IN-DEPTH SURVEY REPORT:

CONTROL OF AIRBORNE SOLVENTS IN A SMALL OFFSET PRINT SHOP

at

Economy Printing
Parchment, Michigan

REPORT WRITTEN BY
Keith G Crouch
Michael G Gressel

REPORT DATE
September 1996

REPORT NO
ECTB 205-12a

U S DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health
Division of Physical Sciences and Engineering
4676 Columbia Parkway, R5
Cincinnati, Ohio 45226

PLANT SURVEYED	Economy Printing 600 Shopper's Lane Parchment, Michigan 49004
SIC CODE	2752
SURVEY DATE	May 8-10 & 22-24, 1995
SURVEY CONDUCTED BY	Keith G Crouch Dennis M O'Brien Daniel R Farwick Donald J Murdock, Jr
EMPLOYER REPRESENTATIVE CONTACTED	Bruce Hannapel President Economy Printing
EMPLOYEE REPRESENTATIVE CONTACTED	No Union
ANALYTICAL WORK PERFORMED BY	Data Chem
MANUSCRIPT PREPARED BY	Bernice L Clark Robin Smith

DISCLAIMER

Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention (CDC)

INTRODUCTION

This report contains the results of personal exposure and area sampling for airborne solvent vapors conducted at a small printing establishment during two visits in May 1995 Also included are the sampling methods, the exposure standards, ventilation flow measurements, and some recommendations for follow-up work Between the visits, a heat recovery ventilator (HRV) containing an air-to-air heat exchanger (United Air Specialists, Inc , Cincinnati, OH) was installed to remove stale air and supply fresh dilution air to the two press rooms The sampling data provided a basis for evaluating the effectiveness of the HRV in reducing personal exposure levels to the airborne solvent vapors

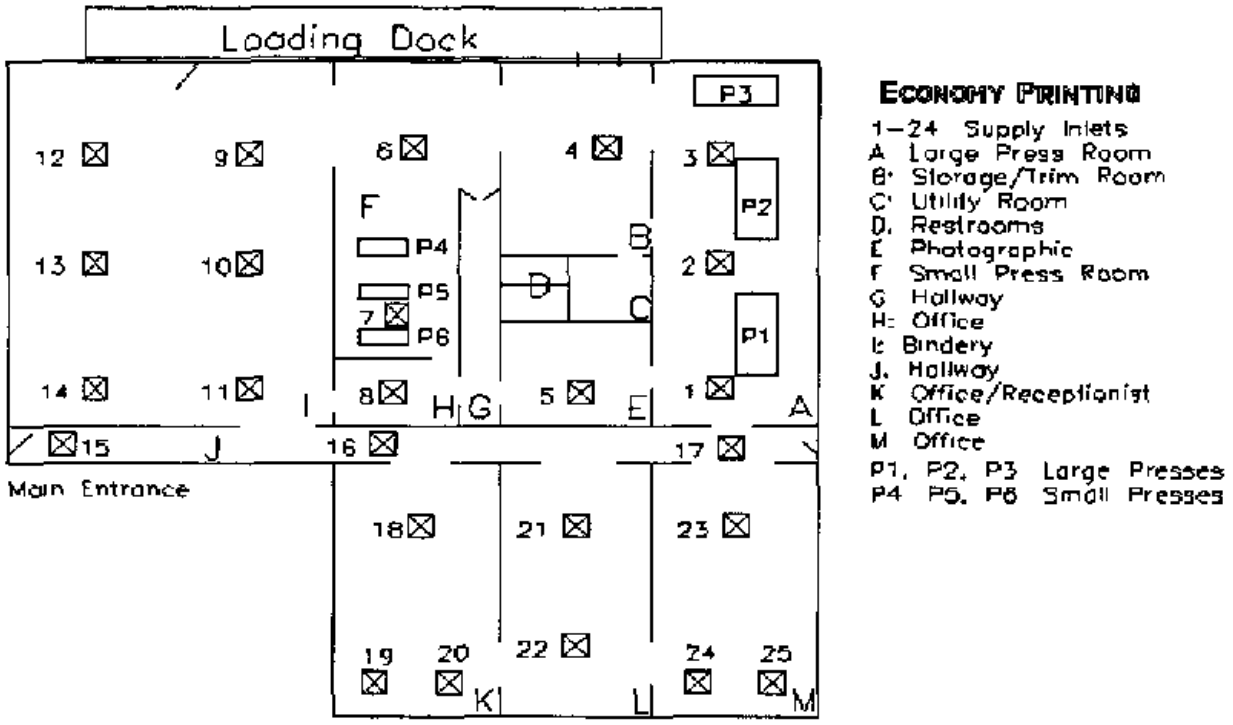
SOLVENT EXPOSURES: AIRBORNE AND SKIN CONTACT

Time-weighted average concentrations of airborne solvent vapors that the press operators were exposed to are shown in Tables 1-6 Tables 3 and 5 cover the same operator Employees are exposed to several solvent vapors simultaneously, and these vapors have some adverse health effects in common Therefore, additive levels are shown in bar charts, as well as levels for the individual species Because their concentrations were negligible compared to the other solvents, the contribution to the additive concentrations of 1,1,1 trichloroethane, toluene, ethyl benzene, and cumene were not shown Definition of the exposure standards is given in Attachment 1, and details of the calculation of the additive exposure levels can be found in Attachment 2

The horizontal bar charts of cumulative exposures and Table 8 show that before the fresh air supply was added, six of eight personal exposure samples for the press operators were at or above 50 percent of the Permissible Exposure Limit (PEL) After the addition of a fresh air supply, no exposures were above 50 percent of the PEL These results are based upon the narcotic effects of the solvents, which is the basis for the PELs for all the solvents except methylene chloride and benzene For these two solvents, the PEL or proposed PEL is based upon their potential carcinogenic effects For purposes of estimating additive exposures only, the PELs for narcotic effects for methylene chloride and benzene were approximated as 200 ppm, based upon statements found in the toxicological literature [Federal Register, 29 CFR Parts 1910, 1915 and 1926, Occupational Exposure to Methylene Chloride, Proposed Rule, 56 (216) 57080-57081, 1991, and Documentation of the Threshold Limit Values and Biological Exposure Indices, Benzene, ACGIH, 1991, p 113] These two compounds are not, in this case, large contributors to the cumulative PEL, so even moderate errors in estimating their narcotic PELs would have little or no effect on our conclusions

However, based upon the carcinogenic potential of methylene chloride, after installation of the fresh air system, two samples for the press operators were still over the Recommended Exposure Limit (REL) of 25 ppm, and one was between the REL and 50 percent of the REL See Attachment 2 for further details The NIOSH action level for methylene chloride is 12 5 ppm

Tables 7 and 8 show cumulative concentrations before and after control installation The average cumulative concentration as determined by the area sampling was reduced by 58±11% (95%



confidence interval) as a result of control installation The average cumulative concentration determined from the personal sampling was reduced by 54±13% These concentrations were not normalized for solvent usage rates, and day-to-day variations are obviously large, so the contribution of the control to concentration reduction has significant uncertainty

