counsel
Sea Ray Boats, Inc.
2600 Sea Ray Boulevard
Knoxville, Tennessee 37914

Dear Mr. Cronkhite:

The Department received your September 13, 1990, request for an extension of the expiration dates and revision of emission limits for the construction permits referenced below. The request is acceptable and the following shall be changed:

PROJECT	FROM	TO
AC 05-165270	September 30, 1990	December 31, 1990
AC 05-165271	September 30, 1990	December 31, 1990

Specific Condition No. 4 (AC 05-165270):

FROM:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 65.5 lbs/hr, 1048 lbs/day (30 day average), and 125.8 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	272.5	0.06	16.4
Styrene (Gel Coat)	37.7	0.30	11.3
Methyl Methacrylate	125.7	0.05	6.3
Methylene Chloride	2.5	0.30	0.8
Aromatic Hydrocarbon	21.9	0.16	3.5
1,1,1-Trichloroethane	2.5	0.60	1.5
Acetone	24.4	1.00	24.4
Xylene	21.9	0.06	1.3

TO:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 60.7 lbs/hr, 971.2 lbs/day (30 day average), and 105.6 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin)	258.9	0.06	15.5
Styrene (Gel Coat)	49.3	0.30	14.8
Methyl Methacrylate	94.8	0.05	4.7
Toluene	9.5	0.08	0.8
1,1,1-Trichloroethane	9.5	0.68	6.4
Acetone	11.6	1.00	11.6
Paints (Misc.)	16.8	0.41	6.9

Specific Condition No. 4 (AC 05-165271):

FROM:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 26.2 lbs/hr, 420 lbs/day (30 day average), and 50.5 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin-AME)	10.2	0.06	0.6
Styrene (Resin-RCI)	40.8	0.06	2.5
Styrene (Gel coat)	6.4	0.30	1.9
Methyl Methacrylate	18.3	0.05	0.9
1,1,1-Trichloroethane	0.2	0.68	0.1
Acetone	20.1	1.00	20.1
Toluene	0.2	0.08	0.02
Misc.	0.1	1.00	0.1

TO:

Hydrocarbon emissions (VOC) shall not exceed the following calculated values and total VOC emissions from the facility shall not exceed 26.2 lbs/hr, 420 lbs/day (30 day average), and 50.5 tons/year. Compliance shall be demonstrated by applying the following raw material utilization rates and emission factors:

	Utilization Rate lbs/hr	Emission Factor	Emissions lbs/hr
Styrene (Resin-AME)	10.2	0.06	0.6
Styrene (Resin-RCI)	40.8	0.06	2.5
Styrene (Gel coat)	6.4	0.30	1.9
Methyl Methacrylate	18.3	0.05	0.9
1,1,1-Trichloroethane	0.6	0.68	0.4
Acetone	19.8	1.00	19.8
Toluene	0.6	0.08	0.05
Misc.	0.1	1.00	0.1

Attachment to be Incorporated:

Letters from Sea Ray Boats, Inc. dated September 13, 1990 requesting a change in the expiration dates and emission limits.

A copy of this letter must be attached to the above construction permits and shall become a part of these permits.

Sincerely,

STEVE SMALLWOOD, P.E.
Director
Division of Air Resources
Management

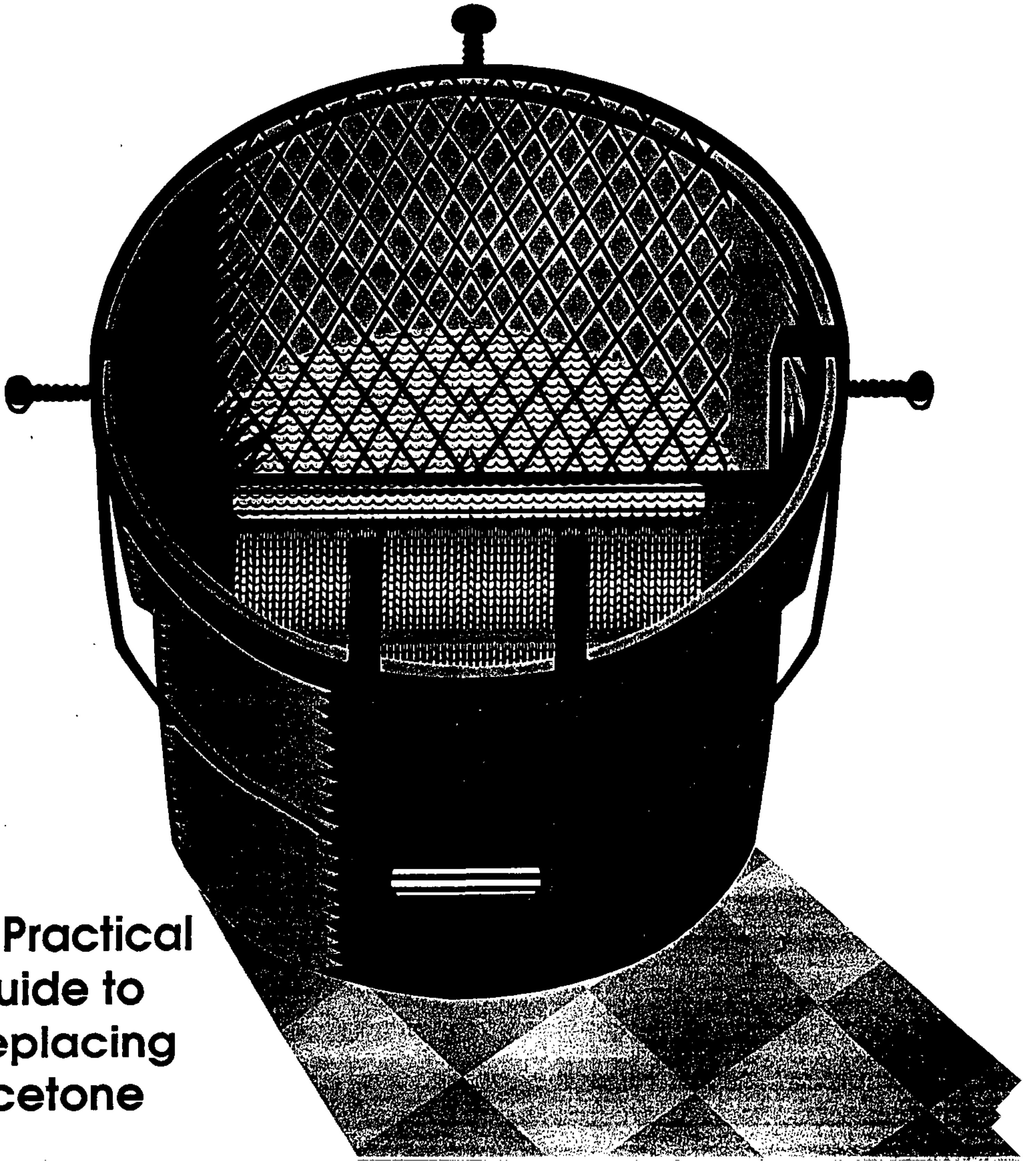
SS/JR/plm

c: C. Collins, Central Dist.
G. E. Cantelou, Jr., P.E.

April 1990

FABRICATION NEWS

OFFICIAL PUBLICATION OF THE FIBERGLASS FABRICATION ASSOCIATION



A Practical Guide to Replacing Acetone

Replace Acetone Successfully –A Practical Guide–

The pace of movement away from acetone as a cleanup solvent has certainly quickened lately. To help you keep up, Dr. Reidar Halle, an acknowledged world-class expert on peroxides, and Joe Brennan have teamed for this very informative and easy-to-follow article.

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feature

Replace Acetone Successfully —A Practical Guide—

By:
Dr. Reidar Halle
Joseph A. Brennan
Managing Directors
Qual Tech Enterprises, Inc.
1485 Bayshore Boulevard
San Francisco, CA 94124
Telephone: 415-467-7887

- **Introduction to Emulsifier Technology**
    - **General comments**

Like the revolutions in Eastern Europe, the revolution within the FRP Industry away from acetone as a cleanup solvent had a slow, sluggish and hesitant start. Now, the pace of both revolutions is brisk and broadly-based!

FRP laminators have two acetone replacement technologies available: resin emulsifiers and higher boiling point organic solvents. Emulsifier technology costs less than acetone and is significantly safer and more environmentally sound! In addition, emulsifiers, used correctly, actually clean better than acetone. Emulsifiers can easily replace 75-100% of the cleanup acetone in most shops—almost all used for cleaning rollers, brushes and hands. Sometimes, more elaborate techniques are needed to clean internal-mix spray guns and pultrusion dies.

In the past, there was some worker resistance to substitute any product for acetone—the only resin cleaner ever used by most laminators. Today, many FRP shops have implemented acetone replacement systems to comply with health, environmental and fire regulations. Many of these shops, both workers and management, now sing the praises of the safety, ease, efficiency and economy of their new emulsifier systems.

Both emulsifiers and high boiling point solvents reduce VOC (Volatile Organic Compounds) emissions, but the emulsifiers in most cases have the added advantage of not generating hazardous waste. Replacing acetone with high boiling solvents is initially a simpler process; however, the contaminated solvents must be distilled and/or hauled away for waste treatment. Also, solvent still bottoms present disposal problems in more and more states.

Why then does this technology, with its inherent advantages of lower fire, health and environmental dangers, fail to be adopted quickly by every FRP fabricator? The answer to this enigmatic question seems to be a widespread lack of understanding of the new emulsifier technology within the FRP industry. As a result, some FRP shops have neglected to implement an ongoing training programs to teach employees how to use emulsifiers effectively.

Unfortunately, far too many fabricators were presented with a sample of an emulsifier (identified as "an acetone replacement") for evaluation; accompanied only with an MSDS—no demonstrations or detailed instructions were offered! Therefore, in the absence of any other advice, many FRP companies evaluated the emulsifiers in the same manner they used acetone, rather than as a new technology with different techniques. Some laminators complained bitterly to management about the difficulty of cleaning with emulsifiers; and justifiably so, acetone methods don't work with emulsifiers. These complaints frequently led to the abandonment of the acetone replacement project.

On the other hand, if you examine those FRP shops that have successfully implemented emulsifier systems vis-à-vis the unsuccessful shops, you will conclude: The successful shops have the common thread of hands-on management commitment to eliminate hazardous waste generation, close supplier support, and a company-wide training program.

The following is a step-by-step look at the fundamentals of emulsifier technology and the recommendations for FRP shops to choose the correct system to successfully make the transition from acetone to emulsifier technology.

- **Emulsifiers versus Solvents**
    - **How does an emulsifier differ from acetone?**

Separation versus dissolving: Organic solvents, whether acetone or higher boiling point products, clean the resins by dissolving them homogeneously, creating a dilute solution of the resin—also hazardous waste and varying levels of VOCs. In the process of cleaning resins with acetone, the sticky resin is diluted and spread around, rather then removed from the cleaning solution as with emulsifier technology.

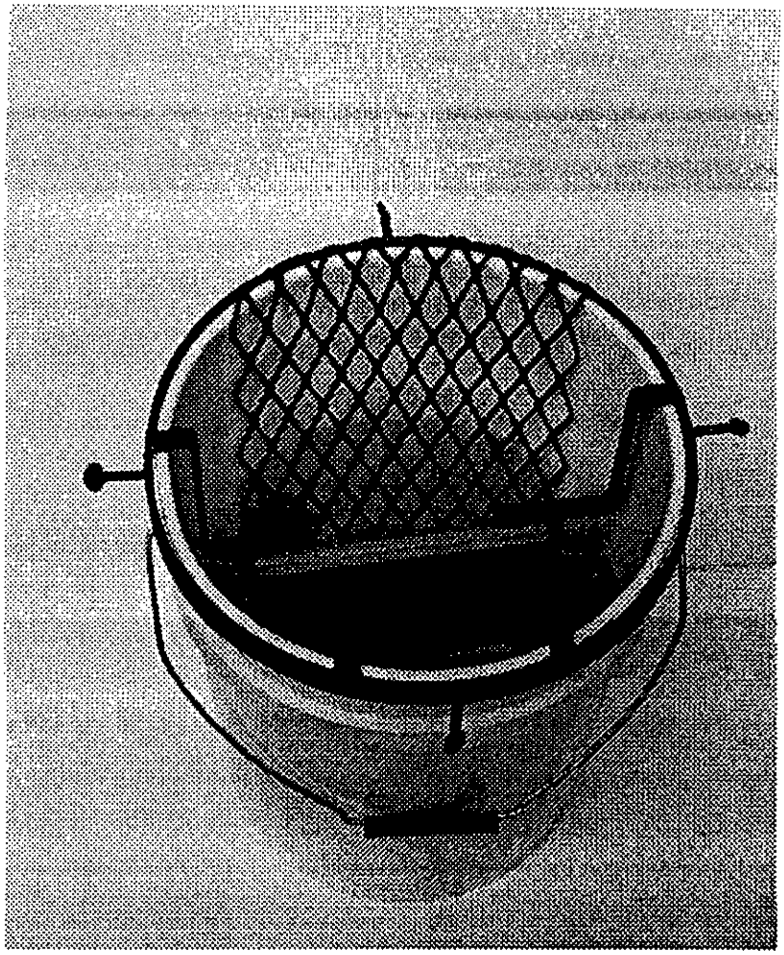
The result is: The efficiency of solvents used for resin cleanup declines rapidly after the first use. Emulsifier cleaning solutions, on the other hand, actually become clearer as the resin settles to the bottom, allowing continued use of the cleaning solution.

The most important differences are:

Hazardous Waste Generation: Solvents used for cleaning resins always generate hazardous waste, emulsifiers usually don't.

VOC Emissions: Acetone generates 6,600 pounds of VOCs for each 1,000 gallons consumed in cleaning; typically, 75-100% evaporates. In addition, recycling

Replace Acetone Successfully



solvents, regardless of boiling point, eventually loses all the solvent to evaporation, spillage or still bottoms. A comparable amount of a low-solvent emulsifier cleaner generates only 30-50 pounds of VOCs—a >99% reduction. This point becomes more critical when increased FRP production levels threaten to exceed total plant VOC allowable limits.

