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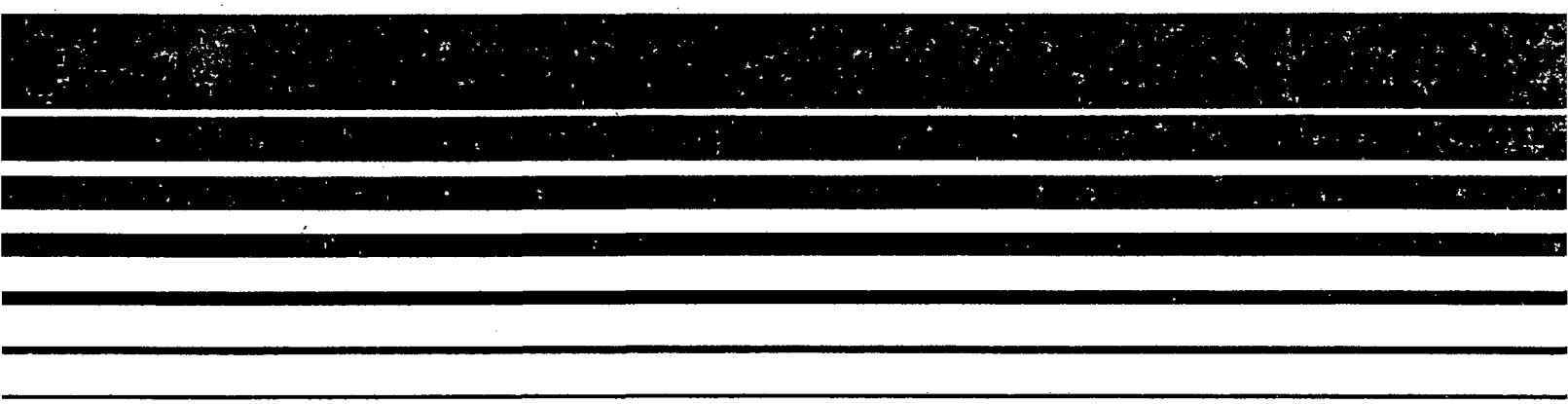
Emission Test Report General Tire and Rubber Company Reading, Massachusetts

Test Series 2



PROCESS EMISSION TESTS AT THE GENERAL TIRE AND RUBBER COMPANY VINYL-COATED FABRIC PLANT IN READING, MASSACHUSETTS MARCH, 1981

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PREFACE

The work described herein was conducted by personnel from TRC Environmental Consultants, Inc. (TRC), the Radian Corporation, Engineering Science, General Tire and Rubber Company (GTR) in Reading, Massachusetts, and the United States Environmental Protection Agency (EPA).

The scope of work was issued under EPA Contract No. 68-02-3543, Work Assignment 2. The work was performed under the supervision of the TRC Work Assignment Manager Mr. Samuel S. Cha.

Radian personnel responsible for monitoring process operations during the testing program included Mr. Hal Laube, Senior Engineer, and Ms. Nancy Krohn, Chemical Engineer. Engineering Science was responsible for fabric residual solvent analyses. Personnel of the GTR Reading, Massachusetts, plant whose assistance and guidance contributed greatly to the success of the test program include Mr. Henry Waldron, Senior Process Engineer.

Ms. Nancy D. McLaughlin, Office of Air Quality Planning and Standards, Emission Measurement Branch, EPA served as Task Manager and was responsible for coordinating the test program.

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1.0 INTRODUCTION

1.1 Background

Section 111 of the Clean Air Act of 1970 charges the Administrator of the U.S. Environmental Protection Agency (EPA) with the responsibility of establishing Federal standards of performance for new stationary sources which may significantly contribute to air pollution. When promulgated, these standards of performance for new stationary sources are to reflect the degree of emission limitation achievable through application of the best demonstrated emission control technology. EPA utilizes emission data, obtained from controlled sources in the particular industry under consideration, as a partial basis for new source performance standards.

The EPA Office of Air Quality Planning and Standards selected the General Tire and Rubber Company (GTR) vinyl-coated fabric plant in Reading, Massachusetts, as a site for an emission testing program. This plant produces wallcoverings and is considered to employ process and emission control equipment representative of the state-of-the-art in the vinyl coating industry. The test program was designed to provide a portion of the emission data base required for the vinyl-coating industry new source performance standards.

EPA engaged TRC to measure volatile organic compound (VOC) emissions from the printing operation at the GTR plant. Most measurements were conducted during times of normal operation of the wallcovering printing process and associated emission control equipment. Some special operating conditions were established for the purposes of this measurement program. The measurement program was conducted during March 16-27, 1981, and was the second EPA test conducted at this plant. The first test was performed by TRC in September and October 1980 (1), but because of printing process and emission control operation problems a second test was needed.

1.2 Brief Process Description

Figure 1-1 presents an overhead view of the plant facilities associated with the printing operation, and Figure 1-2 presents a schematic of the printing operation. This process is described very basically in the following paragraphs.