Skin contact with solvents can cause dermatitis, and some can be absorbed through the skin Press operators should wear impermeable gloves when performing cleaning operations Solvent manufacturers can suggest appropriate glove materials (on the Material Safety Data Sheets) Methylene chloride, toluene, xylene, ethyl benzene, and cumene, for example, can all be absorbed through the skin to a significant extent, in addition to the airborne route of exposure Therefore, press operators may have higher solvent exposures than indicated by the results of our airborne sampling In order to evaluate the total absorbed from these multiple exposure routes, biological sampling of the employee's blood, urine, or expired air is necessary The primary concern in this study was the airborne exposure route, since the skin absorption route can be controlled through the use of gloves, so biological sampling was not conducted If glove wearing cannot be assured, it would be necessary to carry out biological sampling of the press operators to see if the additional absorption through skin contact resulted in a health hazard

VENTILATION SYSTEMS

The facility had two HVAC systems that mixed and recirculated the air throughout the building They had no provision for the introduction of outside air Three supply inlets (1, 2, and 3) fed by an HVAC system provided 512 cfm total to the large press room Two inlets (7 and 8) supplied 222 cfm total to the small press room The two return inlets for these building HVAC systems

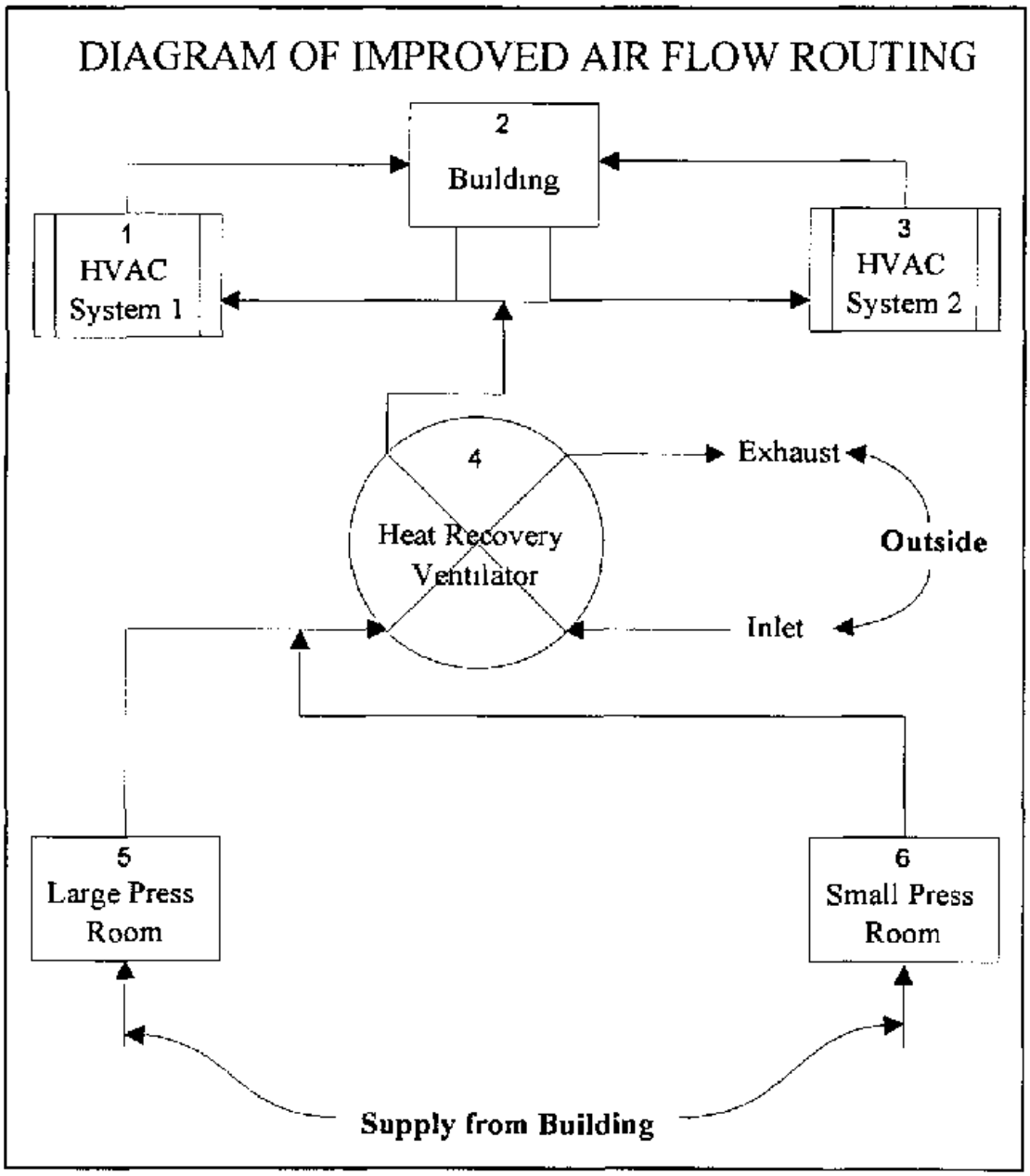
were located in the hallway (J) and in an office, room L

The new fresh air system, which includes the air-to-air heat exchanger, supplied a total of 742 cfm of fresh air, 427 cfm to the large press room, and 315 cfm to the small press room It removed a total of about 716 cfm from the press areas, 406 cfm from the large press room, and 310 cfm from the small press room In each of the press rooms, the fresh air was admitted from ceiling outlets at one end of the room and removed from ceiling inlets at the other end of the room In a smoke release study, some of the smoke released in the press rooms tended to drift slowly into adjacent areas of the building

RECOMMENDATIONS

Although the addition of the fresh air system did reduce solvent vapor concentrations, significant further improvement can be made at little additional cost

The solvent concentration data shows a relatively uniform distribution of solvent vapors throughout the building The aim of the following modifications is to contain the solvent emissions to the press rooms and prevent their spread throughout the building This will facilitate the control of the airborne solvents and reduce the exposure of non-press personnel To begin, the two press rooms should be maintained at a negative pressure with respect to other areas of the building This can be accomplished, in part, by closing off the large openings between the press rooms and other areas with a combination of walls and/or doors Second, the fresh air system ducting should be partially redone Please refer to the Diagram on the following page It should still exhaust all of its air from the two press rooms, but the fresh makeup air should be routed into the return side of the two building HVAC systems, rather than directly into the two press rooms, as it does currently The rate of flow through the supply inlets for the HVAC systems in the two



press rooms should be reduced to maintain a slight negative pressure These measures will ensure that the makeup air for the press rooms will flow into the rooms from adjacent areas of the building, reducing the spread of airborne material out of the press rooms Finally, by placing the exhaust inlets for the fresh air system as close as possible to the solvent emission sites on the presses, the solvent concentrations in the press rooms can also be minimized On the small presses, a single exhaust point near the paper delivery point (see the photo) has been effective On the large, two-color presses, an additional exhaust point near the roller train for the second color would be necessary for good control