Fire & Health Hazards: Emulsifiers are water-based solutions that present no fire danger—preferred by fire marshals and insurance companies. Organic solvents often burn; some, such as acetone, burn vigorously and are red label. Solvents often have workplace air concentration and exposure limits to protect workers; emulsifiers pose no air quality problems.

• How does an emulsifier work?

An emulsifier formulation for resin cleaning is a mixture of surfactants (surface tension modifiers), combined with wetting and complexing agents in water—the system is usually alkaline. Some emulsifier formulations contain excess amounts of solvents; this initially improves the cleaning action of the formulation, but has some serious drawbacks. Solvents dissolve metal salts (Cobalt), styrene, and other organic compounds that can cause disposal problems. In general, a FRP shop manager should check the data sheet and MSDS of the emulsifier product before the evaluation to determine the potential for sewer disposal problems.

An emulsifier surrounds the globules of tacky resin and renders them tack-free by chemical action. These globules, unable to fight gravity by sticking to a surface, fall to the bottom of the cleaning vessel, where they cure, if catalyzed. The emulsified resin in the cleaning vessel should separate to the bottom efficiently to keep the cleaning solution free from resin. Emulsifier products that contain inefficient surfactants, high solvent content, or require heating, can retard this desirable quality of efficient separation. There is a simple resin screening test (covered later in this article) to determine qualitatively the separation capabilities of various emulsifiers.

The emulsifier cleaning solution can continue to be used until the product is depleted—roughly twice as long as solvents—then discharged into the sewer when the proper procedures are followed, and the neccesarry sewer permits are obtained. The cured resin at the bottom of the emulsifier cleaning vessel should be removed, dried and can be discarded with other solid nonhazardous waste.

• Why have acetone-replacement projects failed?

Most FRP shops that have had little or no success switching from acetone to emulsifiers haven't approached the project as an engineered system designed for the plant's unique needs. A system—integrating a basic understanding of the technology in choosing an emulsifier and hardware, a workers' training program, and a disposal method for the spent emulsifier—is essential for the successful conversion from acetone to emulsifier technology.

Typically, companies that failed to make the transition from acetone to emulsifiers on the first attempt did not fully understand that emulsifier cleanup was a different technology involving new strategies and techniques.

Technology Change: Using the long established techniques developed for acetone cleanup will not work with water-based emulsifiers. FRP laminators have to change their work techniques, and sometimes the type of tools and the cleanup systems employed. Actually, acetone replacement is not a direct product replacement, but a technology change.

Laminators can not merely dip-rinse and soak hand tools as with acetone. Tools must be cleaned immediately free of resin.

Instead of simply dissolving resin from the surfaces as solvents do, emulsifiers work best when the liquid bond of the resin to the surface is physically broken by mechanical brushing or swirling. Once the bond is broken, the emulsifier coats the resin, making it nonsticky. The critical step for FRP shops is to select the best mechanical device—brushes in most cases set in place on racks suspended in the emulsifier solution.

Also, there has been some confusion over the technique of cleaning rollers and brushes, as well as dewatering the tools before returning to the laminate. Emulsifier techniques are specific and often re-

feature

Replace Acetone Successfully

serted, is the best solution to this problem. Mechanical devices in combination with emulsifiers clean efficiently and allow higher dilution ratios and better cost effectiveness.

• Spray guns

Spray guns, both internal and external-mix, are cleaned with a 1:5 dilution ratio.

• Hand & light-wipe cleaning

Simple hand cleaning and wiping down a cured FRP part requires a dilution of 1:15 to 1:20 in most cases. A hands-only type of Jiffy-Cleaner (with softer brushes) is recommended for best results. Hands must be rinsed in clear water to remove the residual emulsifier to prevent skin irritation or rash.

Using spray bottles of emulsifier diluted 1:20 in water is the best approach to wiping off cured gel coat surfaces and laminates. This minimizes the fire and air pollution dangers posed by acetone cleaning.

• Dilution methods

Management should determine a standard method of emulsifier dilution and appoint an employee to be responsible for preparing the emulsifier solution. This step avoids inconsistent results (over dilution) and waste (under dilution). Either batch mixing or the use of a proportioning hose connection gives satisfactory results.

• How to clean with emulsifiers

• Roller & paint brushes

The following are directions for cleaning rollers and brushes in a Jiffy-Cleaner—the most popular and versatile cleaning tool:

Fill a diluted emulsifier solution into a Jiffy-Cleaner to a level of 1" above the top of the brushes. Fill a second pail with clean water to approximately three-quarters full; change the rinse water periodically as needed.

Insert rollers soiled with resin between the Jiffy-Cleaner scrub brushes and plunge the rollers three or more times between the brushes. The bottom bracket of the Jiffy-Cleaner is elevated several inches from the bottom of the bucket so the rollers do not touch the curing resin collected there.

Shake off excess emulsifier and suds and briefly dip the rollers in the clear water pail. Give three to four sharp snaps of the wrist to dispel water from the surface of the rollers. In most cases the rollers are now dry enough to return to the laminate. If not, hang the rollers to dry for several minutes. All tools must be cleaned immediately in order to avoid the resin curing on parts. This is important: Soaking tools before cleaning is unnecessary—and a problem, if the resin is allowed to cure on the tools. Rollers cleaned with emulsifiers are nonsticky and noticeably cleaner than those cleaned with organic solvents.

A small number of FRP shops use the larger felt paint-type of rollers to apply resin uniformly to the laminates. These rollers clean well in a 1-inch or 2-inch Jiffy-Cleaner. After the felt cover is cleaned and rinsed in clear water, it should be wrung by hand and hung on a peg to dry. The removable felt cover should have a plastic core, not paper or cardboard. The roller holder can be cleaner in the Jiffy-Cleaner and dried before another felt roller cover is attached.

For brushes, the technique is important:

Insert the paint brushes in the Jiffy-Cleaner by pressing the bristles against the top of the Jiffy-Cleaner brushes on one side. Move the handle of the paint brush downward along the open space between brushes to scrub the interior paint brush bristles clean. The bristles should be pointing upward and be spread out like a bird's tail. Pull up. Turn the paint brush over and repeat. Depending upon the size of the brush, repeat this technique several times until the paint brush is free from resin. Squeeze the bristles to expel the excess emulsifier and suds.

Rinse the paint brush in clear water by forcing the bristles against the side of the pail beneath the water. Wring the bristles and hit them against the top of the bucket rapidly several times to dispel water droplets from the brush. Hang brush to dry if still moist, or use dry air.

Use splash goggles to prevent emulsifier solution from getting into the eyes. Read MSDS and product data sheets before use.

• What system tools are required?

Fixed Brushes

A Jiffy-Cleaner was invented to aid in the cleaning of the tools using emulsifiers. The Jiffy-Cleaner, with fixed brushes on a rack, is widely used to clean rollers and brushes. It is a versatile tool that is available in various container sizes (5, 15 & 55-gallon) and brush configurations.

Air-driven brushes

Air-driven brushes, despite their lack of versatility and mobility, are well suited for some specialty cleaning: Very large or odd-sized tools and rollers; intricate parts and dies. Air-driven brush machines cause a powerful churning action that finely disperses the emulsified resin in suspension for a considerably longer time. This vortex flow also stirs up the resin collecting at the bottom of the cleaning reservoir—this tends to decrease the efficiency of the emulsifier solution and possibly poses a sewer disposal problem. For this reason, air-driven brush systems should have deep reservoirs equipped with baffles.

Heated Baths

Heated reservoirs are not widely used, but do have specific applications (e.g., intricate parts, pipes, dies). They suffer from the same lack of versatility and mobility as air-driven brush machines. Hot water baths do improve cleaning somewhat by reducing the resin viscosity and improving the emulsifying action. However, heated baths increase the levels of styrene, cobalt salts, MEKP, etc. in the emulsifier solution, and can cause sewer disposal problems.

• Hands

Hands are cleaned best in a dedicated hand Jiffy-Cleaner, followed by a clear water rinse to remove residual emulsifier. Soft sponges and hand brushes also clean well. Hands may be dried with towels or air. Insufficient rinsing and drying of hands, or a combination of emulsifier residue with solvents and resins can cause skin irritation.

• Spray & gel coat guns

Due to wide variations in emulsifier effectiveness with various resins and fillers, it is difficult to give specific cleaning instructions for internal-mix and gel coat spray guns. Spray gun manufacturers and emulsifier suppliers should be consulted. External-mix guns can be cleaned with an emulsifier spray bottle and small brush, and dried with clean cloths similar to solvent cleaning.

• Dies and molds

This normally involves heavily-filled resins with specialty additives that even make acetone cleanup difficult due to stickiness. An emulsifier system, with air-driven brushes and heated reservoir, can do a

more effective job than solvents. Almost every system is unique, but all are based on the basic principles of emulsifier technology: Use of mechanical energy to break the resin liquid bond with the surface; emulsification and separation of the resin; clear water rinse and drying.

• Wipe off of cured FRP parts

Emulsifiers diluted to 1:20 in spray bottles can be used with clean cloth wipes to clean oil, dirt or liquid resin from cured resin parts. This type of cleaning is similar to acetone cleaning. However, acetone spreads a portion of the diluted residue over the entire surface; emulsifiers remove the resin, oil or dirt from the surface.

• Cured resin

Cleaning cured resin is a problem for emulsifiers as well as acetone. Methylene Chloride is somewhat effective, but is being restricted as a resin cleanup solvent. Most solvents that remove cured resins also carry health and environmental warnings. Preventive maintenance is essential to minimize this problem by dealing with the resin waste before it cures.

• How to solve cleaning problems

• Introduction

If possible, FRP managers should get an in-plant demonstration from their emulsifier supplier. This allows management and production personnel to see the proper techniques and procedures to clean their currently used resins from their own tools first hand from experienced professionals. If demonstrations are not possible, complete "How to Use..." and "How to Dispose of..." instruction guides are available from suppliers. Finally, follow-up training is necessary to ensure that proper procedures are maintained.

• Cleaning efficiency

Cleaning efficiency with emulsifiers is dependent on the speed of separation of the emulsified resin to the bottom of the cleaning vessel. Even if the chemical separation is good, if the vessel is shallow (especially critical with air-driven brushes), the curing resin is stirred up into the cleaning zone, causing inefficient cleaning. Therefore, it is important to use deep containers (5-gallon minimum) with fixed brushes that are at least two inches off the bottom; air-driven brushes should be considerably higher because of the churning action caused by the rotating brushes. If more than 4-5 laminators are cleaning tools, additional cleaning buckets should be set up. Regular changing of the emulsifier cleaning solution is best—daily changing, if that works in your operation.

• Possible pitfalls

Below is a summary of the typical problems with the use of emulsifiers if the proper procedures are not performed. All of the pitfalls associated with rollers, brushes and hands can be avoided by using the proper hardware tools and techniques to clean, rinse and dewater the rollers.

• Rollers

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and correct technique.

Water in barrel

Remedy: Learn technique of snapping wrist to force water from rollers.

Barrel freeze

Remedy: Use Jiffy-Cleaner and learn technique to rinse and dewater. Also, use quick-release rollers to minimize barrel freeze.

• Brushes

Inadequate cleaning

Remedy: Use Jiffy-Cleaner and learn the technique of cleaning the interior bristles of the paint brush, and use the proper dewatering method.

Water in handle

Remedy: Punch holes in the ferrule on the handle to allow excess water to drain; hang up to dry with bristle toward the ceiling to minimize the drying time.

Moisture

Remedy: Brushes may be air dried or forced dried with compressed air.

• Hands

Inadequate cleaning

Remedy: For inadequate cleaning—sticky hands—use a hand brush or soft-brush Jiffy-Cleaner to remove the resin before rinsing. Hand rinsing with clear water is essential to prevent skin rash or discomfort. Hand cleaner systems should be placed at or close to waist level for the best results.

Moisture on hands

Remedy: Supply soft clean towels or air driers near the hand cleaning station.

• Spray guns

Cleaning spray guns, especially internal-mix and gel coat guns, is not a simple task. It will probably involve the technical assistance of your emulsifier supplier and your gun manufacturer. Certain resin types, fillers and pigments can cause inefficient cleaning and excessive plugging of guns if the proper emulsifier is not used. It is strongly suggested that this conversion be made last after the replacement of the open acetone containers used for cleaning rollers, brushes and hands. It is essential for each plant to establish and follow a standard procedure for cleaning spray guns.

• Training

Almost all pitfalls outlined above can be avoided or minimized by good training, follow-up programs and the help of your suppliers. An in-plant demonstration is worth thousands of words. Call your supplier.

• How to handle your spent cleaning solution

Liquid solution

Filter the solid resin from the emulsifier cleaning solution at the end of each day. The cleaning solution can continue to be used until it is completely spent. When the cleaning solution is no longer effective, allow at least 24 hours settling time before the final filtering. Then, the spent emulsifier liquid can be discharged into the sewer if permits have been obtained.

Resin sediment

The wet resin sediment, separated from the liquid portion of the spent solution, must be dried before disposal. Spread the wet solid for ease of drying. The dried, cured resin can be disposed of as solid nonhazardous waste along with the hardened resin and trim. Note: Only catalyzed resins cure to a solid.

★• How to dispose of the waste

Liquid effluent

The spent emulsifier solution can be discharged into the sewer if the Federal, State and Local regulations have been met. However, navigating the maze of regulations necessary to obtain a sewer disposal permit is difficult, detailed and time-consuming. Contact your emulsifier supplier for assistance and guidance.

Normally, spent emulsifier solutions from plant operations would not be classified as a hazardous waste. However, any

Replace Acetone Successfully

mixture with a hazardous waste listed in 40 CFR Part 261 Subpart D, Proposition 65, or similar state regulations, etc., would make the resultant waste stream hazardous.

In addition, if a waste stream generated from the use of an emulsifier exhibits one or more of the characteristics of hazardous waste (Corrosivity, EP toxicity, reactivity, or ignitability), it likewise would be subject to the hazardous waste regulations. If in doubt, have your waste stream analyzed.

Use splash goggles to prevent eye injuries when handling.

Septic systems

Septic systems are local issues, and it may not be possible to dispose of the effluent into leaching fields. Consult your emulsifier supplier.