The printing operation consists of a Baker-Perkins rotogravure printing machine utilizing six printing heads. The vinyl-coated substrate is fed through a preliminary dryer, the six print heads, and an embossing unit. Premixed ink is supplied to each print head from a pump tank located next to each print head. Ink is pumped from the pump tank to a tray within the print head where a print roller, half-submerged in the tray, transfers ink from the tray to the substrate. The inked substrate is dried in an oven contained within each print head. Excess ink is gravity fed back to the pump tank. During a print run, solvent or ink base is occasionally added manually to the pump tanks to maintain the required ink viscosity. The solvent used in the inks is primarily methyl ethyl ketone (MEK) with some methyl isobutyl ketone (MIBK) and toluene.

Emissions from the preliminary dryer and print head ovens are manifolded and ducted to a carbon adsorption (CA) unit before being released to the atmosphere. The CA unit has three carbon beds, but only beds 1 and 3 were used during the test program. Emissions from the embosser are controlled with an electrostatic precipitator (ESP). Fugitive emissions within the print-line building are vented to the atmosphere through a pair of wall exhaust fans. Air is supplied to the print-line building by a make-up fan on the roof and from seven doors that open to the outside and to other areas of the plant. During the test program only one wall fan was operated and then only briefly. The make-up fan was off at all times. All doors but one were closed.

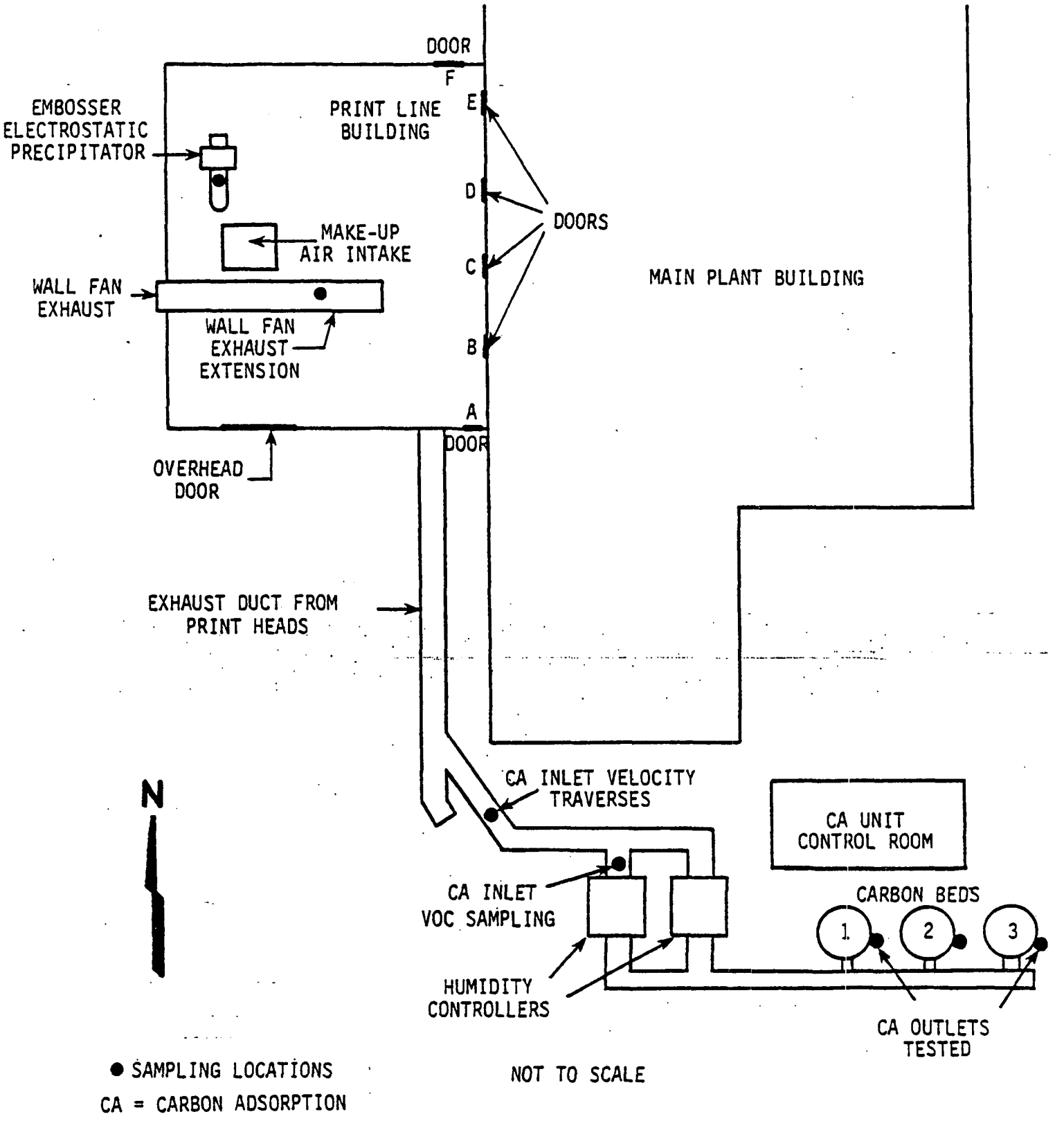
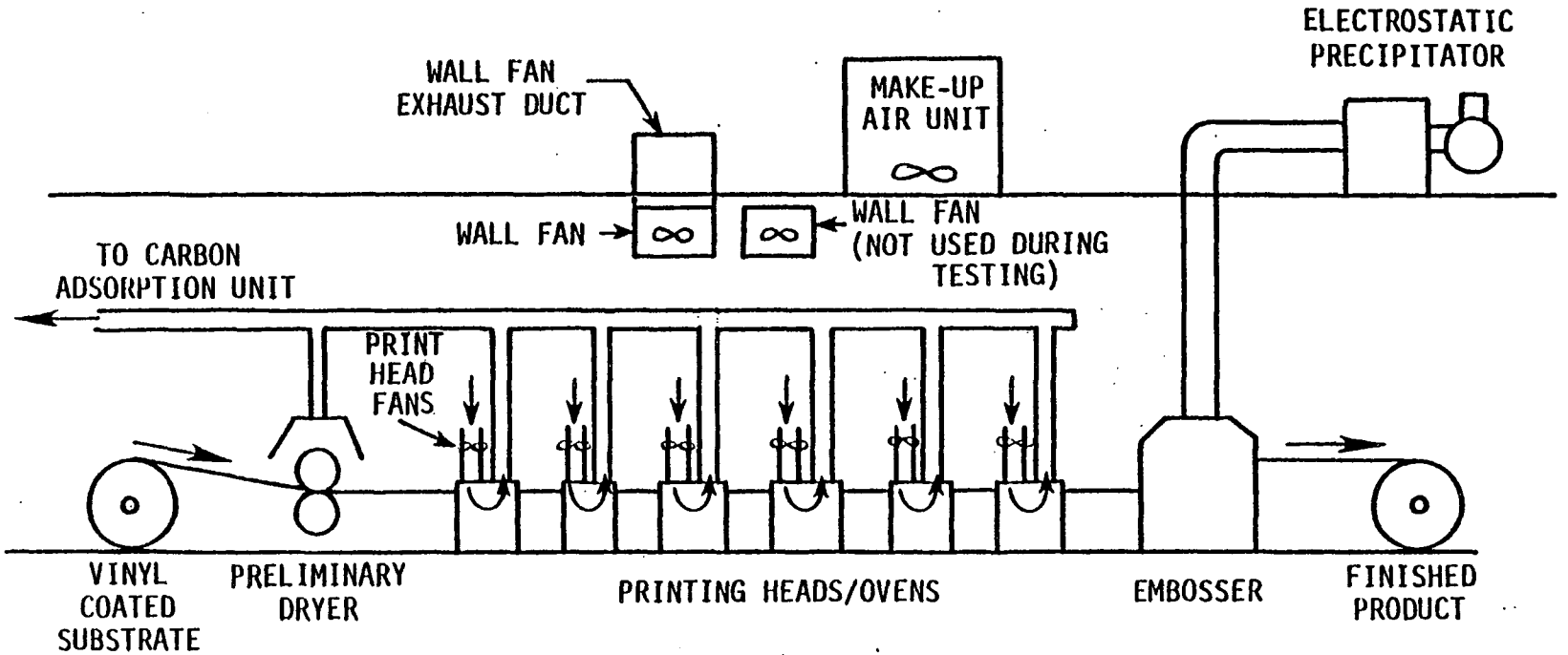