If effective substitutes can be found, replace solvents that contain methylene chloride with ones that are free of it Be sure that the replacement solvents contain no potentially carcinogenic or otherwise highly toxic components (avoid benzene, for example)

The following suggestions affect the maintenance and efficiency of the ventilation control systems discussed above The ducts should be smooth on the inside and have a circular cross-section This minimizes dust accumulation in the duct and resistance to air flow Also, round duct withstands larger negative pressures, and can be cleaned, in contrast to most flexible, corrugated, or rectangular duct The duct should be sized to maintain at least 3000 feet per minute air velocity in the duct to prevent settling and accumulation of the anti-offset powder inside horizontal duct runs There should be a dust filter at the inlet to the fresh air system to protect the air-to-air heat exchanger from degradation caused by dust accumulation The use of an electrostatic precipitator at this point might also be effective The anti-offset powder can otherwise build up quickly, resulting in a recurrent maintenance problem

If these recommended changes are made, employee exposures to solvents should be reduced below levels currently considered or anticipated to be hazardous The nuisance caused by anti-offset dust from the printing operations settling throughout the building can be largely avoided

TABLE 1
LARGE PRESS OPERATOR A

	CONCENTRATION, ppm						
Solvent	5/9/95	5/10/95	5/23/95	5/24/95	TLV	REL	PEL
Methylene Chloride	19 6	36 2	31 9	10 4	50	25	500
1,1,1 Trichloroethane	3 4	6 4	0 0	0 0	350	350	350
Toluene	0 2	0 2	0 1	0 1	50	100	100
Xylene	2 7	4 9	2 9	1 2	100	100	100
Ethyl Benzene	0 8	1 6	0 9	0 4	100	100	100
Cumene	0 1	0 1	0 1	0 0	50	50	50
Trimethyl Benzene	2 3	2 6	1 6	0 9	25	25	25
Other Hydrocarbons*	15 8	23 1	13 8	6 8	*100	*60	*500
Sampling Time, min	481	432	435	516			

* - Treated as Stoddard Solvent

TABLE 2
LARGE PRESS OPERATOR B

	CONCENTRATION, ppm						
Solvent	5/9/95	5/10/95	5/23/95	5/24/95	TLV	REL	PEL
Methylene Chloride	9 0	26 4	31 9	10 4	50	25	500
1,1,1 Trichloroethane	2 1	0 1	0 0	0 0	350	350	350
Toluene	0 2	0 2	0 2	0 1	50	100	100
Xylene	1 9	3 7	1 5	0 9	100	100	100
Ethyl Benzene	0 6	1 2	0 4	0 2	100	100	100
Cumene	0 1	0 1	0 1	0 1	50	50	50
Trimethyl Benzene	2 3	3 3	1 6	1 8	25	25	25
Other Hydrocarbons*	12 7	21 3	10 8	7 6	*100	*60	*500
Sampling Time, min	442	507	444	226			

* - Treated as Stoddard Solvent

TABLE 3
LARGE PRESS OPERATOR C

Solvent	CONCENTRATION, ppm 5/23/95	5/24/95	TLV	REL	PEL
Methylene Chloride	17 3	9 1	50	25	500
1,1,1 Trichlorocthane	0 0	0 0	350	350	350
Toluene	0 1	0 1	50	100	100
Xylene	1 8	1 0	100	100	100
Ethyl Benzene	0 5	2 9	100	100	100
Cumene	0 1	0 0	50	50	50
Trimethyl Benzene	1 3	0 7	25	25	25
Other Hydrocarbons*	11 0	5 3	*100	*60	*500
Sampling Time, min	507	531			

* - Treated as Stoddard Solvent

TABLE 4
SMALL PRESS OPERATOR A

Solvent	CONCENTRATION, ppm 5/9/95	5/10/95	5/23/95	5/24/95	TLV	REL	PEL
Methylene Chloride	43 3	53 9	34 2	4 2	50	25	500
1,1,1 Trichloroethane	0 5	0 6	0 0	0 0	350	350	350
Toluene	0 1	0 2	0 1	0 0	50	100	100
Xylene	4 7	6 4	3 3	0 7	100	100	100
Ethyl Benzene	1 6	2 0	1 0	0 2	100	100	100
Cumene	0 0	0 1	0 0	0 0	50	50	50
Trimethyl Benzene	1 3	1 6	0 6	0 3	25	25	25
Other Hydrocarbons*	18 7	25 4	13 8	2 9	*100	*60	*500
Sampling Time, min	491	488	464	134			

* - Treated as Stoddard Solvent

TABLE 5
SMALL PRESS OPERATOR B

Solvent	Concentration, ppm 5/9/95	TLV	REL	PEL
Methylene Chloride	42 0	50	25	500
1,1,1 Trichloroethane	0 4	350	350	350
Toluene	0 2	50	100	100
Xylene	5 5	100	100	100
Ethyl Benzene	1 8	100	100	100
Cumene	0 1	50	50	50
Trimethyl Benzene	2 0	25	25	25
Total Hydrocarbons*	8 2	*100	*60	*500
Sampling Time, min.	332			

* - Treated as Stoddard Solvent

TABLE 6
SMALL PRESS OPERATOR C

Solvent	CONCENTRATION, ppm 5/10/95	5/23/95	5/24/95	TLV	REL	PEL
Methylene Chloride	36 2	22 5	13 2	50	25	500
1,1,1 Trichloroethane	7 4	0 0	0 0	350	350	350
Toluene	0 2	0 1	0 0	50	100	100
Xylene	7 0	3 8	2 2	100	100	100
Ethyl Benzene	2 2	1 1	0 7	100	100	100
Cumene	0 1	0 0	0 0	50	50	50
Trimethyl Benzene	1 9	0 5	0 4	25	25	25
Total Hydrocarbons*	25 3	14 1	8 9	*100	*60	*500
Sampling Time, mn	474	453	495			

* - Treated as Stoddard Solvent

Table 7. Summary of area sampling data.

	Before				After			
Date	9		10		23		24	
Area	Cumulative	MeCl	Cumulative	MeCl	Cumulative	MeCl	Cumulative	MeCl
Large Press	0 24	0 44	0 42	0 81	0 16	0 38	0 08	0 11
Small Press	0 37	0,97	0 43	0,97	0 17	0 46	0 09	0 17
Reception	0 18	0 39	0 31	0 71	0 26	0,74	0 06	0,11
Bindery	0 2	0,52	0 32	0 68	0 12	0 38	0 08	0 19
Photo	0 22	0 42	0 39	1 1	0 14	0 37	0 06	0 12
Supply	0 19	0 37	0 35	1 1	0 12	0 34	0 06	0 1
Trim	*	*	*	*	0 21	0 56	0 1	0 15
Average	0,23	0 52	0,37	0,90	0,17	0,46	0,08	0,14

Cumulative Average Before 0 30
Cumulative Average After 0 12
MeCl Average Before 0 71
MeCl Average After 0 30

* = Data not collected

Cumulative = Cumulative concentration relative to the PEL, using 200 ppm for the PEL of methylene chloride

MeCl = Concentration of methylene chloride relative to its carcinogenic PEL of 25 ppm

% Reduction in Cumulative concentration, 58 +/- 11 (95% confidence interval)

% Reduction in methylene chloride concentration, 52 +/- 16 (95% confidence interval)

Table 8. Summary of personal sampling data.