Evaporation

Evaporation by heating of the water phase of the spent emulsifier solution is possible, but it is energy-intensive and expensive.

Cleaning water for recycling

This a costly affair, but it might be of interest to large companies that already have recycling/treatment plants.

Dried cured resin residue

The generated solid cured resin, when dried, may be able to be disposed of as nonhazardous waste. If the residual resin is not completely cured, add a small amount of catalyzed resin to complete the cure before disposal.

Cost comparison with solvents

The purchase price of cleanup solvents—without disposal costs included—are from $2+ per gallon for acetone to 3-4 times as much for higher boiling solvents.

Diluted emulsifier solutions typically cost $1.00 per gallon and last at least twice as long as solvents. The cost effectiveness of emulsifiers versus solvents is substantial, even if the solvents are recycled—only 50-60% of all cleanup solvents are reclaimed. Emulsifiers offer considerable cost advantages even before the additional hidden costs of solvent recycling losses and disposal are factored into the comparison.

- Summary

Replacing acetone with emulsifiers is a technology change. At least 75% of all acetone used for cleanup can be replaced easily by emulsifiers, but most FRP shops initially require the close involvement of their emulsifier supplier to accomplish this.

FRP shops should begin by replacing the solvents used for cleaning tools and hands first; this switch is the easiest and represents the biggest cost reduction and environmental benefits. The remaining areas, such as spray gun cleaning, require a more detailed and systematic approach.

The bottom line is: The choice of emulsifier suppliers is critical because the FRP fabricator often must rely on his supplier for his resin-cleaning systems for the 1990s, worker training, disposal methods and a sewer discharge permit.

JWP INC. ENERGY AND ENVIRONMENT

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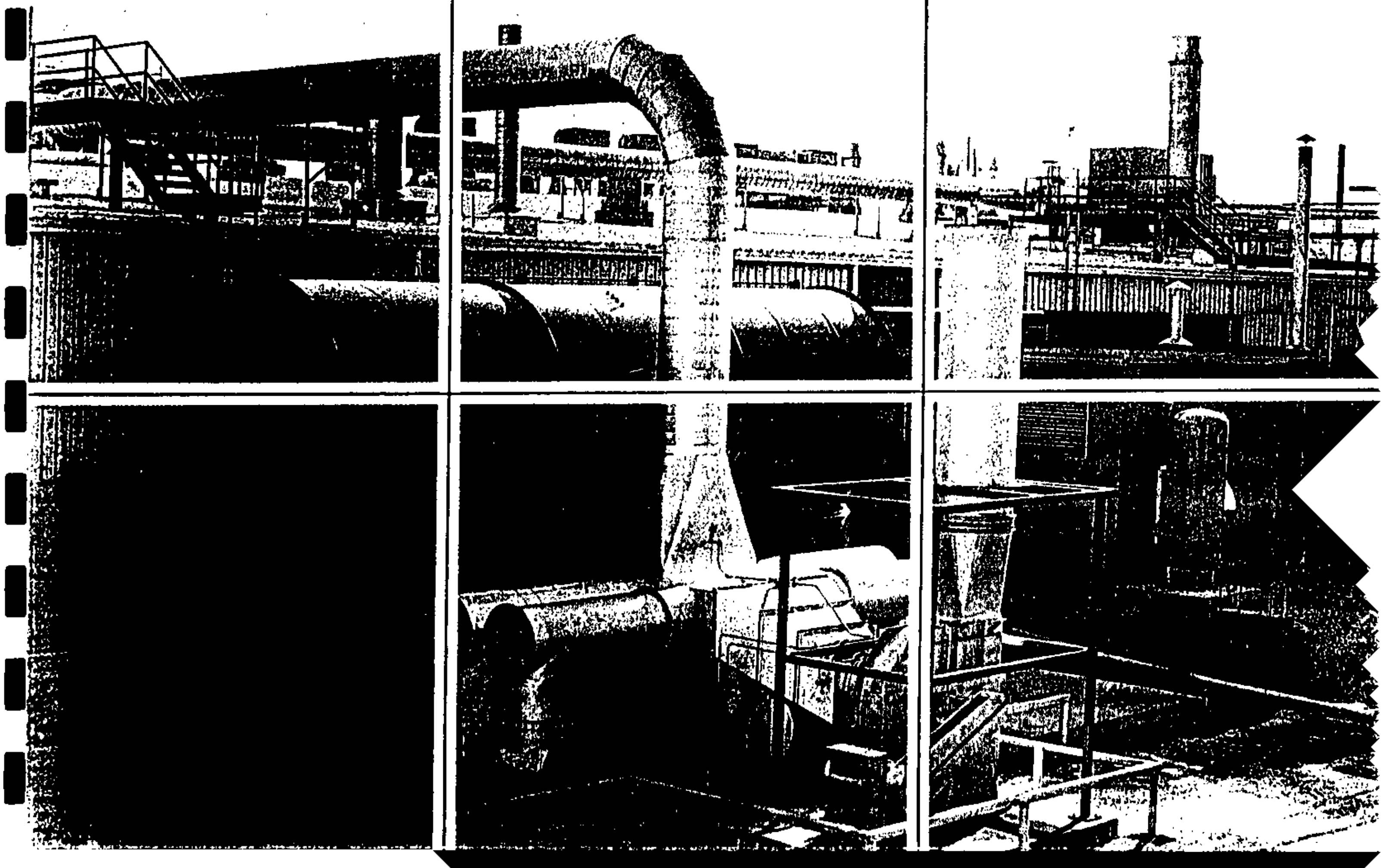
Huntington Energy Systems designs and installs the most thermally efficient fume oxidation systems available to industry today.



HUNTINGTON ENERGY SYSTEMS

Preserving the environment and meeting EPA standards in a cost efficient manner requires state-of-the-art engineering. HES engineers, manufactures and installs the most technologically advanced and thermally efficient fume oxidation systems available to industry today, through its patented designs. With a staff of experienced engineering and sales professionals, supported by advanced Computer Aided Design (CAD) equipment, HES has delivered systems to customers and industries ranging from local printers to major manufacturers. Over the years, HES has developed a reputation for high quality, reliability and low maintenance life cycle costs.

System Operation – The HES Regenerative Fume Oxidation system destroys noxious fumes containing organic solvents, hydrocarbons and odors by oxidation at temperatures in the realm of 1500 degrees Fahrenheit. The fumes are converted to harmless water vapor and carbon dioxide. The regenerative cycle stores combustion heat energy for reuse to preheat process emissions prior to oxidation, providing the most thermodynamically efficient system of fume oxidation. It is, therefore, the most cost effective means available for compliance with government requirements for pollution control.

System Simplicity – The concept of the HES design is simplicity. The patented single valve drive shaft minimizes operation and maintenance problems. All other systems utilize multiple electric operators or complicated hydraulics. This also substantially reduces the amount of field wiring required.

System Performance – The HES Regenerative Fume Oxidation System incorporates the latest fume oxidation technology. Its patented design destroys the pollutants in contaminated exhaust streams while recovering up to 95% of the input heat energy for preheating the process emissions. The requirement for auxiliary fuel is thereby minimized to the lowest possible level. The system will meet and/or exceed the current VOC destruction requirements mandated by local and federal Environmental Protection Agencies.

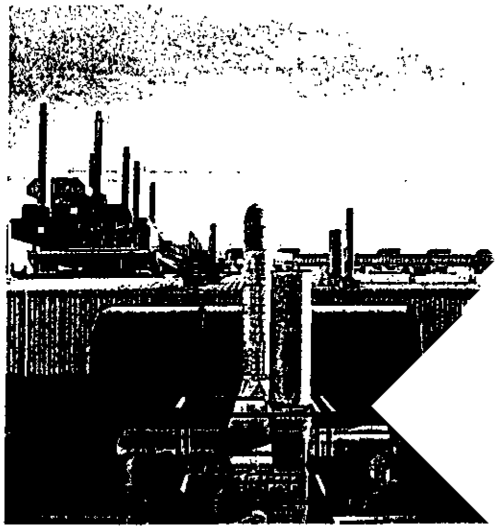
Total System Responsibility – HES takes full responsibility for the installation and start-up of its systems on a turnkey contract basis, including the design and modification of connected processes, e.g. air-volume reduction.

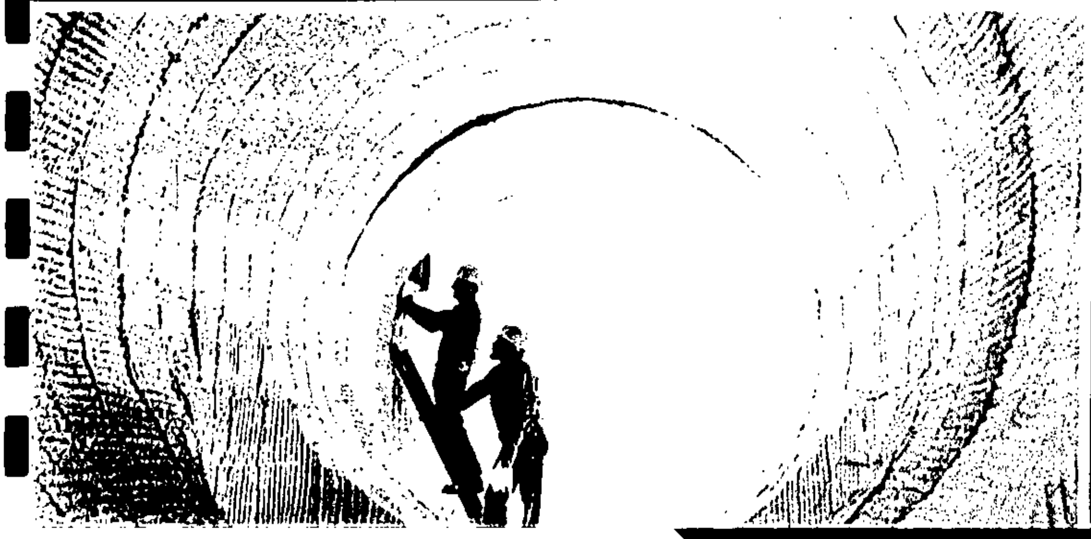
System Economy – "Life-Cycle Cost" ...the cost of owning and operating capital equipment is the total of its capital cost, its operating cost and the cost of maintaining the equipment over the period of its anticipated useful life. The life-cycle cost of HES's Regenerative Fume Oxidation system is substantially lower than that of alternate systems.

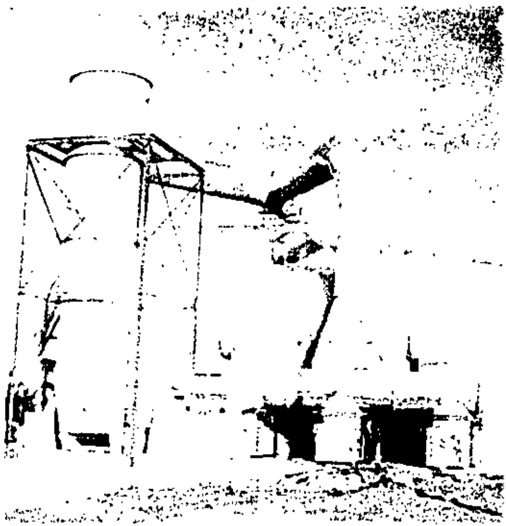
Who Is HES? HES is a wholly owned subsidiary of JWP, INC., a NYSE corporation with annual sales well in excess of a billion dollars. HES customers can expect systems to reflect dedication to quality performance.

Application: A major manufacturer of military tract vehicles such as tanks, troop carriers and construction vehicles. The final stage of manufacturing requires painting of the vehicle with solvent-based coatings. The HES System destroys air pollutants emitted from the paint spraying and drying processes. (Size: 20,000 SCFM)

Application: A residential wood cabinet manufacturer which coats the wood with stain, antiquing, sealants, and other finishes. Prior to discharge into the atmosphere, these predominantly solvent-based coatings are oxidized by the HES System, allowing the manufacturer to meet EPA standards in a cost efficient manner. (Size = 75,000 SCFM).







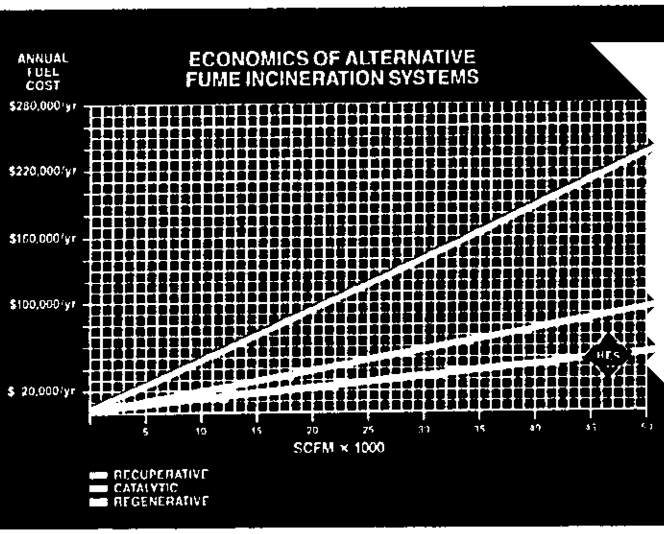
"MINIMIZING THE COST OF FUME EMISSIONS CONTROL"

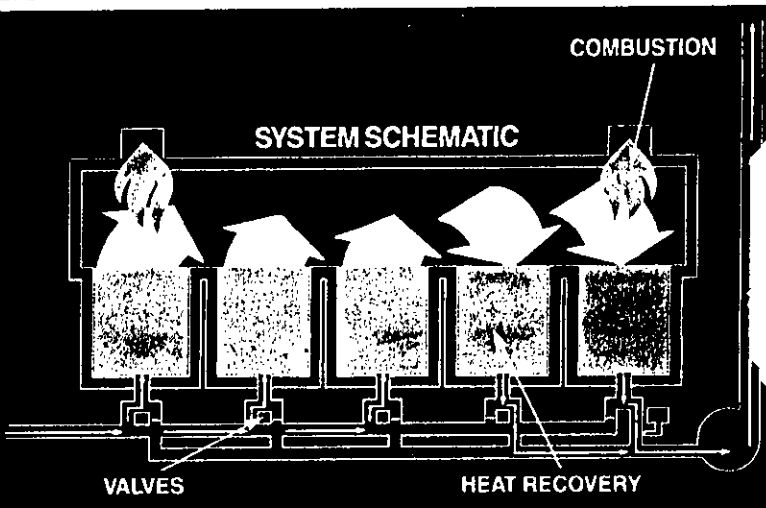
Application: a major vinyl floor covering manufacturer, which was required to meet the new clean air standards. Its problem was dealing with the VOCs released during the printing of resilient vinyl sheet flooring. By installing an HES regenerative fume oxidation system specifically designed for its needs, the firm has been able to heat the plant with recycled air resulting in a substantial fuel cost savings. This processor is also realizing additional savings on natural gas. (Size = 36,000 SCFM)

Not every system can have substantial savings designed into it because of the many variables involved, but we analyze every system for potential savings as well as for changes required to meet state and federal EPA requirements.

