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Industrial Environmental Research
Laboratory
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Research and Development

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EPA

Project Summary

Assessment of Organic Emissions in the Flexible Packaging Industry

Inks, coatings, and adhesives used in the manufacturing of flexible packaging materials must be dried before the product can be stored or used further. This step is accomplished in the drying portion of the process machine, where heated air is blown over the web of material as it passes through the machine. It is the discharge of solvents removed by the heated air during the drying process that gives rise to emissions of volatile organic compounds (VOC).

The purpose of this project was to study emissions of volatile organic compounds by the flexible packaging industry and to determine the effectiveness and cost of available means for controlling these emissions. The Flexible Packaging Association (FPA) cooperated in the program by conducting a survey to provide current data about the flexible packaging industry, particularly with regard to the solvents used and experience with control systems

A questionnaire was designed to provide data on solvent use and emissions from the flexible packaging industry. Of the 1,136 questionnaires mailed out, 13.6% resulted in responses that have been incorporated into this analysis. This survey covers responses from 154 flexible packaging plants, containing 799 prime machines.

This Project Summary was developed by EPA's Industrial Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Survey Results

The largest annual solvent use reported in this survey was for a two-plant complex using almost 9 million lb/yr; the smallest plant use was less than 1,000 lb/yr. Eighty-one plants use less than 500,000 lb of solvent per year. Although these 81 locations account for more than 50% of the total number of plants, they use less than 5% of the total solvents reported in the survey.

Inks account for approximately 50% of the total solvents used by the respondents. More than 17% was used in coatings, a similar amount in adhesives, and about 14% was used in varnishes, cleaners, and other uses combined.

Table 1 gives a summary of some of the survey data. It can be seen that flexographic presses are the most common type of machine, and also that these presses were smaller on the average. Gravure presses were the next most common, and as they were generally considerably larger, these presses consumed the most solvent. A broad range of both water-soluble and insoluble solvents were used, a fact which can complicate efforts to reclaim solvents.

Table 1. *Flexible Packaging Machine Data*

	Presses: Flexo	Presses: Gravure	Laminators	Coaters	Priming Stations	Combination Machines	TOTAL
No. Reporting	366	153	88	59	47	86	799
Percent	46	19	11	7	6	11	100%
Solvent Usage[1] (MM Gal/year)							
Alcohols	26.2	7.0	2.3	2.4	4.1	2.0	44.0
Ketones	.3	5.3	5.3	2.6	0.8	1.3	15.6
Esters	8.2	21.6	3.8	3.0	0.6	0.8	38.0
Hydrocarbons	2.2	14.9	6.8	11.3	0.5	0.6	36.3
Other	2.2	0.6	0.6	0.3	0.1	0.7	4.5
TOTAL	39.1	49.4	18.7	19.6	6.1	5.4	138.4
Median Stack Volume, SCFM[2]	5,000	16,000	8,000	11,000	10,000	8,000	-----
Exhaust VOC Median ppm[3]	350	140	249	400	166	---	-----
Median 1,000's pounds/year	60	127	50	151	67	---	-----

(1) 146 plants reporting usable data out of 154 responding
(2) 498 machines reporting usable data out of 799 responding
(3) 711 machines reporting usable data out of 799 responding

Cost Estimates

To obtain an estimate of the cost of controlling VOC, the costs of incinerators and activated carbon adsorption units were obtained from manufacturers and from the literature. There was considerable variation in the cost figures obtained, especially in the costs of incinerators, where the spread in values was approximately ±50%. Equations were developed to estimate capital and annual costs of equipment to control VOC emissions based on machine size and operation.

Cost figures based on annual cost and dollars/pounds of VOC removed were calculated for 342 machines that had responded to the survey with sufficient data. Costs were calculated for thermal incineration without heat recovery, thermal incineration with 70% heat recovery, activated carbon with steam regeneration, without credit for recovered solvent, and activated carbon, including a condensate disposal charge. From the cost data, the following conclusions can be drawn:

1. For 84% of the machines, activated carbon was the least expensive VOC control method; incineration with 70% heat recovery was less costly on 15% of the machines, and incineration without heat recovery was least expensive on only 1% of the machines. When a charge for condensate disposal was included, activated carbon adsorption was still the least expensive option for 70% of the machines.

2. Average costs per pound of solvent vapor removed ranged upward from less than $0.10/lb VOC. The distribution of these costs (in percent) for various control technologies are shown in Table 2.

3. For activated carbon units, the costs associated with capital charges, maintenance, and labor are the major part of the annual costs, ranging from 60% for some of the larger, more heavily used machines, to over 90% for smaller units that are used only on a part-time basis. When condensate disposal is necessary, this cost can vary from less than 10% of the total annual cost to over 80% if this control technique were to be applied to a gas stream of high VOC content.

For incinerators, except when the VOC content of the exhaust is high and for very small or rarely used units, fuel costs are the major portion of the annual expenses; and because of this, heat recovery is almost always economical. The 70% heat recovery level considered here was found to be economical in most cases in spite of the higher capital costs. Units with up to 90% heat recovery are available at increased capital costs.

4. In general, the annual costs for such items as capital, maintenance, labor, fuel, and water increase almost in proportion to the amount of contaminated air sent through the control device (SCFM). As the amount of VOC in the incoming air increases, the cost of incineration decreases, since the heat-value of the VOC replaces part of the fuel required to reach incineration temperature; the cost of activated carbon adsorption increases, since regeneration is more frequent and there may be cost of condensate disposal if the solvent is water soluble. This study indicates that when condensate disposal is required, the break-even point is in the range of 500 to 700 ppm VOC; below this point, activated carbon usually is less expensive; and above, incineration with heat recovery will be less costly, with, of course, some overlap. When the solvents are not water soluble and condensate disposal is thus not required, this break-even range increases to 900 to 1,000 ppm.

Table 2.

Cost Range ($/lb VOC)	Carbon (1)	Adsorption (2)	Incineration: No Heat Recovery	Incineration: 70% Heat Recovery	Least Expensive Technique (2)
Under $0.50	31	8	1	17	19
$0.50-$1.00	22	34	12	20	27
$1.00-$3.00	29	37	30	32	35
Over $3.00	18	21	57	31	19

(1) Charge for disposal of steam regeneration condensate not included.
(2) Includes charge for activated carbon steam regeneration condensate disposal.

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The complete report, entitled "Assessment of Organic Emissions in the Flexible Packaging Industry," (Order No. PB 81-135 378; Cost: $12.50; subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
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