	Before				After			
Date	9		10		23		24	
Area	Cumulative	MeCl	Cumulative	MeCl	Cumulative	MeCl	Cumulative	MeCl
Press Operator 1	0 38	0 79	0 58	1 47	0 38	1 29	0 17	0 42
Press Operator 2	0 26	0 37	0 50	1.07	0 25	0.54	0 08	0 07
Press Operator 3	0 52	1 76	0 67	2.19	0 36	1.39	0 07	0 17
Press Operator 4	0 59	1 70	*	*	0 26	0 70	0 13	0 37
Press Operator 5	*	*	0 59	1 47	0 31	0 91	0 19	0 53
Average	0.44	1.16	0 59	1.55	0.31	0.97	0 13	0.31

Cumulative Average Before 0 51
Cumulative Average After 0 22
MeCl Average Before 1 35
MeCl Average After 0 64

* = Worker absent
Cumulative = Cumulative concentration relative to the PEL, using 200 ppm for the PEL of methylene chloride
MeCl = Concentration of methylene chloride relative to its carcinogenic PEL of 25 ppm

% Reduction in Cumulative concentration, 54 +/- 13 (95% confidence interval)
% Reduction in methylene chloride concentration, 45 +/- 23 (95% confidence interval)

ATTACHMENT 1
EXPOSURE STANDARDS

The term *time-weighted average* (TWA) is applied to an exposure which is averaged over the duration of the sampling, typically for a full shift

TLVs - The American Conference of Governmental Industrial Hygienists (ACGIH) recommends exposure limits for chemical and physical agents These limits are called Threshold Limit Values or TLVs and are widely recognized in the field of industrial hygiene They are updated yearly as new information becomes available

(American Conference of Governmental Industrial Hygienists *1993-1994 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices* Cincinnati ACGIH, 1993)

(American Conference of Governmental Industrial Hygienists *Annual Reports of the Committees on Threshold Limit Values and Biological Exposure Indices* Cincinnati ACGIH, 1994)

PELs - The Occupational Safety and Health Administration (OSHA) is the federal regulatory agency which promulgates and enforces the legal limits for exposures to chemical and physical agents They are called PELs, or Permissible Exposure Limits Few changes have been made in the PELs since OSHA was originated in 1971, and they are not generally considered to be the most protective limits

(*Air Contaminants*, Code of Federal Regulations Title 29, Part 1910 1000 1993)

RELs - The National Institute for Occupational Safety and Health (NIOSH) is a federal research organization which recommends limits for chemical and physical agents They are called Recommended Exposure Limits, or RELs, and are widely recognized in the field of industrial hygiene NIOSH's criteria for establishing standards are based on health effects and the most sensitive method available for measuring contaminants, so RELs are often lower than other limits

(National Institute for Occupational Safety and Health Pocket Guide to Chemical Hazards, DHHS(NIOSH) Publication No 94-116 Cincinnati NIOSH, 1994)

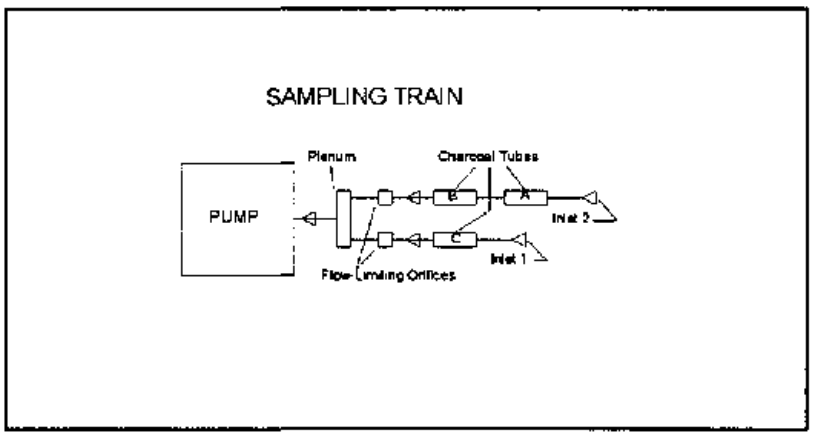
ATTACHMENT 2
PRINTING PROCESSES AND AIRBORNE SAMPLING METHODS

Employees are involved in sales, layout, duplication, bindery, and press operations The primary airborne contaminants are generated by press cleanup operations of the plate, rollers, and other press components of the seven offset lithographic presses Also, normal press operation involves some evaporation of ink solvents and fountain solutions Because of their proximity, the press operators could be expected to have the highest exposures to these airborne emissions

The sources of the airborne emissions of concern are likely the following products

Lithographic Press Wash, Econo Wash - Low Odor (*RBP Chemical Corp*)
Fast Dry Blanket and Roller Wash, #10-00860 (*Rogersol, Inc*)

Full-shift personal sampling for solvents contained in these products was conducted on five employees for all or part of four days Also, area sampling was conducted at six locations inside the building and one outside The results are shown in Tables 1-8 and in the charts titled Concentrations Relative to the PEL The personal sampling was discontinued during the employees' lunch break, and at other times when they left the building, and resumed when they returned The area sampling proceeded continuously throughout the day



Both the personal and the area sampling made use of the sampling train shown in the diagram The sampling inlets for the personal sampling were located in the breathing zone of the individuals, clipped to their collars The collection medium was coconut shell charcoal tubes (100 mg/50 mg) Air for charcoal tubes A and B entered through inlet 2 at a rate of 10 cm^3/min The charcoal tubes were analyzed using gas chromatography for the following species according to the NIOSH Manual of Analytical Methods 1003 and 1005 with modifications 1,1,1-Trichloroethane and Methylene Chloride Air for charcoal tube C entered through inlet 1 at a rate of 50 cm^3/min These charcoal tubes were analyzed by gas chromatography using Methods 1501 and 1550 with modifications for the following species Toluene, Xylene, Ethyl Benzene, Cumene, Trimethylbenzene and Total Hydrocarbons