FIGURE 1-1: OVERHEAD DIAGRAM OF PRINTING OPERATION FACILITIES AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS



NOT TO SCALE

FIGURE 1-2: SCHEMATIC OF PRINT-LINE OPERATION AT GENERAL TIRE AND RUBBER COMPANY READING, MASSACHUSETTES

1.3 Measurement Program

The measurement program was conducted at the GTR vinyl-coated fabric plant in Reading, Massachusetts during March 16-27, 1981. The emission tests were designed to quantify controlled and uncontrolled VOC emissions from the printing process. General sampling locations are shown in Figure 1-1. The measurement program consisted of the following:

Flowrate Measurements

Velocity traverses were performed at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets. Flowrates were calculated from the velocity head and temperature data obtained during these traverses. Measurements were performed in accordance with EPA Methods 1 and 2.

VOC Measurements by FID Analyzer

VOC concentrations were continuously monitored at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets using flame ionization detection (FID) analyzers. Sampling and calibration were performed in accordance with proposed EPA Methods 25A and 110.

NMO Measurement by Method 25

Integrated gas samples were periodically drawn at the four sampling locations during the FID continuous monitoring. This sampling was performed in accordance with EPA Method 25, and samples were analyzed for non-methane organics (NMO).

Print Room Ambient Air Measurements

VOC concentrations in the ambient air throughout the print room were periodically monitored with a portable hydrocarbon analyzer, and flowrates through open doorways were measured with a portable hot-wire anemometer and a vane anemometer. Eight-hour exposure sampling was performed at selected points in the print room using charcoal tubes purged continuously with ambient air.

Carbon Adsorption Unit Wastewater Sampling

Samples of wastewater from the CA unit were collected during two days of the testing program. These samples were analyzed for solvent and total organic carbon content.

Fabric Solvent Residue Measurements

Samples of the finished and unfinished wallcovering product were collected during two days of the testing program and were analyzed for residual solvents.

1.4 Description of Report Sections

The remaining sections of this report present a summary and discussion of test results (Section 2), description of the printing operation (Section 3), description of the sampling locations (Section 4), and a discussion of the sampling and analysis methods (Section 5). Field data sheets and laboratory analysis data are presented in the various appendices, as noted in the Table of Contents.