STANDARD FEATURES

- Single operator valve drive system
- Independent control and gas pipe trains for each burner
- Machined cast steel valves
- 1/4" ASTM A 36 steel housing
- Stainless steel ceramic support grids
- IRI/FM burner system
- 2400° soft ceramic insulation
- Programmable logic controller
- Expansion capabilities
- Prewired & Tested control panel





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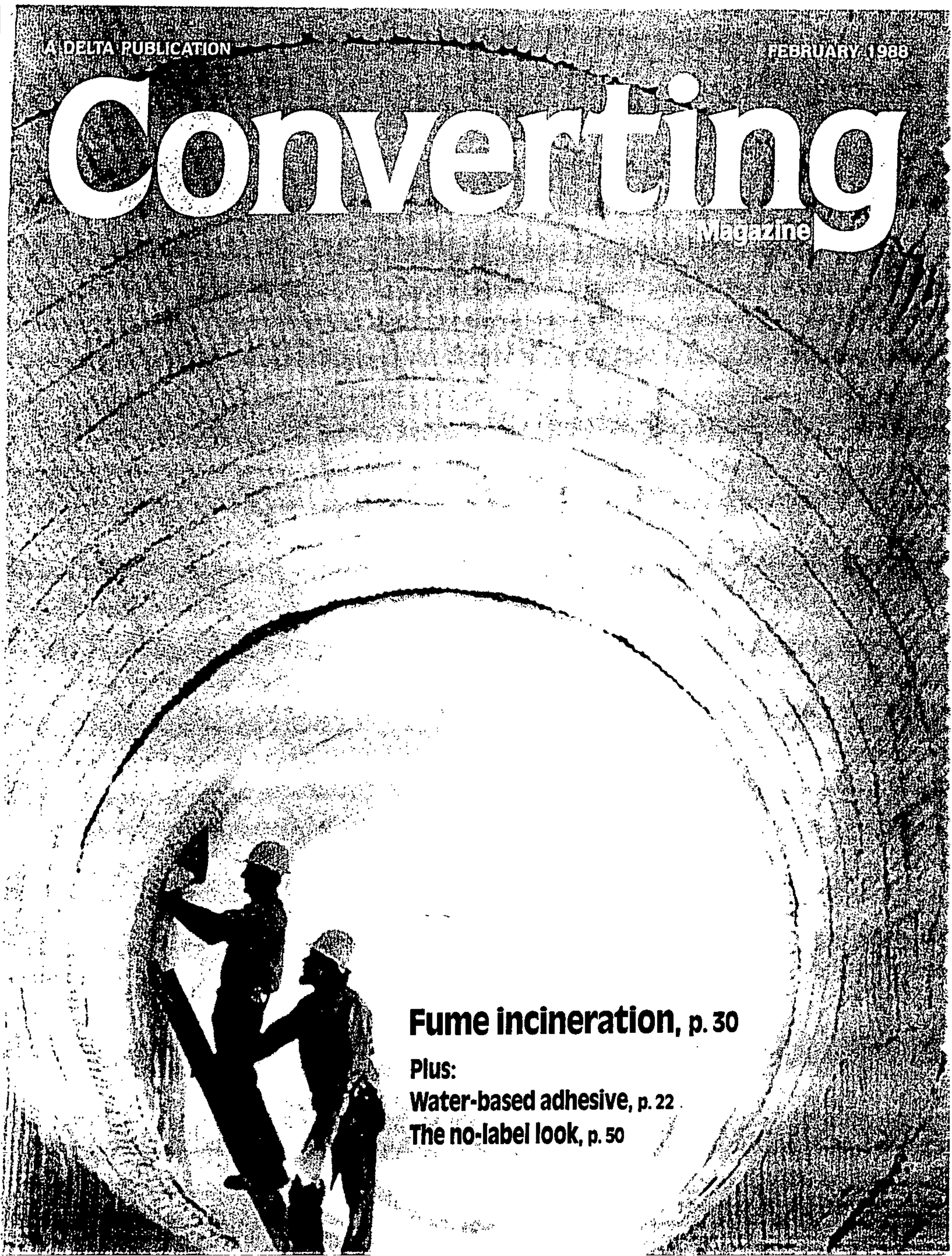
JWP INC. Company

A DELTA PUBLICATION

FEBRUARY 1988

Converting Magazine



Fume incineration, p. 30

Plus:

Water-based adhesive, p. 22

The no-label look, p. 50

Technical Forum

Shopping for FUME INCINERATION

The purchase of an incineration system will impact not only on the state of EPA compliance, but can affect total operations in the long run. Knowing what to look for will greatly increase the chances of a successful selection. . . . by **Richard J. Greco,** vice president of engineering, Huntington Energy Systems

In order to meet the stringent clean-air standards set by the Environmental Protection Agency, a substantial segment of American industry is choosing to install fume incineration systems as the method of compliance.

The choice of the proper system can mean much more than just meeting EPA requirements. It can mean a significant impact on profit. In fact, the proper system can actually pay for itself within a few years and lower manufacturing costs thereafter.

Fume incineration systems incorporate thermal oxidizers that destroy volatile organic compounds (VOCs) by high-temperature conversion of hydrocarbon-laden fumes to simple, harmless water vapor and carbon dioxide. While the various types of systems have acceptable clean-up efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks.

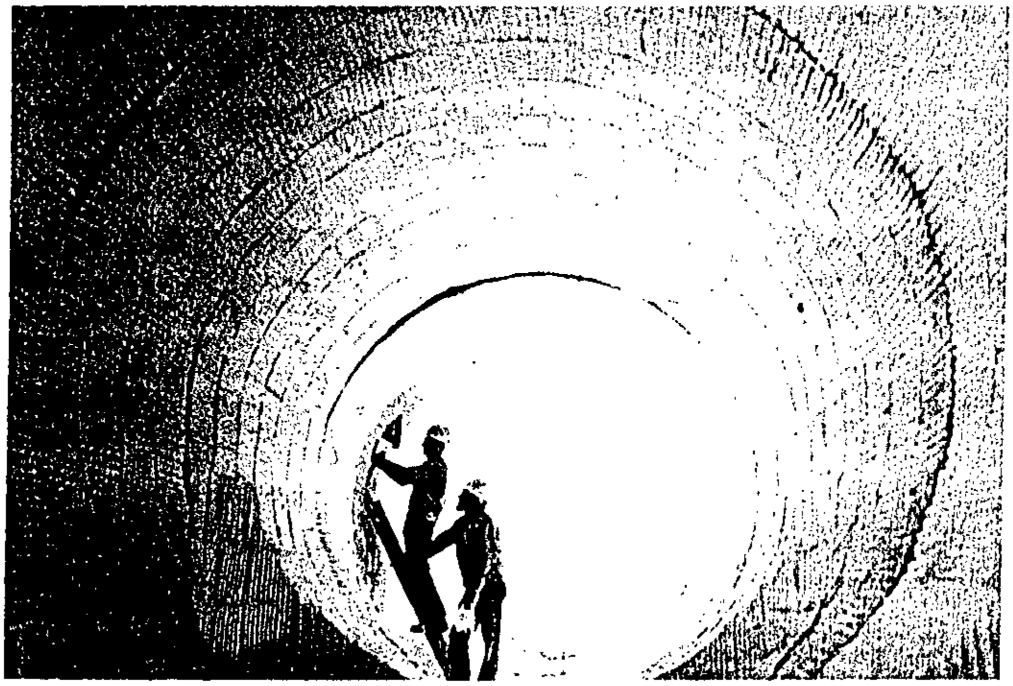
There are four types of fume incineration systems: common afterburner; catalytic converter; recuperative thermal oxidizer; and regenerative thermal oxidizer.

- ***Common afterburner*** (see Figure 1):

Function: Raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually ¼ sec at 1,400 deg F.

Benefits: The afterburner is relatively inexpensive to manufacture and install.

Drawbacks: It is not designed for efficient use of



Workmen put the finishing touches on the interior of a Huntington Energy Systems regenerative fume incinerator. The system is typical of those Huntington installs at converting operations. The incinerator is lined with Manville Z-Blok® refractory ceramic fiber modules to withstand temperatures up to 2,300 deg F and 1,000 AFPM air flow velocity.

FIGURE 1

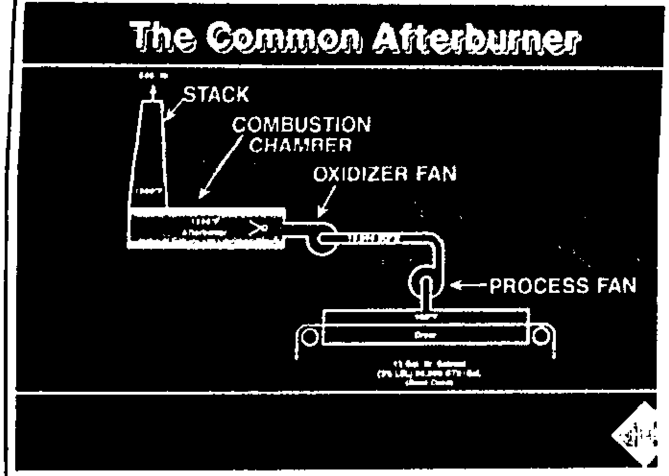

The Common Afterburner

FIGURE 2

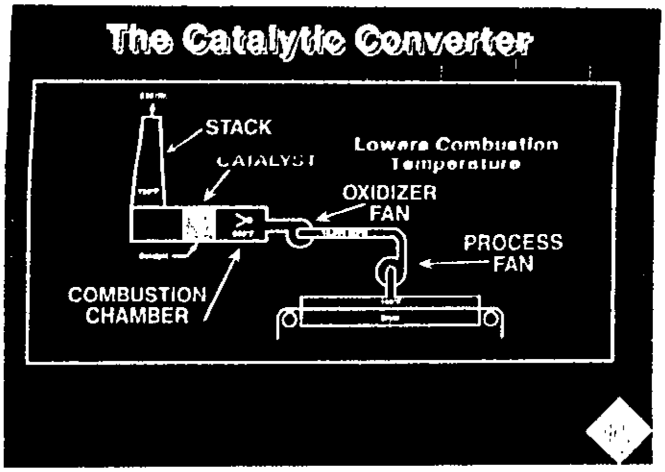
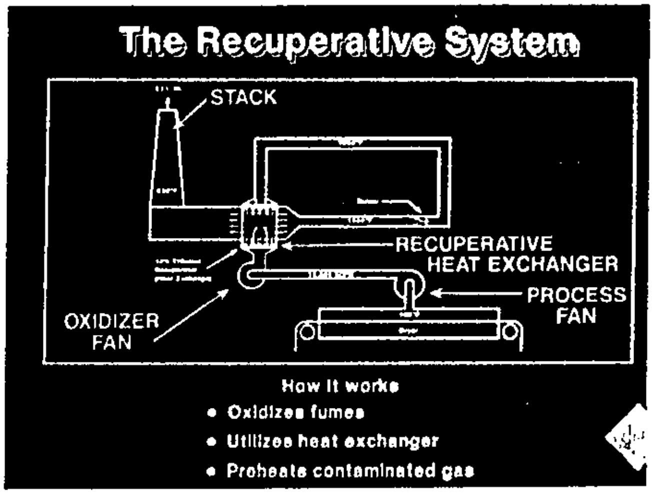
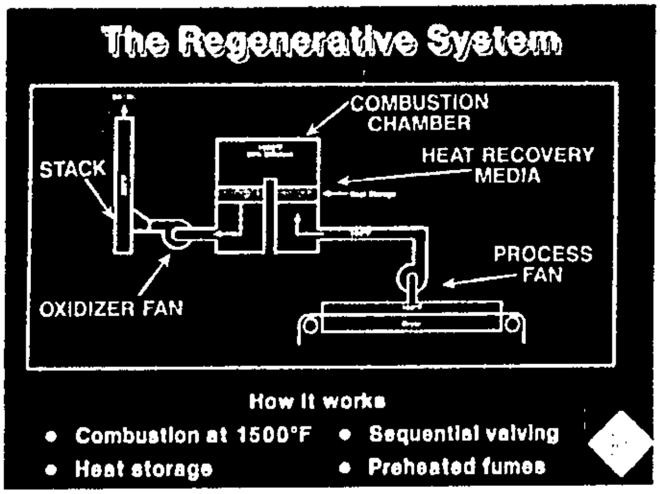

The Catalytic Converter

FIGURE 3


The Recuperative System

How it works
- Oxidizes fumes
- Utilizes heat exchanger
- Preheats contaminated gas

FIGURE 4


The Regenerative System

How it works
- Combustion at 1500°F
- Heat storage
- Sequential valving
- Preheated fumes

fuel and typically consumes 2,000 percent more fuel than other systems.

Industries/processes for which suitable: Small processes of 500 SCFM (Standard Cubic Feet Per Minute) or less.

Cost: Installed cost of equipment only is under $150,000 for a 500 SCFM unit. The cost to operate is approximately $10,000 for 2,000 hrs/yr, or about $20/SCFM year.