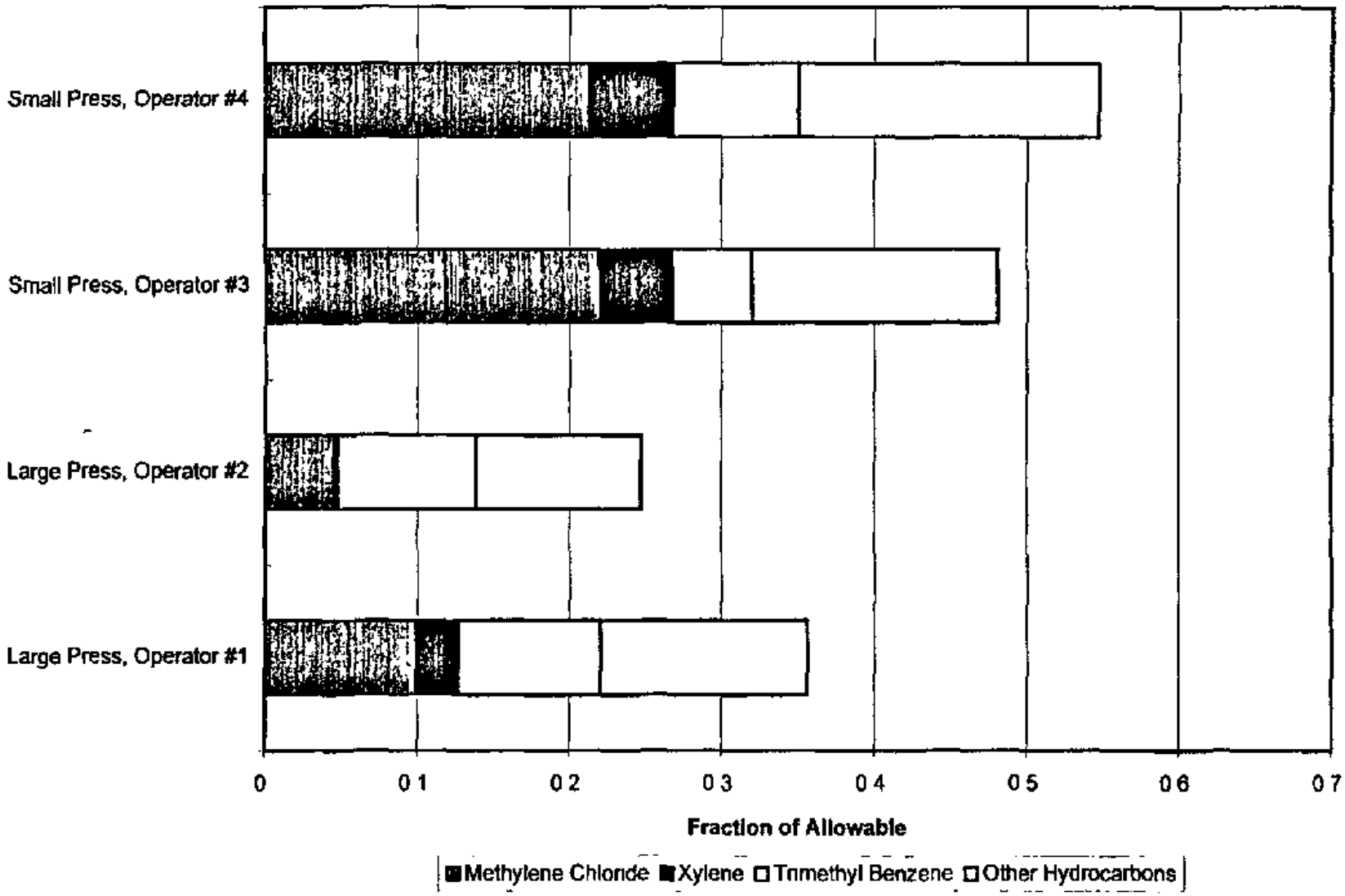
Additive exposures were calculated using the formula

$$C_1/L_1 + C_2/L_2 + \quad = \text{Additive Exposure},$$

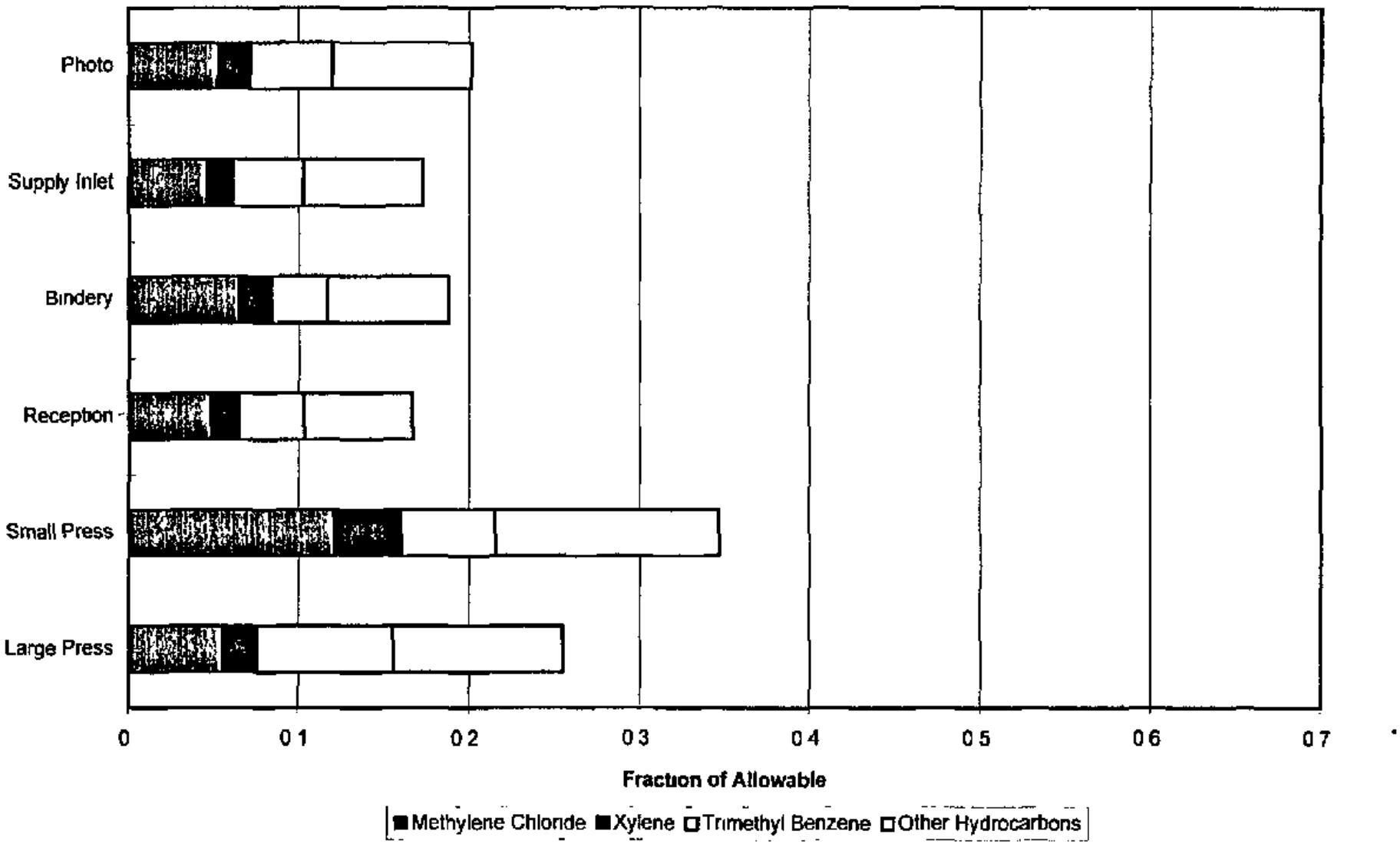
where C is the measured exposure for a species and L is the corresponding exposure limit Additive exposures greater than 1 0 are considered overexposures