2.0 SUMMARY AND DISCUSSION OF RESULTS

This section presents the results of the VOC emission tests conducted during March 1981 at the GTR vinyl-coated fabric plant in Reading, Massachusetts. The purpose of these tests was to measure the controlled and uncontrolled VOC emissions from the wallcovering printing and embossing operations.

VOC measurements were performed with flame ionization detection (FID) analyzers at five ducted locations: carbon adsorption (CA) unit inlet, CA outlets to beds 1 and 3, embosser electrostatic precipitator (ESP) inlet, and wall fan exhaust. In addition, ambient air VOC sampling was performed in the print-line building with a portable photoionizer hydrocarbon analyzer.

VOC sampling was performed at the embosser ESP inlet, wall fan exhaust duct and CA unit inlet on March 18, 19, 20, and 23, 1981. These results characterized the emissions at these locations, and were used to determine the capture efficiency of the print-line hoods. VOC sampling was performed at the CA unit inlet and outlets on March 25 and 26, 1981, to determine the control efficiency of the CA unit. No measurement work was performed on March 24 because no wallcovering was printed that day.

2.1 Summary of Results

VOC concentrations and air flowrates were measured at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets during print-line operations. Ambient air VOC measurements were made inside the print-line building (print room). The results of this measurement program showed that:

1. Under the operating conditions of this measurement program (make-up air fan and wall exhaust fans off), the majority of print-line VOC emissions is ducted to the CA inlet.

2. The VOC ducted to the embosser ESP inlet is a combination of embosser-generated VOC and ambient print room VOC.

3. The amount of print room ambient air VOC that is ducted to the embosser ESP inlet appears to be small, but can only be estimated from the results of this program.

4. The control efficiency of the CA unit carbon beds is approximately 98 percent averaged over times when the print-line was operating and not operating, and approximately 99 percent averaged over just those times when the print-line was operating.

2.2 Duct Flowrate Measurements

Velocity traverses were performed periodically at the VOC sampling locations during each measurement day. The flowrates measured at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets (carbon beds 1 and 3) are shown in Table 2-1. No flow existed in the wall fan exhaust duct except during the afternoon of March 19, 1981. Prior to about 1330 on March 19, the fan motor was on but the fan belt was slipping. When the belt was tightened flow in the duct was about 10000 SCFM. After March 19 the wall fan was kept off in order to maximize the VOC loading to the CA unit.

VOC measurements were discontinued at the embosser ESP inlet after March 23, 1981. However, velocity traverses here were continued on March 25 and 26. No velocity traverses were performed at the CA unit outlets until March 25, when the VOC sampling was begun at this location.

The moisture content of the duct gases at the embosser, wall fan and CA inlet was estimated from ambient air temperature measurements made in the print room. These measurements indicated a very low moisture content (less than 0.5 percent) and the gases in these ducts were considered dry. A moisture content of 5 percent was assumed for the CA outlet, and Table 2-1 shows CA outlet flowrates corrected and uncorrected for moisture content.

Dry flowrates at the CA outlets exceed those at the CA inlet by 3 to 17 percent. According to plant personnel this is expected because the humidity controllers do leak, and because excess air pressure in the water/solvent dis-

TABLE 2-1

FLOWRATE MEASUREMENTS AT THE PRINTING OPERATION
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

	Embosser			Wall Fan			CA Inlet			CA Outlet		
Date	Time	Flowrate		Time	Flowrate		Time	Flowrate		Time	Flowrate	
3-18-81	1030	3440		No			0900	10800		No		
	1500	3200	3350*	Measurable			1115	8310	8383*	Measurments		
	1600	3410		Flow			1515	8450		Until 3-25		
3-19-81	0930	3270		1415	10100		1000	8330				
	1100	3330	3280*	1530	10000	10050*	1100	8190	8260*			
	1645	3250					1440	7500				
							1508	7700	7600*			
							1611	6830				
3-20-81	1015	3370		Wall Fan			1015	8690				
	1340	3430	3400*	Off			1050	8150	8550*			
	1515	4340					1310	8810				
3-23-81	1020	3390					0955	8650				
	1225	3260	3330*				1300	8560				
	1700	2790					1410	8780	8720*			
							1725	8900				
											Wet	Dry**
3-25-81	1135	3340					1000	8140		1055	9000	8550
							1200	7600		1150	9970	9470
3-26-81	1050	2840					1010	8410		1020	10000	
	1345	3200					1225	8840		1040	10400	9660*
	1500	3230	3220*				1420	8890	8940*	1150	10100	
							1445	9080		1237	9630	
							1600	8330		1400	9900	
										1455	9870	9290*
										1545	9700	

* Average of indicated flowrates.

** Estimated 5% moisture in CA outlet. Dry = 0.95 wet. Duct gases at embosser, wall fan and CA inlet were considered dry. Dry flowrates were needed in association with the Method 25 VOC test results which were on a dry basis.

tillation column is vented to a point just upstream of the CA unit fan (between the humidity controller and the fan).