- ***Catalytic converter*** (see Figure 2):

Function: Hydrocarbon-laden fumes are pushed by a fan through a preheat section wherein the temperature of the fumes is raised to a maximum of 700 deg F. The fumes then pass through another section of the system containing the catalyst, which reduces the oxidation temperature to 700 deg F, at which the hydrocarbons are thermally oxidized.

Benefits: The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams).

Drawbacks: It performs poorly with fumes contaminated with ash, paper, dust, resin, heavy metals or silicone—commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also reduces flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation. Ultimately, the catalyst becomes useless and the system becomes clogged, forcing the catalytic converter to function in the same way as a common, fuel-intensive afterburner.

Industries/processes for which suitable: clean ink processes; no silicone.

Cost: Costs to install depend on type of catalyst used. For a 10,000 SCFM unit, approximate cost to

Richard J. Greco is vice president of engineering for Huntington Energy Systems, Inc., a JWP Inc. subsidiary. He has been a mechanical engineer in the field of pollution control and combustion since 1965 and has designed and managed the installation of approximately 30 fume incinerator systems throughout the United States.

operate is $13,000 for 2,000 hrs/yr, or $1.30/SCFM year.

- ***Recuperative thermal oxidizer*** (see Figure 3):

Function: This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1,500 deg F gas by passing it through the low-temperature inlet gas stream via an indirect shell and tube heat exchange—thus preheating the incoming contaminated gas to within 65 percent (maximum of 80 percent) of oxidation temperature.

Benefits: The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to overcome the fuel required for combustion. The 20 to 35 percent of the heat lost during incineration can be reused for indirect building heat or steam, or it can be returned to the process.

Drawbacks: Auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as size, heat transfer coefficients and stress limit the system's preheat efficiency. Reusing the 20 to 35 percent lost heat requires an additional investment for heat transfer equipment and its maintenance.

Industries/processes for which suitable: High solvent concentrations above 25 percent LEL (lower explosive limit), coil coating and gravure printing.

Cost: No fuel usage when LEL is above 25 percent.

- ***Regenerative thermal oxidizer*** (see Figure 4):

Function: Oxidized gases exit the combustion chamber, passing through a porous heat-transfer section, storing by conduction 95 percent of its heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where, by conduction, fumes are preheated to within five percent of oxidation temperature by the already-stored heat on its way up to the combustion chamber. There is a continuous cycle of storing and releasing heat alternately within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

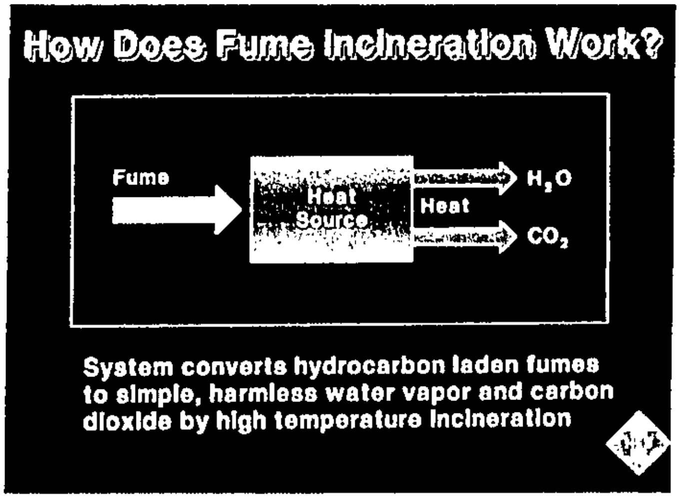
Benefits: The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5 percent of normally-required fuel is needed for oxidation. In many cases, just a burner pilot is sufficient when coupled with the 95 percent preheat efficiency.

Drawbacks: Most available systems are maintenance-intensive because they use hydraulic or electric drive valving components. However, there are systems available that alleviate most of the maintenance because they **utilize a single speed-reducer mechanical valving system.**

Industries/processes for which suitable: Recommended for larger process flows with lower solvent concentrations because the high primary heat recovery will reduce operating fuel costs. Five percent LEL or greater will result in almost no fuel usage.

Cost: Cost of equipment and system is approximately $45/SCFM.

(Note: The difference between a 95-percent-efficient regenerative unit and a 65-percent-efficient recuperative unit in terms of fuel use may *not* be 30 percent, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel use difference could be as high as 40 percent.)



How Does Fume Incineration Work?

System converts hydrocarbon laden fumes to simple, harmless water vapor and carbon dioxide by high temperature incineration

The following checklist covers the many factors to take into account when considering installation of a fume incineration system.

1. **Operating characteristics of process:**
   - Type of process
   - Emission exhaust volume (SCFM). Are there multiple sources, and what are the maximum and minimum exhaust volumes? At what flow rate is the system operating the majority of the time?
   - Hood exhaust volume (SCFM)
   - Oven exhaust temperature (deg F)
   - Oven temperature (deg F)
   - Process temperature of the stream going to the oxidizer (deg F)
   - Fuel used in process (oil, natural gas)

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*Twenty-five percent LEL equals 10,000 SCFM/1 GPM (gal/min) air solven ratio.

- Cost of fuel (\$/Million BTUs)
- Type of solvent used in process
- Gallons/hour of solvent used on product
- Solvent load at various flow conditions (lb/hr)
- Percent of each constituent in solvent
- Hours/day of process operation
- Days/week of process operation
- Hours/year of process operation
- Percent downtime (flow going to oxidizer without solvent)
- Number of startups/year. (Is unit down every weekend?)
- Contaminants in the stream that could cause problems, e.g., silicone, heavy metals, chlorides, particulates. If no contaminants now, might there be some in the future?

2. Regulatory requirements:

- What level of hydrocarbon destruction must be obtained? (Typically, an overall destruction level is established, which is a combination of collection efficiency at the process and destruction by the oxidizer.)
- What is the schedule? When must the oxidizer be installed and operational?
- What method of test will be required by the regulatory agency? (Various methods are accepted by different states and regions, e.g., flame ionization, gas chromatograph, etc.)
- Must the oxidizer include instrumentation to continuously monitor inlet/outlet temperature, inlet/outlet hydrocarbon concentrations or other constituents in the exhaust, such as CO and NOX?

3. Insurance factors:

- Are there specific insurance approval requirements, such as Factory Mutual (FM) or Industrial Risk Insurers (IRI)?
- Upon system startup, will the process be purged through the oxidizer or indirectly to the atmosphere? (Insurance requirements will dictate that both the process and the oxidizer must be purged with clean air before any burners can be lit, to ensure there are no dangerous concentrations of hydrocarbons built up that may cause an explosion.)

4. Return on investment:

If you want the system to give you a return on your investment, such as using recycled air to heat or cool the building, you must know the following:

- Type of building heating system
- Square footage of building being heated
- Type of installed air conditioning
- Tons of air conditioning
- Capacities of individual air conditioners (tons).

5. Operating costs:

- What are the comparative utility costs, e.g., natural gas and electricity?

6. Ease of maintenance of system:

- Need for adequate maintenance staff to handle technical aspects of the different systems.

7. Expandability of system:

- Does the equipment lend itself to future expansion, should production schedules dictate?

8. Location of system:

- Will the oxidizer be located outdoors, indoors, at grade, on roof?
- What is the availability of utilities, e.g., natural gas, oil, propane?
- What is the electrical service available, and is there sufficient capacity?
- Is noise pollution a consideration? (Is there housing nearby?)
- Are soil conditions adequate for the foundation?
- Is there sufficient access for construction equipment?
- Is the site selected clear of any underground obstructions, such as drain sewers, tanks, etc?
- Where is the control panel to be located?

9. Bid evaluation:

- Is this to be a turnkey project? Many companies prefer a single-source, including installation.
- Are you comparing equivalent bids? Has each of the vendors included all of the necessary equipment and services? Has a bidder left something out in order to better his price position? (Compare your bids to each other, and to all the guidelines enumerated here, to avoid accepting an incomplete bid.)
- Has each vendor supplied the proper performance guarantees and equipment warranties?
- Are the terms of payment acceptable?
- Has freight been included in the price?
- Does the vendor have proven operating field installations?
- Can the vendor meet the necessary schedules?
- Carefully evaluate the following for quality of workmanship: construction materials and thicknesses; equipment suppliers for controls, fans, etc; methods of assembly.
- What happens to the oxidizer in the event of excessive solvent loads? Will it over-temperature and cause problems?
- Have the proper safeguards been incorporated in the control scheme, e.g., high-temperature shutdown, audible alarms in the event of shutdown?

Summary

The above information should serve to guide you in evaluating which fume incineration system would be best for your business. It should also help you to initiate meaningful discussions with equipment suppliers and/or independent environmental consultants, and to analyze vendor bids.

In the end, EPA regulations will do more than create a cleaner environment for all of us; they will force us to take a hard look at our manufacturing processes, very possibly resulting in lower production costs in the long run. #

Reprinted from CONVERTING MAGAZINE February 1988

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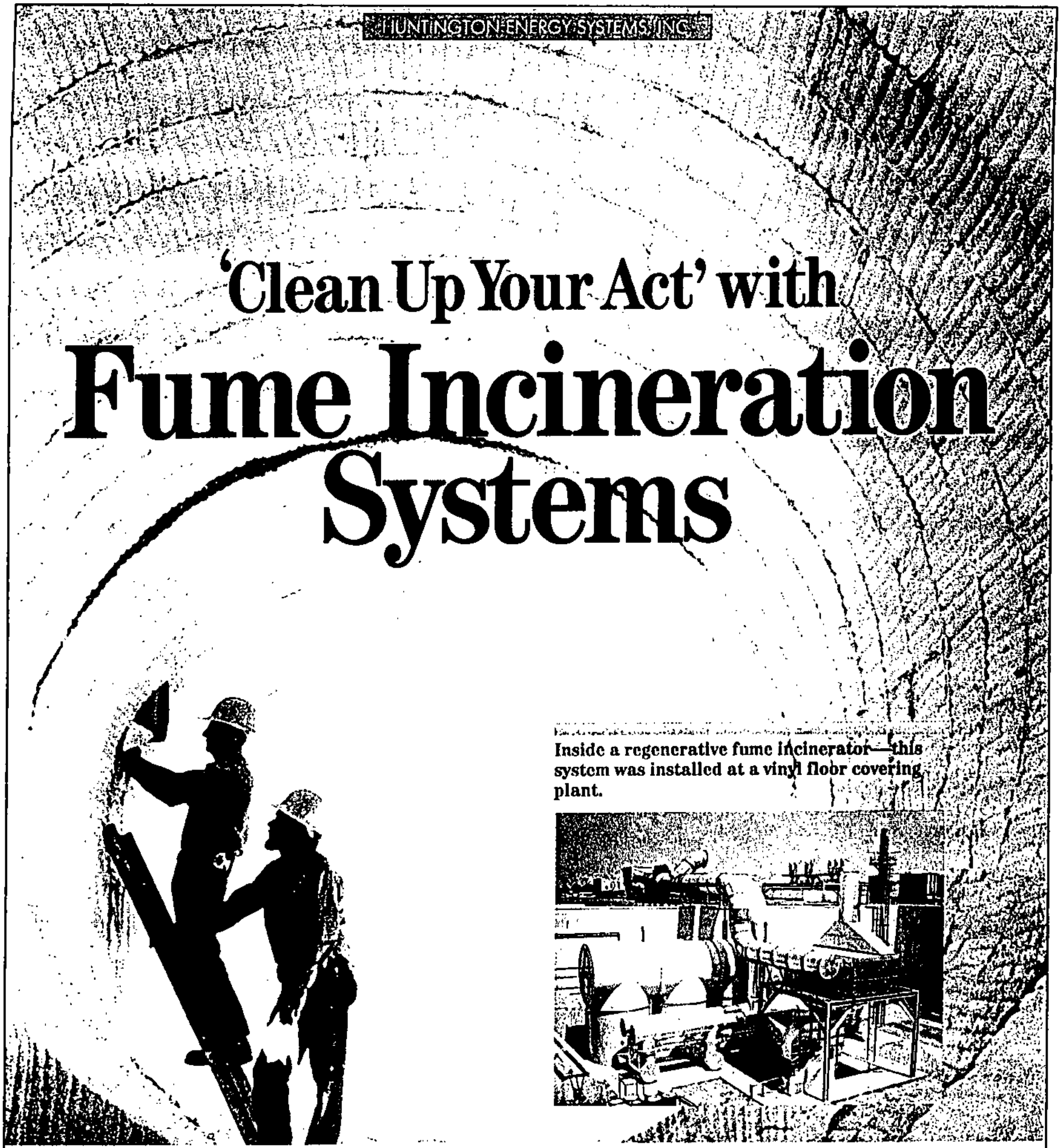

HUNTINGTON ENERGY SYSTEMS, INC.

'Clean Up Your Act' with
Fume Incineration Systems

Inside a regenerative fume incinerator—this system was installed at a vinyl floor covering plant.

To avoid an expected EPA crackdown on VOC emissions, fume incineration may be your best bet. Here's a look at available equipment.

Many plastics processors, along with a substantial segment of the rest of American industry, will soon be forced to install fume incineration systems in order to meet existing EPA clean-air standards, and provisions of possible amendments to the Clean Air Act, or even entirely new environmental bills which Congress may pass. The Federal Environmental Protection Agency has already designated localities that are currently not meeting minimum requirements for the control of volatile organic compound (VOC) emissions, and agency spokesmen have said recently that they will be cracking down on manufacturers located in "non-attainment" areas. There have even been new rules instituted recently that are aimed specifically at application of coatings to plastic business-machine housings (see *PT, March '88, p. 113*).