Tables 1-6 show the personal sampling results for the charcoal tube measurements The additive exposures for both personal and area sampling are shown in the bar charts, and in Tables 7 and 8 Note that the current exposure standards are given in the tables Also, the exposure standard used to calculate the contribution to additive exposures for methylene chloride was estimated, based upon its narcotic effects A PEL of 200 ppm, and a TLV and REL of 100 ppm, established to avoid its narcotic effects, were used for the additive exposures The additive exposures can, therefore, be considered as only an approximate indicator of potential narcotic effects

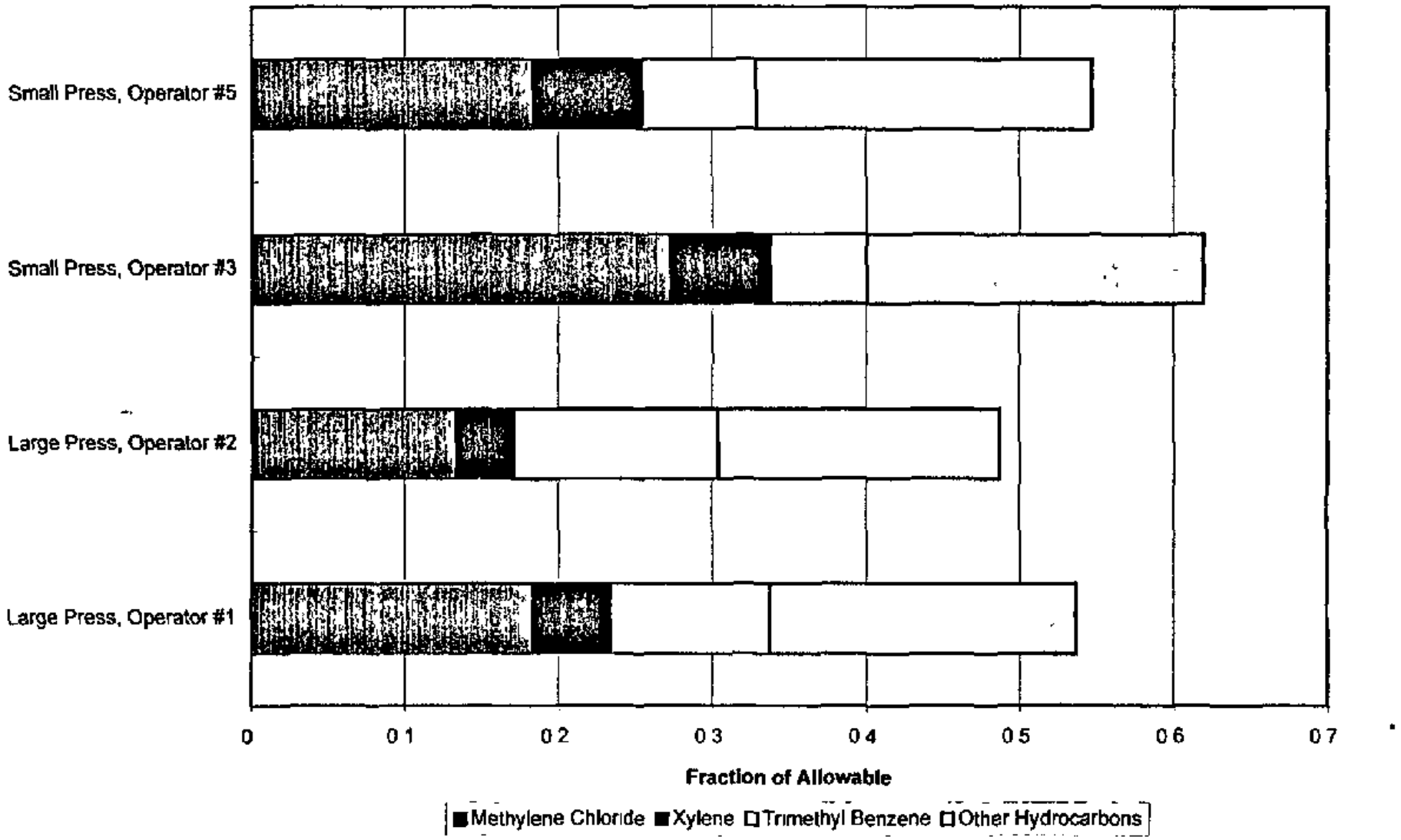
Concentrations Relative to the PEL, Economy Printing, May 9, 1995. Personal Samples.



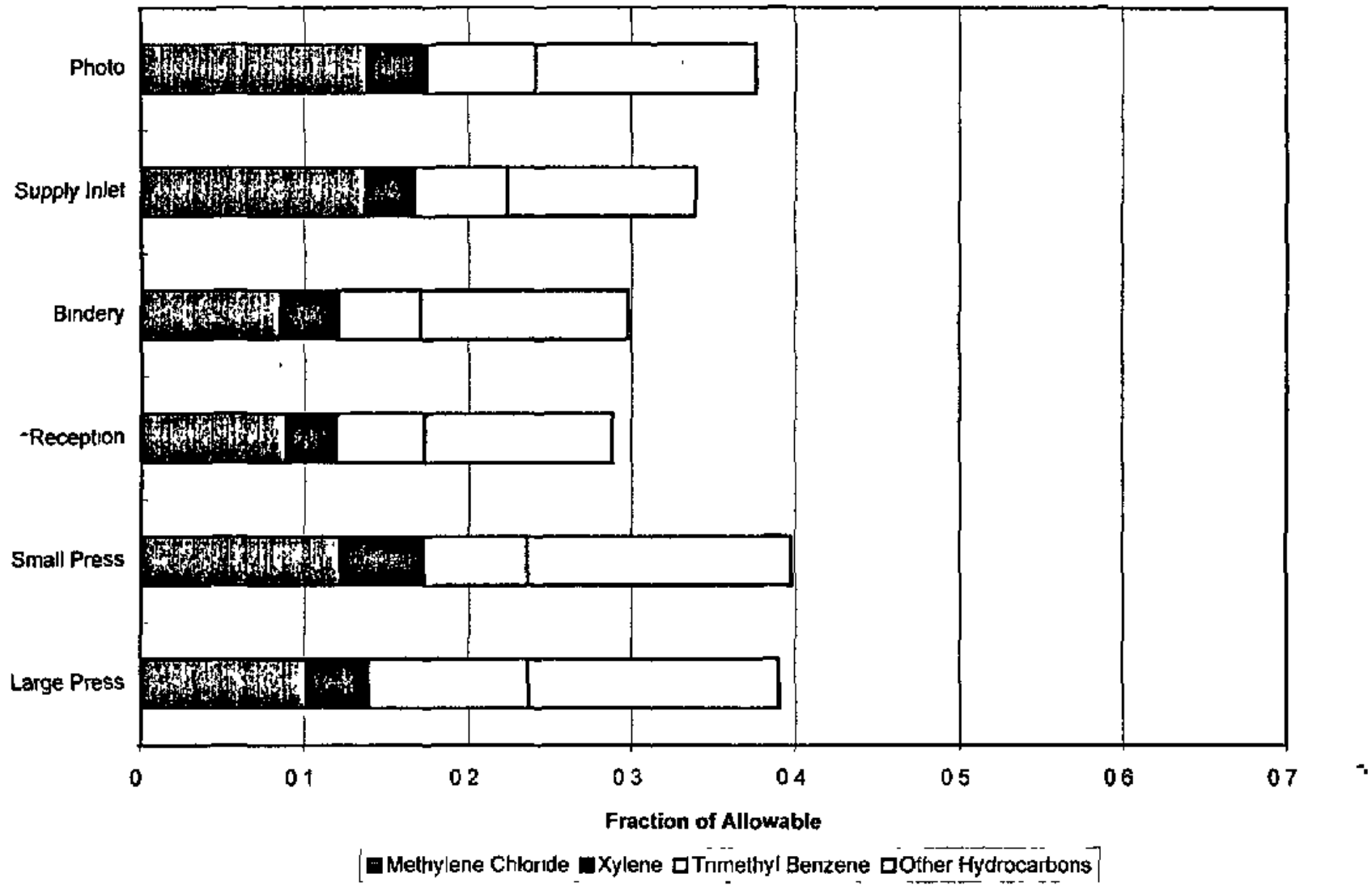
Concentrations Relative to the PEL, Economy Printing, May 9, 1995. Area Samples.