All flowrates shown in Table 2-1 were used with measured VOC concentrations in order to compute VOC mass emissions, as described in Section 2.3. Since flowrate measurements were not made continuously, some judgements were made to estimate the occurrence and significance of flowrate changes. Average flowrates were calculated over two or more consecutive flowrate measurements if flowrate changes were within approximately ±10 percent. This represents a reasonable estimate of the accuracy of the flowrate measurement technique (EPA Method 2 with standard pitot tubes) and a reasonable estimate of random, normal flowrate fluctuations within each duct (unaccompanied by significant process changes). The process log (Section 3.6) and the consistency of the FID analyzer strip chart traces were reviewed to determine if process changes were occurring which could account for any indicated flowrate changes.

2.3 VOC Measurements

2.3.1 FID Sampling

Continuous monitoring of VOC concentrations was performed at each sampling location with FID analyzers calibrated with propane and MEK standards. The purpose of the monitoring was to determine the distribution of print-line VOC emissions to each sampling location, the control efficiency of the carbon beds, and the capture efficiency of the print room air management system.

The calculated VOC emissions at each sampling location are shown in Table 2-2. The mass of VOC (pounds MEK) passing a sampling location during a given time interval was calculated by multiplying the VOC concentration as MEK during that time interval by the flowrate (measured as described in Section 2.2). As noted in Section 2.2, there was no flow in the wall fan exhaust duct

except during the afternoon of March 19, 1981, and except during a few brief periods when the print-line was down. VOC monitoring at the CA unit outlets was performed on March 25 and 26 only. Throughout the measurement program only carbon beds 1 and 3 were operating.

"Total Run Time" includes color matching and other preparatory activities in addition to the time necessary to print the product; "Total Print Time" includes just the time spent to print the product. Both of these time periods include times when the print-line was not running (for various reasons, including maintenance and adjustments). The "1000 Yards Printing" consists of the continuous time periods in which 1000 yards of product was printed.

Table 2-2 presents the calculated control efficiencies of the carbon adsorption unit for each of the indicated time periods on March 25 and 26. During the VOC monitoring on these two days the two operating carbon beds were continually cycling from an adsorbing mode to a desorbing mode. The FID analyzer probe was always moved to the adsorbing bed outlet. One cycle lasted for about 120 minutes: 60 minutes for adsorption and 60 minutes for desorption. Since the cycling times of each bed did not always coincide with the print-line operation time intervals in Table 2-2, the indicated control efficiencies are essentially composite efficiencies for both beds. Control efficiences for each individual bed, based on the observed cycling times, are presented in Table 2-3.

The control efficiencies for "Total Print Time" and "Total Run Time" in Table 2-2 are slightly higher than the average control efficiencies in Table 2-3. This is because the data in Table 2-3 include time intervals in which control efficiencies were noticeably low. For example, at 1108-1217 on March 25 the VOC loading at the CA inlet was relatively low (7.69 pounds), because the print-line was down in this interval and because the wall fan was

TABLE 2-2

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-18-81	T-14582	Preparation	0915	1035	80	NM	0	2.57	--
		Leader Threading	1035	1043	8	0.15	0	0.60	0.75
		Color Matching	1043	1401	198	39.20	0	76.5	115.7
		1000 Yards Printing	1401	1423	22	2.74	0	34.8	37.5
		1000 Yards Printing	1423	1445	22	2.55	0	23.5	26.0
		1000 Yards Printing	1445	1507	22	2.32	0	24.4	26.7
		1000 Yards Printing	1507	1529	22	2.33	0	23.8	26.1
		1000 Yards Printing	1529	1551	22	2.49	0	23.2	25.7
		Completion of Run	1551	1607	16	1.73	0	16.5	18.2
		Threading New Leader	1607	1613	6	0.69	0	4.27	4.96
		Clean Up	1613	1618	5	0.58	0	3.56	4.14
		Clean Up	1618	1640	22	2.23	0	NM	--
		TOTAL PRINT TIME	1401	1607	126	14.2	0	146.2	160.4
		TOTAL RUN TIME	1043	1613	330	54.0	0	230.5	281.0

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-19-81	T-15626	Printing in Progress	0734	0848	74	8.53	0	NM	--
		Printing	0848	0854	6	0.902	0	4.09	4.99
		Stop and Start	0854	0908	14	1.50	0	6.22	7.72
		1000 Yards Printing	0908	0930	22	2.65	0	8.36	11.0
		Stop and Start	0930	0945	15	0.781	0	3.04	13.8
		1000 Yards Printing	0945	1007	22	2.47	0	11.6	14.1
		TOTAL PRINT TIME	0848	1007	79	8.30	0	33.3	41.6
		TOTAL RUN TIME	0848	1007	79	8.30	0	33.3	41.6
	T-15523	Preparations for Next Run	1007	1230	143	2.49	0	7.28	9.77
		Color Matching	1230	1332	62	4.14	0	10.6	14.7
		Embosser Repairs. Wall Fan On	1332	1420	48	4.41	6.24	15.1	25.7
		1000 Yards Printing	1420	1442	22	4.05	2.43	9.22	15.7
		1000 Yards Printing	1442	1504	22	3.85	2.96	10.3	17.2
		1000 Yards Printing	1504	1526	22	3.99	3.20	10.0	17.2
		1000 Yards Printing	1526	1550	24	4.25	3.49	10.9	18.7
		Run Completed	1550	1610	20	3.58	3.14	7.09	13.8
		Clean Up	1610	1628	18	1.14	2.25	10.2	13.6
		Clean Up	1628	1632	4	0.18	0.48	NM	--
		Clean Up	1632	1634	2	0.09	NM	NM	--
		TOTAL PRINT TIME	1420	1610	110	19.7	15.2	47.5	82.4
		TOTAL RUN TIME	1230	1610	220	28.3	21.5	73.2	123.0