Plastics processors within these areas that use solvent-based paints,

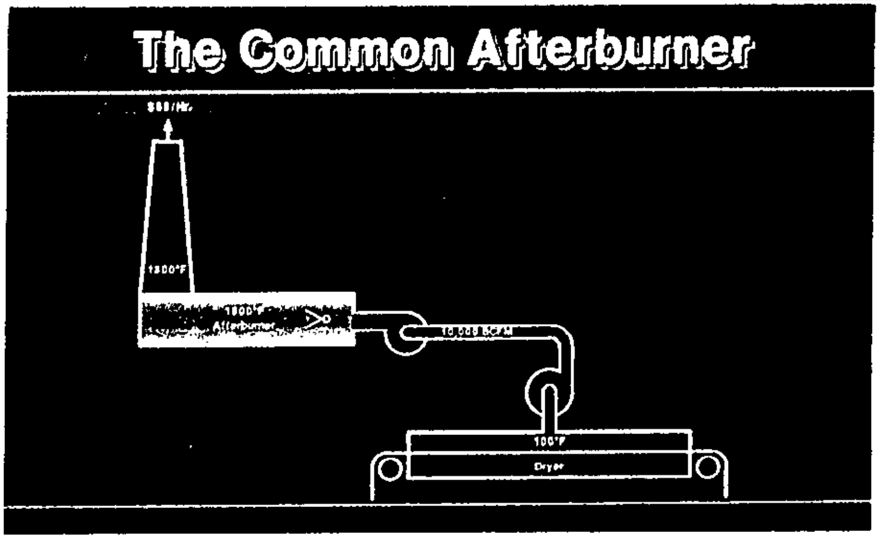
Reprinted from PLASTICS TECHNOLOGY July 1988

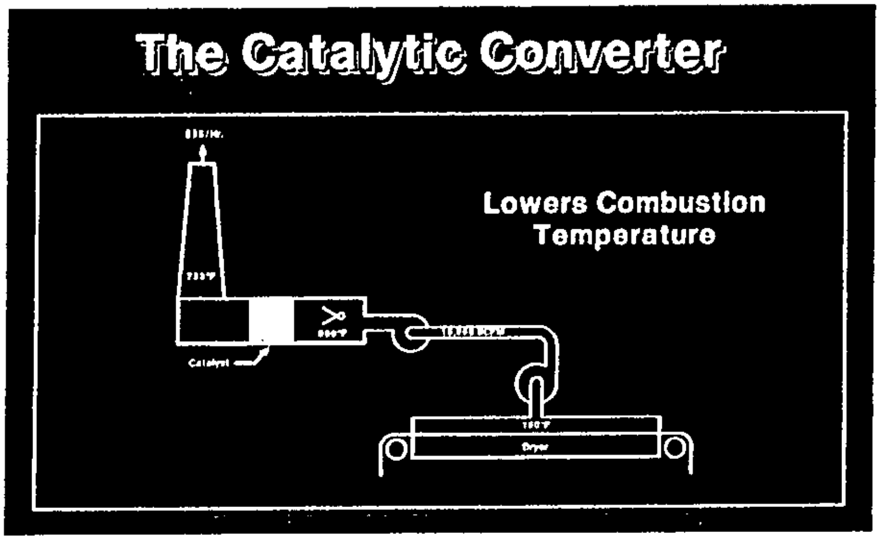
inks, or other coatings will be required by law to measure VOC emissions at their own facilities. The burden of proof will be on them to show compliance, and their testing procedures will also be regulated by the EPA. Specific rules and regulations for compliance will vary between different EPA jurisdictions, but penalties for noncompliance can include fines, annual production limitations, or even plant shutdowns.

The present Clean Air Act had scheduled the deadline for compliance for December 31, 1987, but that deadline was extended by Congress to mid-1988. The lawmakers may choose to extend it again or, more likely, take an even tougher stance on pollution emissions, while giving businesses a longer time to comply. There were still 76 nonattainment areas at the end of 1987, and it's not likely these areas will be within compliance soon.

Fume cleanup is needed to eliminate air contamination by hydrocarbons, such as MEK (methyl ethylketone), MIBK (methyl isobutylketone), toluene and alcohols. These are typically produced in the plastics coating and printing operations.

In addition, many processes that generate VOC and objectionable odors, such as plasticizers from flexible PVC calendering and plastisol processing, and styrene monomer from FRP fabricating, are coming under scrutiny. Whether or not the odor-producing volatile emissions must be cleaned up depends upon specific EPA regulations, as well as on the plant location. And, in addition to Federal EPA restrictions, local environmental regulations on VOC's—such as in Southern California—can also have major impact on plastics operations.





FOUR TYPES OF SYSTEMS

Unlike the problem of dealing with particulate-laden emissions—a relatively simple process utilizing familiar equipment, with minimal operating cost—meeting EPA standards for fume cleanup involves more sophisticated options. Most of these require major investment and operating costs. Therefore, the choice of the proper fume incineration system can have a significant impact on profit. The proper system can actually pay for itself within a few years, and lower manufacturing costs thereafter, in contrast with less efficient systems available.

There are basically four types of fume incineration systems, all of which incorporate thermal oxidizers that destroy VOC's by high-temperature conversion of hydrocarbon-laden fumes to harmless water vapor and carbon dioxide.

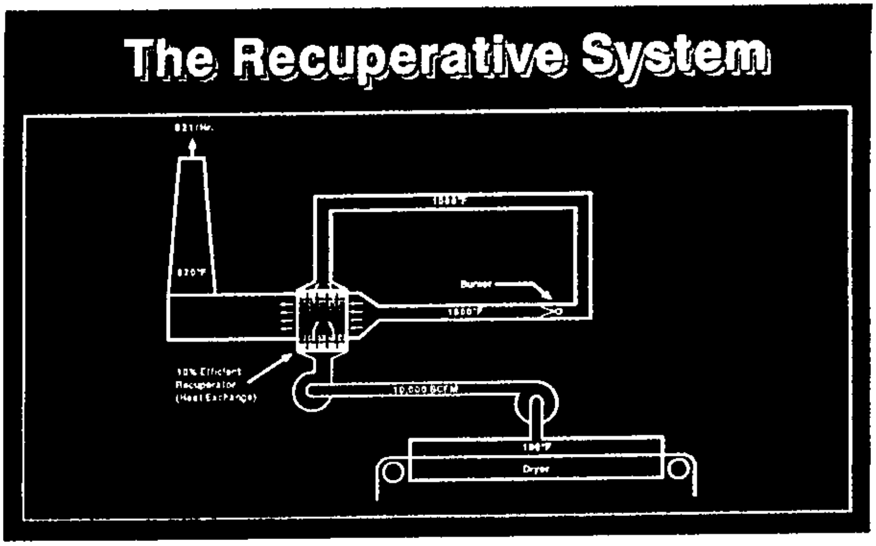
While all the various types of systems have acceptable cleanup efficiencies, each system is different in theory of oxidation and cost of operation; each has its own benefits and drawbacks. The purpose of this article is to illustrate the differences between incineration systems, and to provide examples of current installations.

All costs discussed here are based on a 10,000-scfm (standard cubic foot per meter) system, operating at 2000 hr/yr, maintaining exhaust fume temperatures of 100 F, with fuel costs of $6/million Btu. For a physical description of each system, consult the accompanying diagrams.

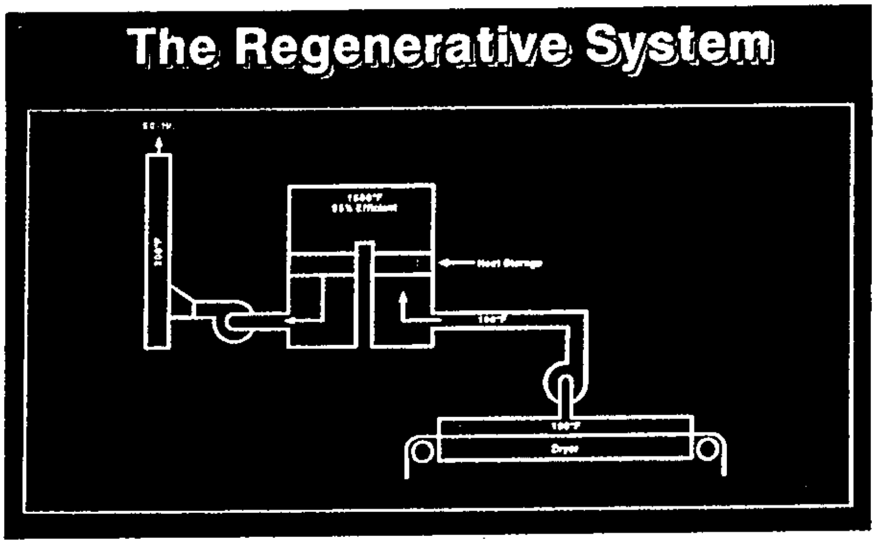
▶ **Common afterburner:** This system raises fumes to incineration temperatures, thereby destroying their offending content, and maintains them at those temperatures for a given period of time as mandated by regulations—usually 0.5 sec at 1400 F.

The afterburner is relatively inexpensive to buy and install. However, it is not designed for efficient use of fuel and, typically, consumes 2000% more fuel than other systems.

It is typically suitable for low-throughput applications, which require processing contaminated air at rates of



The Recuperative System



The Regenerative System

500 scfm or less. Capital investment can be around $70,000, with annual operating costs around $170,000. Installation costs can be $30,000-50,000.

▶ **Catalytic converter:** Hydrocarbon-laden fumes are pushed by a fan through a preheat section, wherein the temperature of the fumes is raised to a maximum of 700 F. The fumes then pass through another section of the system containing the catalyst, which is able to thermally oxidize the hydrocarbons at the reduced temperature of 700 F.

The catalytic converter is more efficient than an afterburner, and is also a simple system. It works well on "clean" hydrocarbon fumes (low solvent concentration streams). It performs poorly with fumes contaminated with particulates, resin, heavy metals or silicone — commonly found in oven or dryer processes. This poor performance is the result of the catalyst's cell structure becoming coated or poisoned with oxidized ash, which deteriorates its ability to oxidize the hydrocarbons at the preheat temperature and also may reduce flow through the system. Consequently, additional fuel must be burned to elevate the fumes to a higher temperature in order to achieve oxidation.

Catalytic converters are best suited for clean ink processes that involve no silicone. Typical equipment costs for a catalytic converter would run around $230,000, with annual operating costs around $24,000. Equipment installation costs of approximately $100,000 can be expected.

▶ **Recuperative thermal oxidizer:** This unit oxidizes the fumes in a combustion chamber but, unlike the common afterburner, makes use of the existing 1500 F gas by passing it through the low-temperature inlet gas stream via an indirect shell-and-tube heat exchanger, thus preheating the incoming contaminated gas to within 65-80% of oxidation temperature.

The recuperative system is economical to operate when the heat release of the hydrocarbons is sufficient to replace the fuel required for combustion. The 20-35% of the heat lost during incineration can be reused for indirect building heat or generating steam, or be returned to the process. However, auxiliary fuel must be used on processes that do not contain ample fume energy for self-destruction, or processes that are cyclical in nature. Factors such as equipment size, heat-transfer coefficients and stress, limit the system's preheat efficiency. Reusing the 20-35% lost heat requires an additional investment for heat-transfer equipment and its maintenance.

The recuperative thermal oxidizer is suitable for processes that need to incinerate fumes with a high solvent content—typically fumes with an air-to-solids ratio above 25% LEL (10,000 scfm/gpm [gal/min]). Capital equipment costs for these systems run around $200,000, with annual operating costs of around $50,000. Installment costs are estimated at $100,000.

▶ **Regenerative thermal oxidizer:** In this system, oxidized gases from the combustion chamber pass through a porous heat-transfer section, storing by conduction 95% of the heat in millions of inert ceramic elements. By the use of valving, incoming contaminated air is directed to the heat-transfer section where the fumes are preheated by conduction of the stored heat to within 5% of oxidation temperature on their way to the combustion chamber. There is a continuous cycle of alternately storing and releasing heat within three heat-transfer sections, which permits an uninterrupted flow of contaminated process gas through the system at all times.

The regenerative system is simple and reliable, requiring little or no additional fuel, even when fume hydrocarbon levels approach zero. When little or no hydrocarbons are present, only 5% of normally required fuel is needed for oxi-

FUME INCINERATION SYSTEM COSTS*

Type of System	% Heat Recovery	Capital Cost, $/scfm	Operating Cost, $/scfm/year
Afterburner	0	7.00	17.55
Catalytic Converter	70	23.00	2.43
Recuperative Thermal Oxidizer	70	20.00	5.27
Regenerative Thermal Oxidizer	95	28.00	0.96

*Costs based on 10,000 scfm operating 2000 hr/yr; process exhaust fume temperature of 100 F; fuel cost of $6/million Btu. Installation costs for afterburner approx. $30,000-50,000 additional; for the other three approx. $100,000 additional.

Regenerative incineration systems can save up to 40% in fuel consumption compared with other incineration alternatives, and operating costs can be $50,000/yr lower.

dation. In many cases, just a pilot burner is sufficient, when coupled with the 95% preheat efficiency. Up to now, most available systems have been maintenance-intensive, because they use hydraulic or electric valving. However, the newest systems eliminate most of the maintenance because they utilize a single-speed-reducer mechanical valving system.

Regenerative thermal oxidizers are recommended for larger process flows with lower solvent concentrations, because the high primary heat recovery will reduce operating fuel costs. A 5% LEL or greater will result in almost no fuel usage. Investment costs are typically around $280,000, with annual operating costs around $9,300.

RECUPERATIVE VS. REGENERATIVE

The difference between a 95%-efficient regenerative unit and a 65%-efficient recuperative unit, in terms of fuel use, may not be 30%; it may be higher, depending upon the type of burner incorporated. The reason is that the higher the exit temperature (dictated by the unit's preheat efficiency), the greater the amount of fuel required to bring the combustion air to the required temperature. When the net fuel value is calculated along with the preheat efficiency, the actual fuel-use difference could be as high as 40%.

As for operating costs, the actual fuel-cost saving for a 10,000-scfm unit could be over $50,000/yr for the regenerative system, with no solvent present, compared with a typical recuperative system.

To further enhance the economics of regenerative thermal oxidation, the spent fumes, now slightly elevated in temperature, can be reintroduced into the process from which they came or, by use of a heat exchanger, used as building heat. What was once an undesirable pollutant becomes a desirable energy source, replacing up to 60% of the fuel used to heat the process.

A typical regenerative system receiving fumes at 200 F would return the clean air back to the process at 265 F, at 95% preheat efficiency.

CASE HISTORIES IN PLASTICS

As was stated at the beginning of this article, the choice of proper fume incineration system can mean not only that EPA requirements are met, but also that the system could pay for itself and, eventually, lower your cost of manufacturing. A recent example is a major vinyl floor-covering manufacturer, which now meets the new clean-air standards with a regenerative fume incineration system. This firm managed to turn a potentially unprofitable situation into a profitable one.