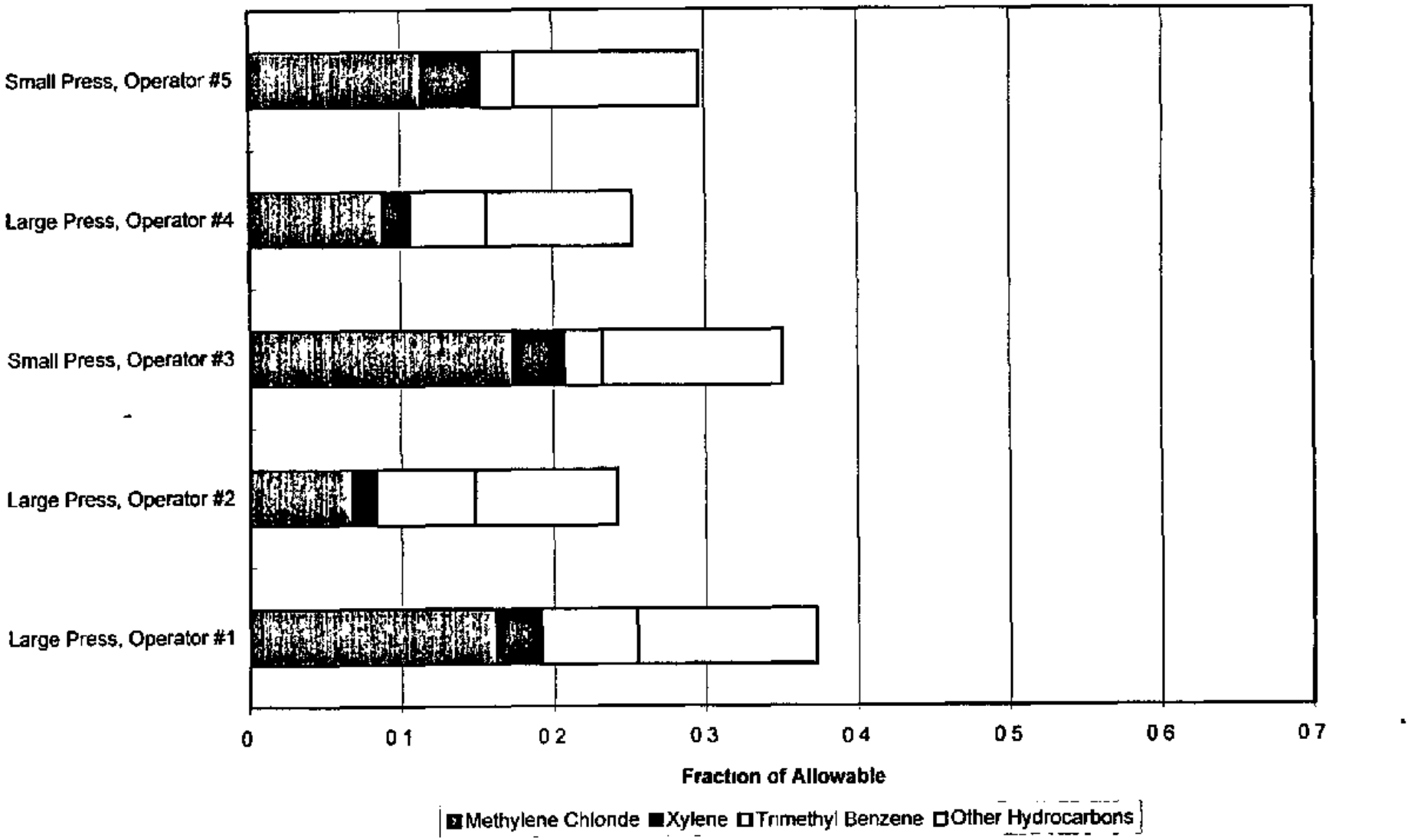
Concentrations Relative to the PEL, Economy Printing, May 10, 1995. Personal Samples.