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-20-81	T-15521	Completing Previous Run	0740	0744	4	0.67	0	NM	--
		Completing Previous Run	0744	0814	30	3.42	0	19.4	22.8
		Preparation for T-15521	0814	0958	104	4.56	0	14.7	19.3
		Color Matching	0958	1019	21	1.91	0	31.2	33.1
		Printing Start/Stop for Repairs	1019	1148	89	7.97	0	35.6	43.6
		Printing, Embosser On	1148	1150	2	0.233	0	1.16	1.39
		1000 Yards Printing	1150	1212	22	4.32	0	18.2	22.5
		Printing Start/Stop for Repairs	1212	1256	44	6.76	0	29.5	36.3
		1000 Yards Printing	1256	1318	22	4.27	0	17.27	21.5
		1000 Yards Printing	1318	1340	22	4.25	0	17.6	21.8
		1000 Yards Printing	1340	1356	16	3.22	0	13.6	16.8
		Run Completed	1356	1402	6	1.15	0	5.30	6.45
		Cleaning Print Heads	1402	1426	24	3.35	0	13.10	16.45
		Clean Up	1426	1532	66	6.06	0	NM	--
		TOTAL PRINT TIME	1019	1410	231	33.4	0	143.8	177.2
		TOTAL RUN TIME	0958	1410	252	35.3	0	175.0	210.3

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-23-81	T-15516	Printing in Progress	0850	0909	19	1.92	Sampling	10.51	12.43
		1000 Yards Printing	0909	0931	22	2.60	Discontinued	13.06	15.7
		1000 Yards Printing	0931	0953	22	2.78		14.70	17.5
		1000 Yards Printing	0953	1015	22	3.12		14.20	17.3
		Run Completed	1015	1025	10	1.48		7.15	8.63
		TOTAL PRINT TIME	0850	1025	95	11.9		59.6	71.5
		TOTAL RUN TIME	0850	1025	95	11.9		59.6	71.5
	T-15519	Threading Leader	1025	1037	12	1.41		24.60	26.0
		Cleaning. PH Fans off. Wall Fan on	1037	1239	122	5.25		4.17	9.42
		Color Matching, Web Alignment Wall Fan Off.	1239	1244	5	0.070		0.180	0.250
		Color Matching	1244	1324	40	0.85		10.3	11.2
		Printing Line Down Once	1324	1351	27	1.88		9.90	11.8
		1000 Yards Printing	1351	1413	22	1.56		9.02	10.6
		Line Up and Down. Trimming Problems	1413	1605	112	6.71		40.0	46.7
		Problems Persist. Run Ended	1605	1628	23	1.14		10.5	11.6
		Repairs	1628	1633	5	0.27		1.16	1.43
		Repairs	1633	1636	3	NM		1.93	--
		TOTAL PRINT TIME	1324	1605	161	10.2		58.9	69.1
		TOTAL RUN TIME	1239	1628	229	12.2		69.6	81.8

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order No.	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds As MEK) CA Inlet	VOC Emissions (Pounds As MEK) Ca Outlet	CA Unit Control Efficiency (%)[b]	Carbon Bed In Operation (Adsorbing)	Time of Bed Switch[c]
3-24-81		Embossing Entire Day								
3-25-81	T-15511	Color Matching	0859	0900	1	0.66	NM	--	3	
		Printing in Progress	0900	0922	22	20.1	NM	--	3	
		Printing	0922	0942	20	21.8	0.048	99.8	1	0922*
		1000 Yards Printing	0942	1003	21	23.5	0.071	99.9	1	
		1000 Yards Printing	1003	1020	17	21.2	0.067	99.7	1	
		1000 Yards Printing	1020	1037	17	22.7	0.093	99.6	3	
		Run Completed	1037	1047	10	10.7	0.065	99.4	3	
		Leader Threading	1047	1108	21	15.7	0.114	99.3	3	
		Wall Fan on Preparation For Next Run	1108	1217	69	7.69	0.317	95.9	3/1	1117**
		Wall Fan on Preparation For Next Run	1217	1230	13	NM	0.053	--	3	
		TOTAL PRINT TIME	0922	1047	85	130	0.344	99.7		
		TOTAL RUN TIME	0922	1108	106	146	0.458	99.7		