Its problem was dealing with the VOC's released during the printing of resilient vinyl sheet flooring. By installing a regenerative fume incineration system specifically designed for its needs, the firm has been able to heat the plant with recycled air, resulting in a savings of $58,000/yr in fuel costs.

This processor is realizing additional savings of $200,000/yr in natural gas by using this system, instead of a less-efficient system with a conventional air-to-air exchanger. Thus, payback in cost of fuel alone will come in about four years.

Not every incineration system can have such substantial payback designed into it, because of the many variables involved. But every process must be analyzed not only for potential savings, but also for any changes that may be required in order to meet state and federal codes.

That's because it is no longer sufficient merely to destroy 95% of a facility's emissions. You are also now required to capture a specified quantity of hydrocarbons being generated within your facility, to yield an overall rate of capture/destroy efficiency. This rate depends on a number of variables, such as the nature of the process, type of VOC's emitted, annual production, and geographic location.

In the state of Connecticut, for example, plants doing flexographic printing on vinyl film must achieve a fume capture/destroy efficiency of 60-75%. This percentage may be different for other manufacturers within the state, or for the same sort of operation in other states. To determine what the regulations are for their specific process, manufacturers must check with their regional office of the state air-quality board.

A recent case in point is a firm doing printing on vinyl film. In order to meet local codes, it required a process modification whereby a "loop" was designed between the print stations and the dryer, which previously had been exhausted individually, as well as more efficient collection exhaust hooding. This hooding and recirculating loop lowered the total exhaust volume, while also making incineration more efficient by increasing solvent concentrations.

This new focus on higher fume collection and destruction efficiencies will obviously require higher capital equipment expenditures. Thus, the more efficient and simple the emission-control device, the lower the annual operating expense to offset ever-increasing capital expense. □□

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INTER/PORT

News and Views for the Recreational Boating Industry

Edited and produced in Chicago, Wednesday, December 12, 1990

HAPPY HOLIDAYS! NMMA directors and staff wish you a Merry Christmas and a Happy New Year. *INTER/PORT* will not be published during Christmas week, so look for the next issue on or about January 2.

EPA GIVES STYRENE CLEAN BILL OF HEALTH In a major development for fiberglass boatbuilders and other industries relying on molding processes, the Environmental Protection Agency has decided not to classify styrene as a carcinogen. The decision from EPA's Office of Drinking Water (ODW) comes after review of all existing evidence and the recommendations of its own Science Advisory Board. Comprised of many of the country's top scientists having expertise in this area, the EPA Science Advisory Board went on record as saying that there was no scientific justification for classifying styrene as a "probable human carcinogen."

The decision is particularly significant to boat manufacturers in light of measures included in the recently passed Clean Air Bill that provide for separate consideration of boat building in the development of styrene emission standards. Under the legislation, determination of emission standards must weigh specific capabilities of manufacturers to meet the standards, including economic costs and technical feasibility of proposed pollution control technology -- determinations which rest with the EPA. The ODW did say that it will set a maximum contaminant level for styrene in drinking water, as required by law for other chemicals, but these levels are not anticipated to pose any serious compliance problems for industry.

EPA's new stance on styrene is due in large part to the efforts of the Styrene Information and Research Center (SIRC), an organization which receives substantial funding from NMMA, and has worked closely with association staff and member firms over the past two years to fend off stringent styrene legislation at both state and federal levels. SIRC chairman Ken Harman was encouraged by EPA's decision. "It is consistent with earlier decisions by OSHA and the National Institute of Occupational Safety and Health (NIOSH) and also with the views of the leading scientific panel of the European Community," he said. "All have now agreed that the facts simply are not there to classify, regulate or label styrene as a carcinogen."

The "facts" that Harman refers to are part of a large body of evidence collected and compiled by SIRC over several years and recently presented at the group's annual meeting by Geoffrey Granville of Shell Canada, chairman of SIRC's