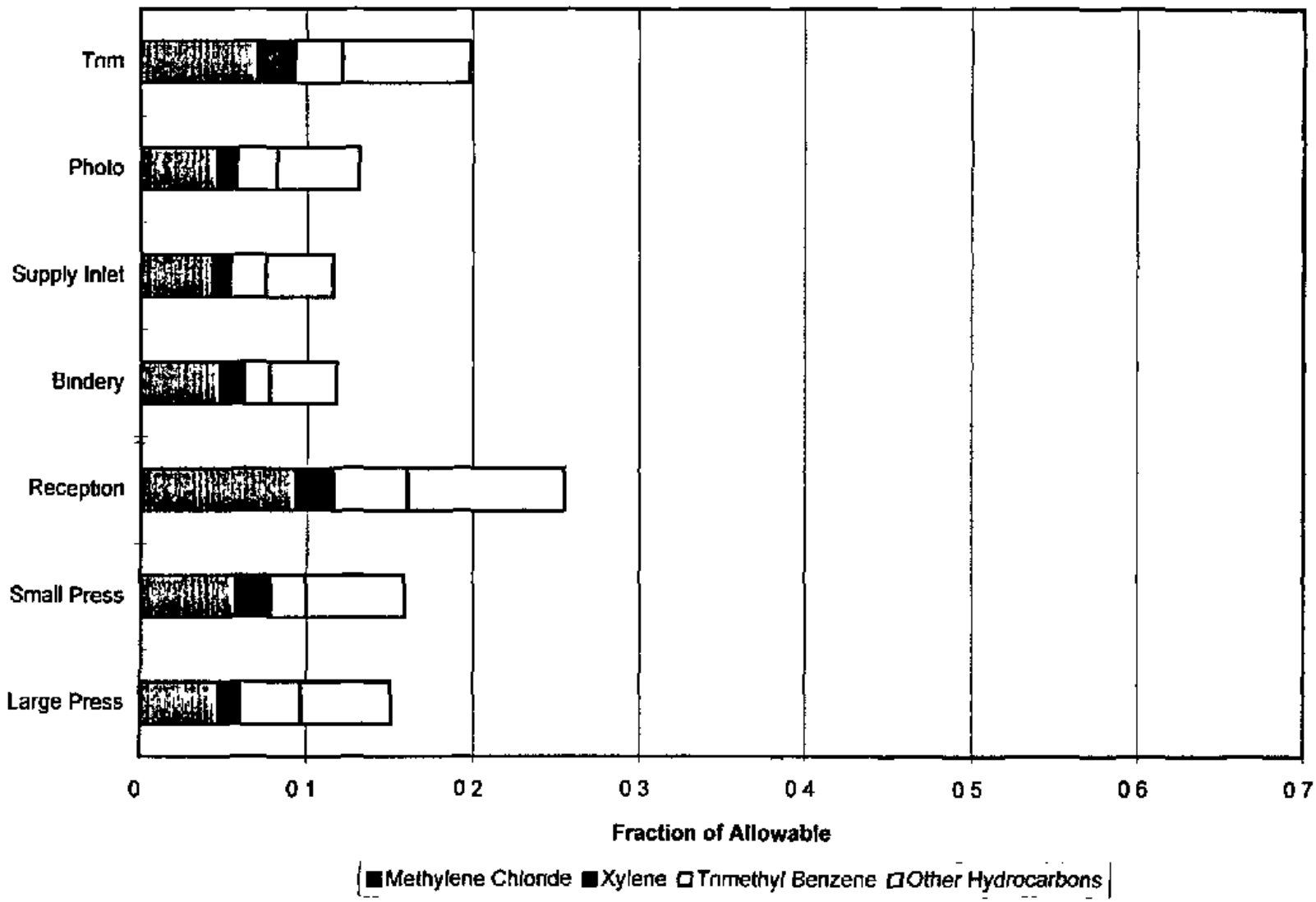
Concentrations Relative to the PEL, Economy Printing, May 10, 1995. Area Samples.



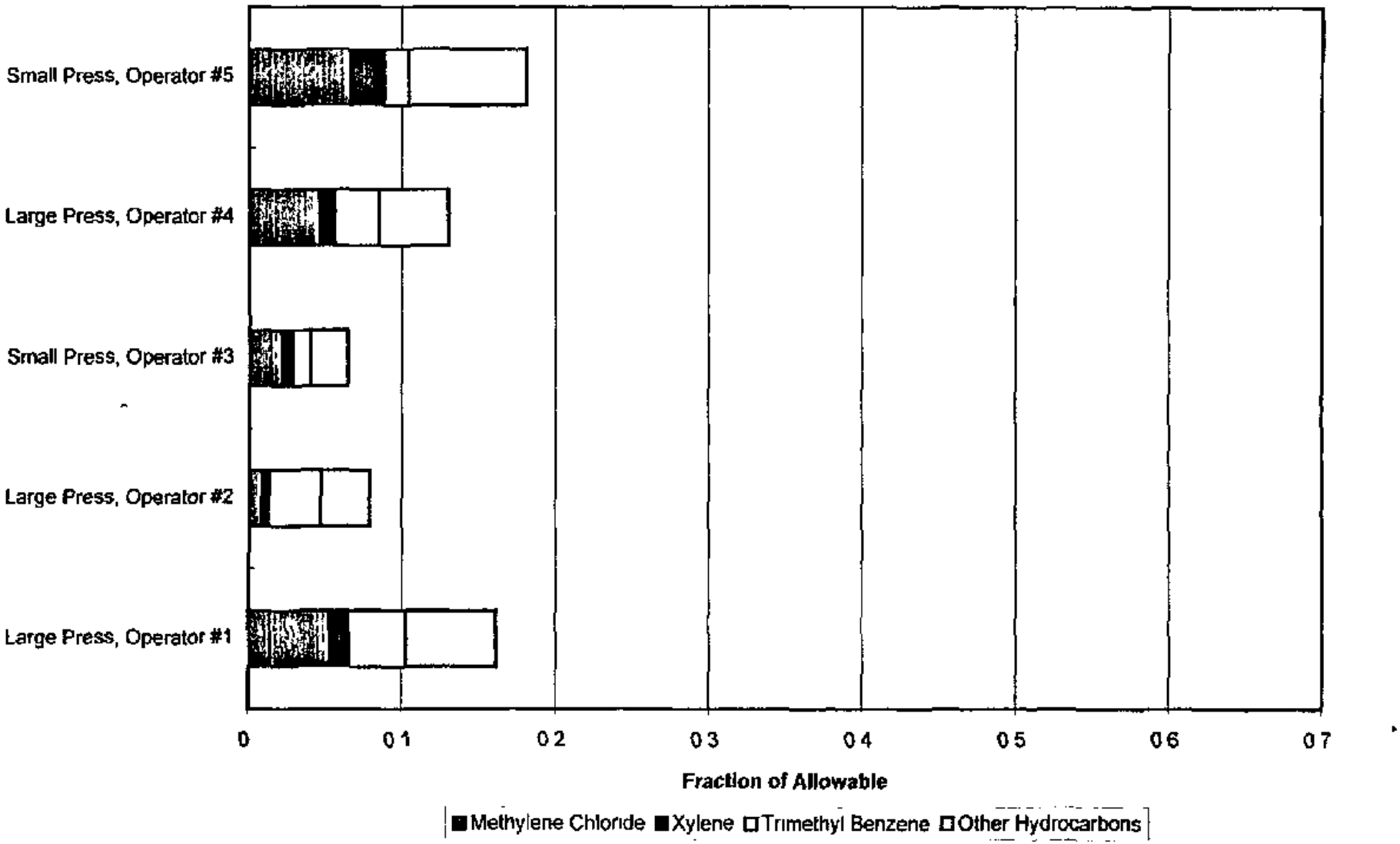
Concentrations Relative to the PEL, Economy Printing, May 23, 1995. Personal Samples.



Concentrations Relative to the PEL, Economy Printing, May 23, 1995. Area Samples.



Concentrations Relative to the PEL, Economy Printing, May 24, 1995. Personal Samples.



Concentrations Relative to the PEL, Economy Printing, May 24, 1995. Area Samples.