* Beginning time of 0922 was estimated, based on observed end time of 1020
** Bed No. 1 began adsorbing 1117 and continued to 1217.
a Start time for the initial time interval is the time when FID monitoring began that day.
b 100 [1-(OUTLET/INLET)]
c Nominal bed cycle (adsorption/desorption) is about 120 minutes.
NM: Not measured - analyzer problems or calibrations in progress.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order No.	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds As MEK) CA Inlet	VOC Emissions (Pounds As MEK) Ca Outlet	CA Unit Control Efficiency (%)[b]	Carbon Bed In Operation (Adsorbing)	Time of Bed Switch[c]
3-26-81	T-15508	Preparation	0856	0936	40	NM	0.194		1/3	0928
		Preparation	0936	0939	3	0.880	0.036	95.9	3	
		Color Matching	0939	1059	80	37.0	1.26	96.6	3/1	1028
		Printing	1059	1126	27	21.1	0.356	98.3	1	
		1000 Yards Printing	1126	1151	25	20.7	0.313	98.5	1/3	1128
		1000 Yards Printing	1151	1216	25	21.6	0.313	98.6	3	
		Run Completed	1216	1222	4	5.15	0.072	98.6	3	
		Embosser off. Clean up	1222	1229	7	5.11	0.156	96.9	3	
		TOTAL PRINT TIME	1059	1222	83	72.6	1.05	98.6		
		TOTAL RUN TIME	0939	1229	163	110.7	2.47	97.8		
	T-15507	Preparation	1229	1326	57	28.8	0.588	98.0	3/1	1233
		Color Matching	1326	1420	54	31.6	0.438	98.6	1/3	1334
		Printing. Line Down Once	1420	1439	19	13.8	0.158	98.9	3/1	1435
		1000 Yards Printing	1439	1501	22	16.9	0.211	98.8	1	
		1000 Yards Printing	1501	1523	22	17.7	0.160	99.1	1	
		Run Completed	1523	1540	17	12.8	0.116	99.1	1/3	1534
		Line Down. Preparation for next run	1540	1612	32	15.0	0.217	98.6	3	
		Line Down. Preparation for next run	1612	1614	2	NM	0.014		3	
		TOTAL PRINT TIME	1420	1540	80	61.2	0.645	98.9		
		TOTAL RUN TIME	1326	1540	134	92.8	1.08	98.8		

[a] Start time for the initial time interval is the time when FID monitoring began that day.
[b] 100 [1-(OUTLET/INLET)]
[c] Nominal bed cycle (adsorption/desorption) is about 120 minutes.

TABLE 2-3

CARBON ADSORPTION UNIT CONTROL EFFICIENCIES
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Adsorption Time	VOC Measurement Time at Both Inlet and Outlet	Carbon Bed in Operation	VOC Emissions (pounds as MEK) CA Inlet	CA Outlet	Control Efficiency (%)[a]
3-25-81	0922*-1020	same	1	96.5	0.186	99.8
	1020 -1117	same	3	50.8	0.321	99.4
	1117 -1217	same	1	6.02	0.268	95.5
				average:		98.2
3-26-81	0928-1028	0936-1028	3	21.6	0.771	96.4
	1028-1128	same	1	38.8	0.910	97.7
	1128-1233	same	3	54.1	0.805	98.5
	1233-1344	same	1	34.4	0.752	97.8
	1344-1435	same	3	34.7	0.423	98.8
	1435-1534	same	1	45.3	0.479	98.9
	1534-1635*	1534-1612	3	19.2	0.258	98.7
				average:		98.1

[a] [1-(outlet/inlet)] 100
* estimated times

turned on at 1108. The flowrate at the CA inlet did decrease from 8140 SCFM at 1000 to 7600 SCFM at 1200 (see Table 2-1), and the measured VOC concentrations in the inlet decreased from about 310 ppm (as MEK) at 1101 to about 110 ppm at 1109 (see Appendix B). The VOC loading at the CA outlet in this time interval is relatively large (0.317 pounds), but only because the time interval itself is much larger (69 minutes) than other time intervals on this day. The relatively low control efficiency from 0936 to 1059 on March 26 is due only to the fact that the VOC concentrations in the CA inlet at this time were relatively low (190-370 ppm) compared to subsequent time intervals (420-540 ppm) (see Appendix B). Reduced control efficiency as a result of reduced inlet concentrations is a general characteristic of carbon bed adsorption units.

2.3.2 NMO Sampling with Method 25

Sampling for non-methane organic (NMO) compounds was performed concurrently with the continuous FID monitoring at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets. Integrated gas samples were collected once each monitoring day (except March 18) over periods of time ranging from 18 minutes to 56 minutes using an evacuated tank and condensible trap in accordance with EPA Method 25. Tank and trap contents were then analyzed at the TRC laboratory for NMO expressed as carbon. The results of these analyses are presented in Table 2-4. Details of the results are presented in Appendix D.2.

There was relatively good agreement between the NMO duplicate sample results for combined traps and tanks. However, there appears to be no correlation between the results obtained from the duplicate traps alone, or between the results obtained from the duplicate tanks alone. The difference between the paired sample collection components may reflect the effects of the ambient

temperature trap purge procedure. The volatility of the solvents is such that at room temperature some of them may be purged into the sample tank. The quantity purged will vary, depending on factors such as trap temperature before insertion into the bath and how long the trap remained in the bath before being returned to room air.

There is poor correlation also between NMO Method 25 results and FID Method 25A results. There is no definite explanation for this poor correlation, though it may be due to problems in the NMO Method 25 analytical procedures. The FID results are considered more reliable since the FID analyzers were calibrated and audited daily.

2.4 Print Room Ambient Air Measurements

Measurements of ambient air VOC concentrations and doorway air flowrates were performed in the print room periodically each day. The results of these various measurements are discussed in the following subsections.