continued

FIGURE 8

Influence of Gel Time
on
Styrene Emissions

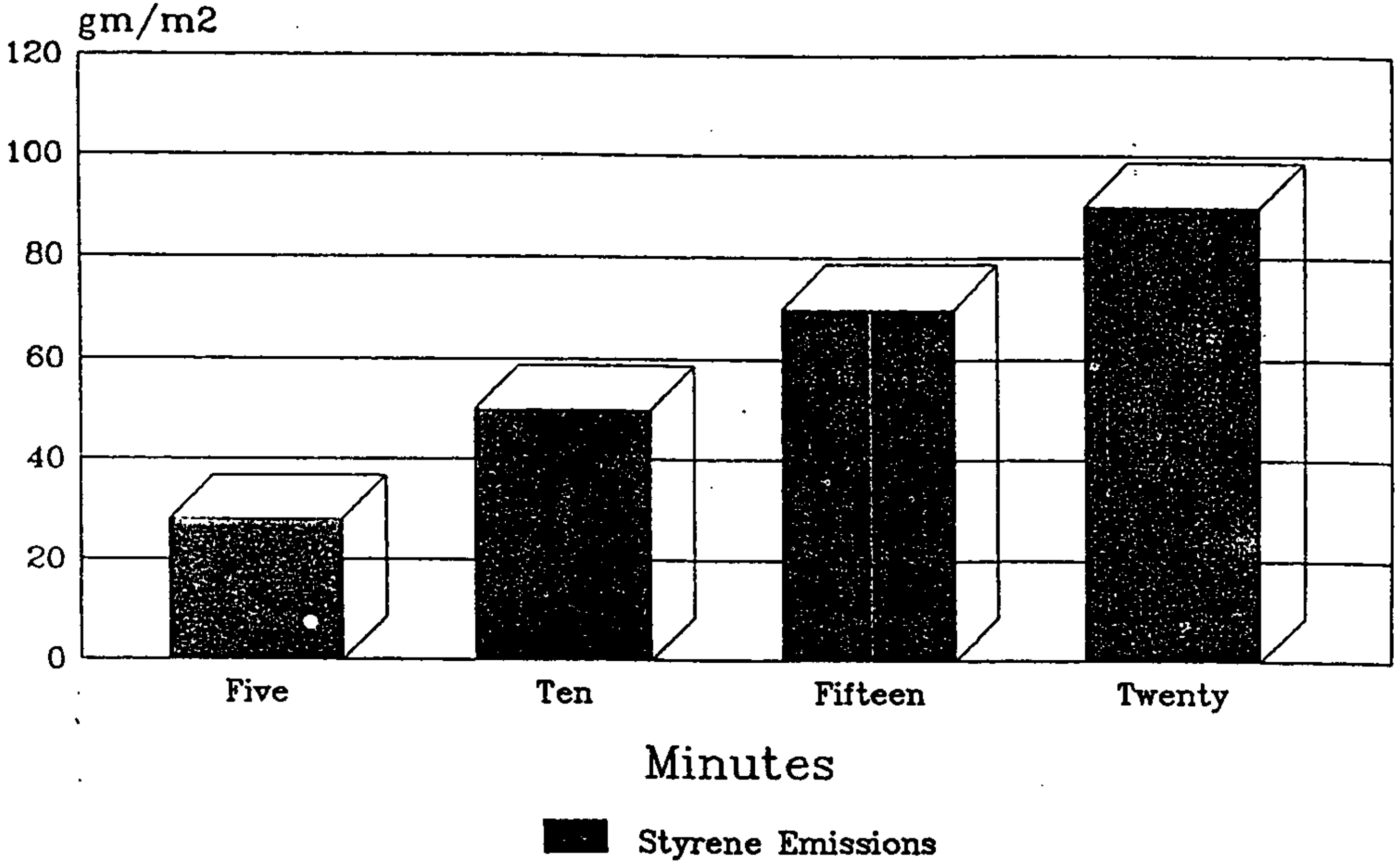


FIGURE 9

Influence of Temperature on Styrene Emissions

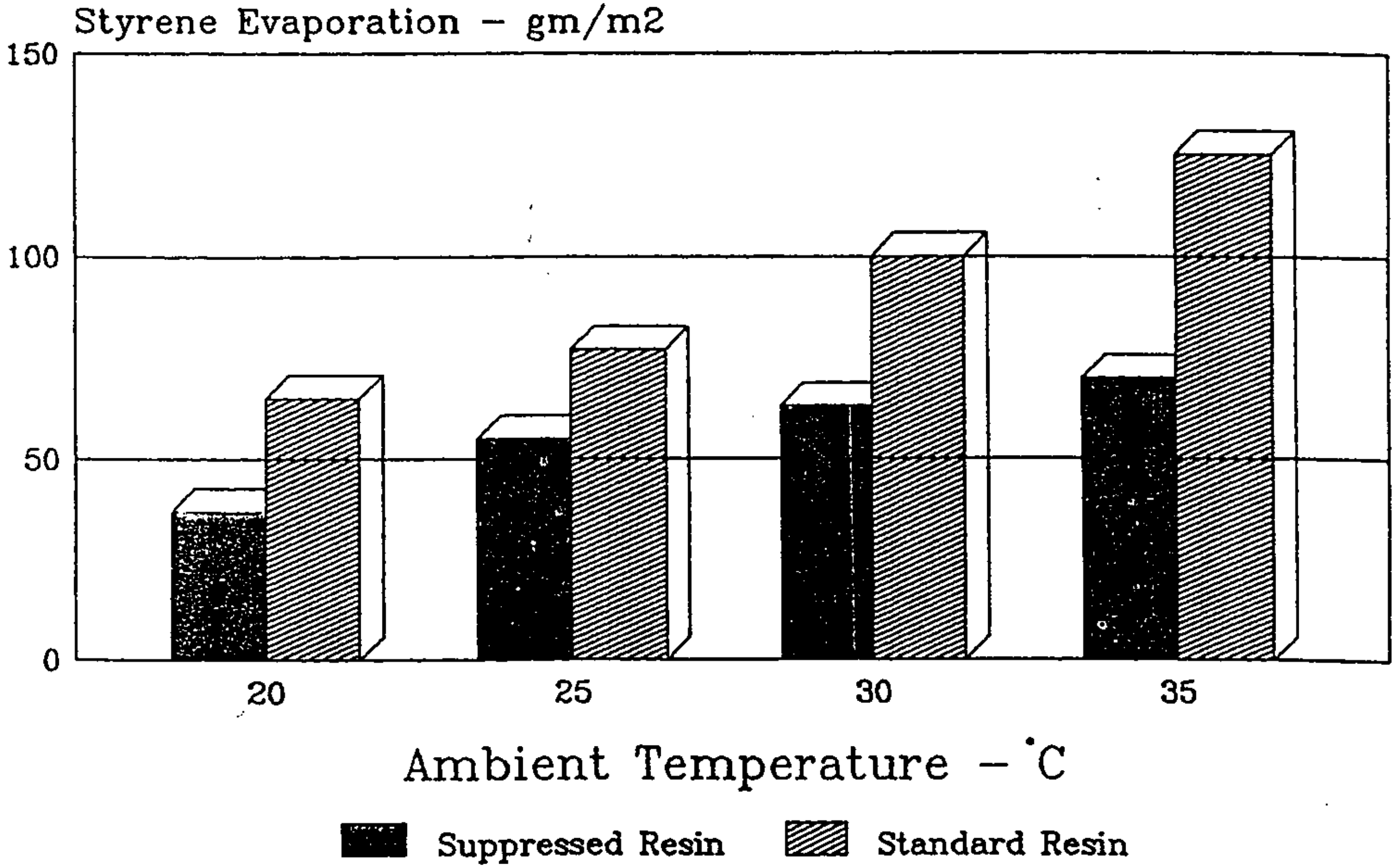


FIGURE 10

Influence of Air Flow Rate
on
Styrene Emissions

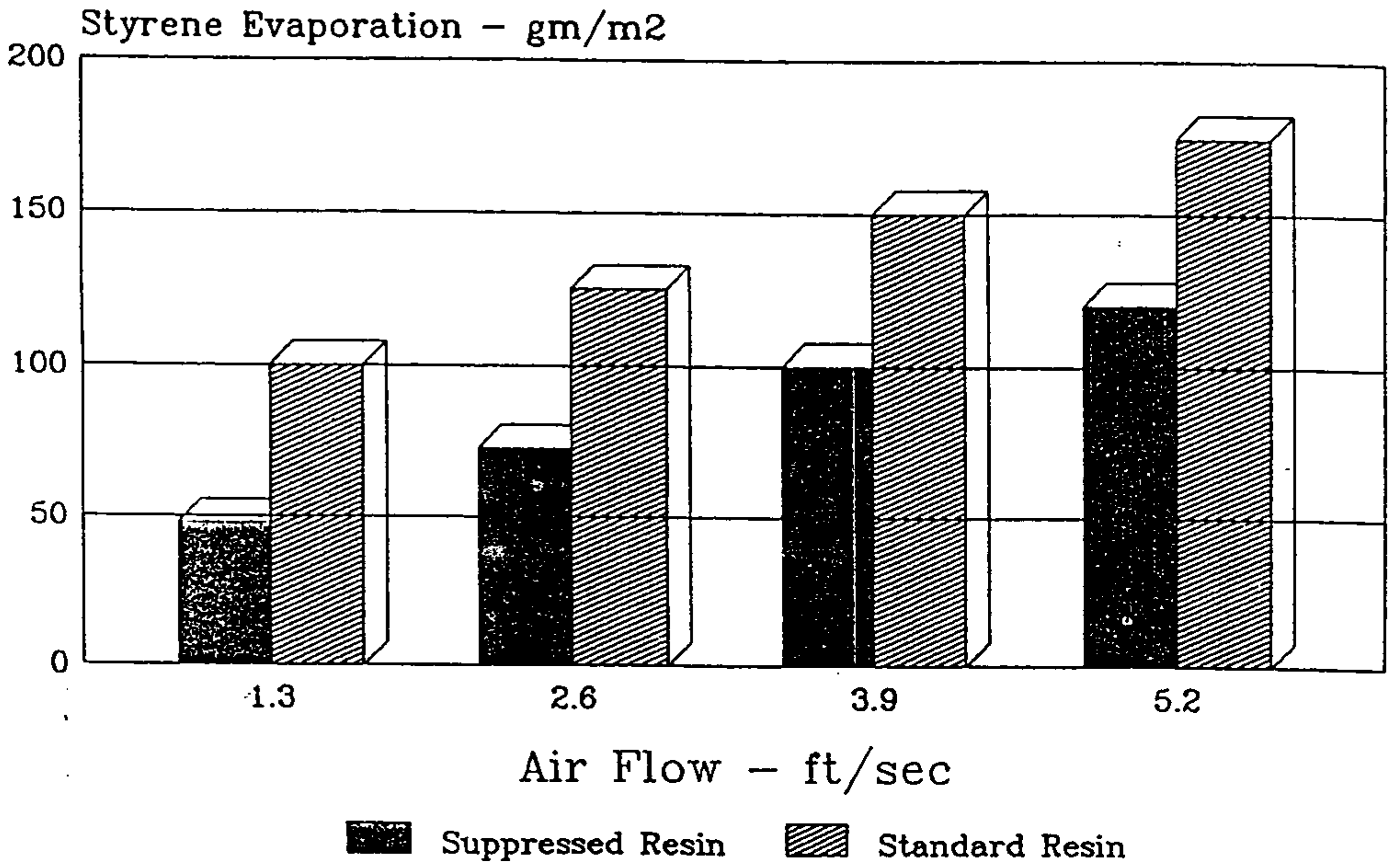


FIGURE 11

Influence of Styrene Content on Styrene Emissions

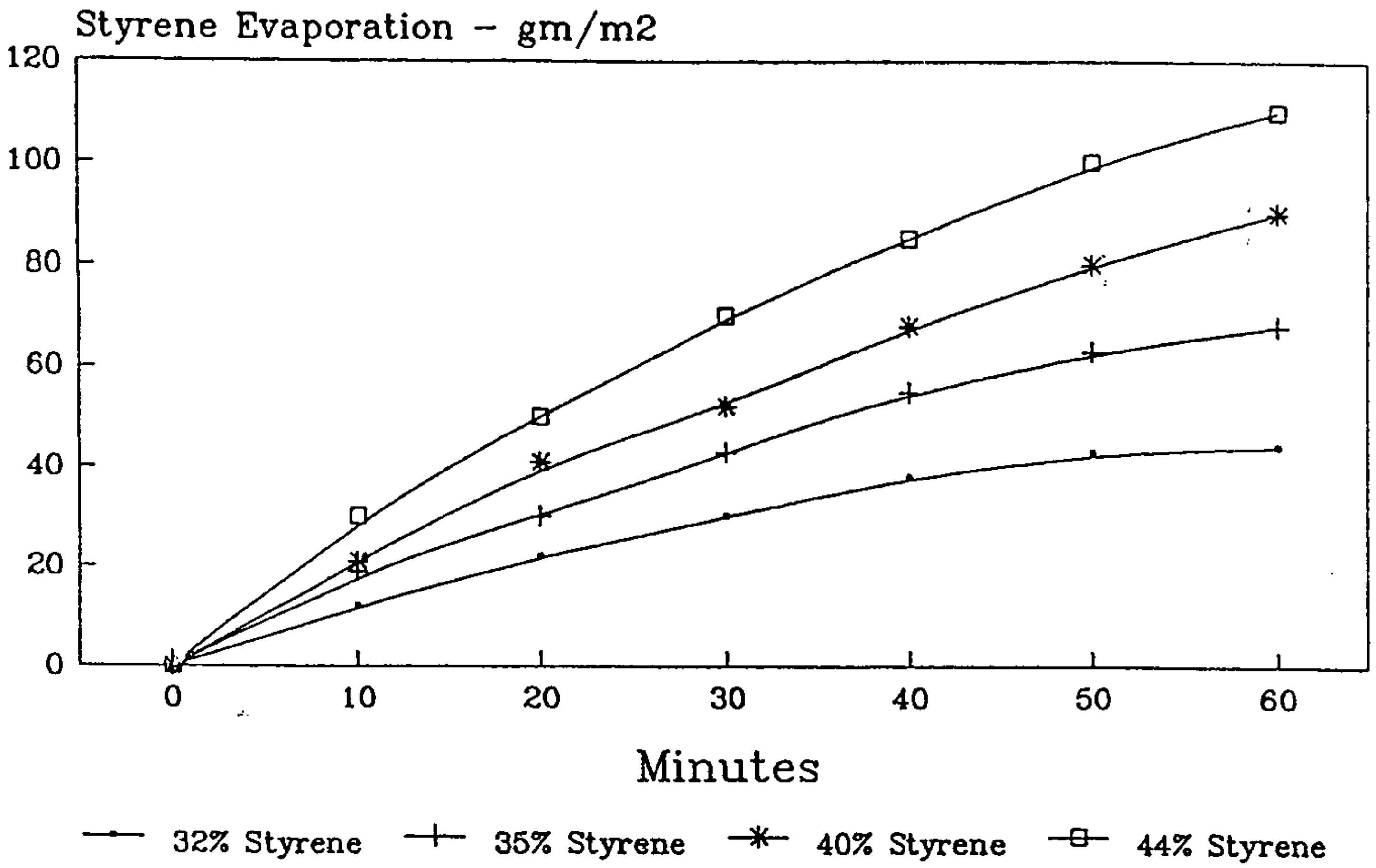


FIGURE 12

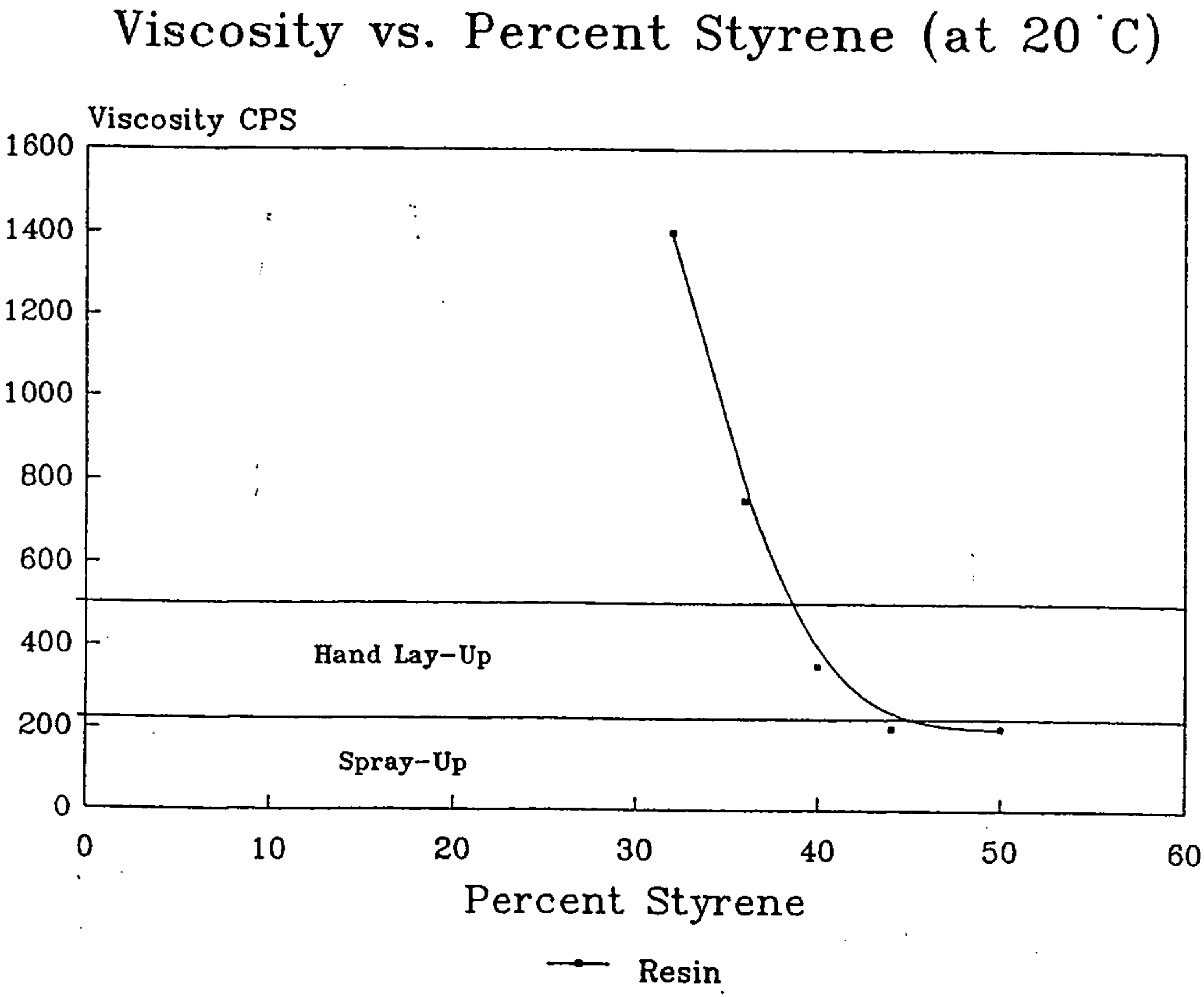
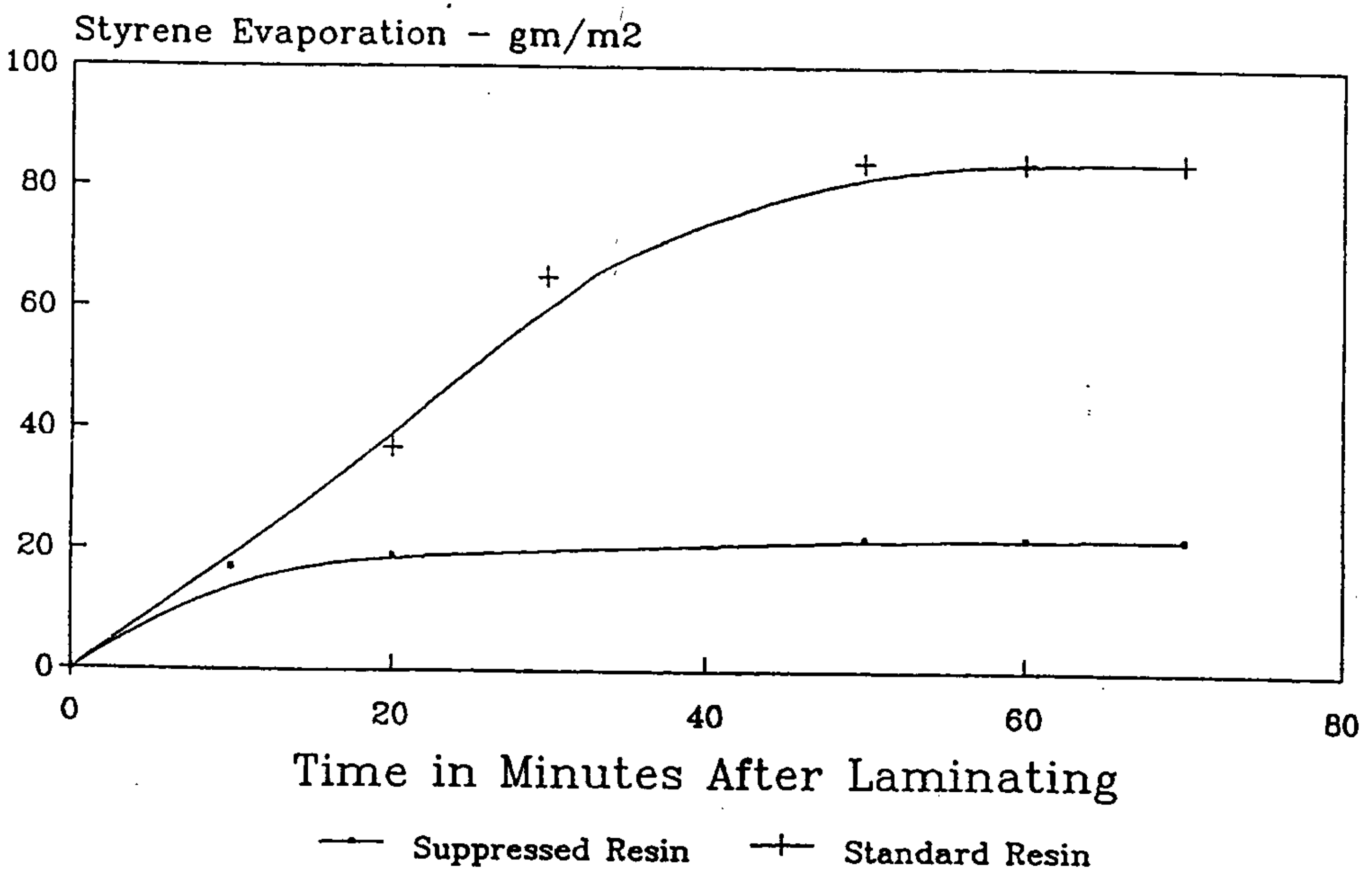

Viscosity vs. Percent Styrene (at 20°C)
Viscosity CPS
1600
1400
1200
1000
800
600
400
200
0
Hand Lay-Up
Spray-Up
0
10
20
30
40
50
60
Percent Styrene
Resin

FIGURE 13

Comparison of Suppressed Resin
and
Standard Resin



Concentration of Styrene in exhaust air stream,

$$5.0\frac{\#}{hr}\cdot\frac{hr}{60min}\cdot\frac{min}{57,075\ ft^3*}\cdot\frac{ft^3}{28.32\ l}\cdot\frac{453,592.4\ mg}{\#}=0.023\ \frac{mg}{l}$$

$$=\underline{5.3\ ppm}$$

Concentration of Acetone in exhaust air stream,

$$19.8\frac{\#}{hr}\cdot\frac{hr}{60min}\cdot\frac{min}{57,075\ ft^3*}\cdot\frac{ft^3}{28.32\ l}\cdot\frac{453,592.4\ mg}{\#}=0.093\frac{mg}{l}$$

$$=\underline{38.75\ ppm}$$

* 6 fans - 19,025 cfm @ 50% efficiency

P.D. 4E.