2.4.1 Ambient Air VOC Measurements

VOC measurements were made in the immediate vicinity (within 5 feet) of the print heads and the embosser, and at locations throughout the print room, using a portable photoionizer hydrocarbon analyzer sampling at approximately breathing level. A summary of these measurements is shown in Table 2-5. All measured concentration data are presented in Appendix E.

The "Print Room" MEK concentrations shown in Table 2-5 represent averages of measurements taken at 10 or 12 locations throughout the print room. The "Print-line" MEK concentrations represent averages of measurements taken within 5 feet of the print heads. These measurements were taken at times between print heads, at times approximately 2 feet away from the print heads, and at

TABLE 2-4

SUMMARY OF NMO METHOD 25 ANALYSIS RESULTS
GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS

Date	Sampling Location	Time Start	Time End	Total Minutes	Concentration (ppm as carbon) Sample A	Concentration (ppm as carbon) Sample B*	FID** Concentration (ppm as MEK)
3-19-81	Wall Fan	1449	1534	45	380	NM	75
	Embosser	1449	1534	45	918 f	833	291
	CA Inlet	1449	1534	45	1,492	2,187	322
3-20-81	Embosser	1301	1346	45	913 f	923	310
	CA Inlet	1301	1346	45	1,104	1,973	501
3-23-81	Embosser	1334	1337	3			
		1410	1423	13			
		1554	1557	3			
				19	642	279	109
	CA Inlet	1334	1337	3			
		1410	1423	13			
		1555	1557	2			
				18	453	317	256
3-25-81	CA Outlet	1022	1049	27	210	492	4
	CA Inlet	1022	1049	27	2,113	2,314	781
3-26-81	Embosser	1105	1150	45	68	NM	NM
	CA Outlet	1105	1119	14			
		1123	1205	42			
				56	880 a	719 a	7
		1205	1231	26			
		1249	1312	23			
				49			
	CA Inlet	1105	1119	14			
		1130	1201	31			
				45	1,226	1,275	506

* Duplicate sample
f Filter in sampling probe
** Time-weighted average
NM Not measured
a Two seperate tanks were used for this run for each sample - one tank from 1105 to 1205, a second tank from 1205 to 1312.

times approximately 5 feet away from the print heads. The "Embosser" MEK concentrations represent averages of measurements made approximately 2 feet in front of the cage surrounding the embosser, at five locations along the cage. The embosser measurements are discussed further in the following sub-section.

2.4.2 VOC Measurements at the Embosser

The primary objective of performing ambient air VOC measurements near the embosser was to compare the VOC concentration of air near the embosser to the VOC concentration measured by FID analyzer in the embosser ESP inlet. This comparison is presented in Table 2-6.

These data indicate that VOC concentrations in the embosser ESP inlet duct are always higher than VOC concentrations in the print room ambient air near the embosser, except perhaps at times when the embosser itself is off. The embosser ESP fan was on at all times during the measurement program.

Continuous VOC monitoring in the ESP inlet was discontinued after March 23, 1981. Ambient air measurements at the embosser were continued on March 25 and 26, as shown on Table 2-5. On March 25 at 0910 and 0955, with the embosser off, ambient air VOC concentrations at the embosser were 170 ppm and 125 ppm, respectively. At 0925 however, a measurement was made at the center of the ESP inlet duct with the portable photoionizer hydrocarbon analyzer. Over approximately a one-minute time interval concentration readings ranged from 1 to 20 ppm, averaging approximately 3 or 4 ppm. These duct concentrations are inconsistent with the print room ambient air concentrations, if one assumes that the ambient air near the embosser is being drawn into the ESP inlet through the hood that hangs over the embosser.

Once on March 25 (1046) and once on March 26 (1159) ambient air flow near the embosser was monitored with a sensitive vane anemometer. No air motion

TABLE 2-5

SUMMARY OF PRINT ROOM AMBIENT AIR SURVEYS AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Time	Print-Line Operations: Order No.	No. Print Heads	Embosser	General	Average MEK Concentration (ppm): Print Room[a]	Print-Line[b]	Embosser[c]	Doorway E Flowrate (SCFM)	MEK Concentration Outside Doorway E (ppm)	MEK Mass Flowrate Into Print Room (Pounds/Hour)
3-18-81	1440-1510	T-14582	5	ON	Printing	120	280	140			
	1520-1540	T-14582	5	ON	Printing				5680	4	0.26
									*3860 (D)	70 (D)	3.04 (D)
									**2930 (B)	20 (B)	0.66 (B)
									12470 (Total)		3.96
3-19-81	0850-0915	T-15626	1	ON	Printing	90	210	105			
	0916-0926	T-15626	1	ON	Printing				6080	2	0.13
	1401-1415	T-15523	4	ON	Printing. Wall fan on				20100	5	1.12
	1458-1513	T-15523	4	ON	Printing. Wall fan on	50	95				
3-20-81	1037	T-15521	4	OFF	Color matching			130			
	1045-1055	T-15521	4	OFF	Color matching	95			2430[d]	4	0.11
	1115	T-15521	4	OFF	Color matching			150			
	1130	T-15521	4	OFF	Color matching				8510	2	0.19
	1155	T-15521	4	ON	Printing			125			
	1215-1225	T-15521	4	ON	Printing	140	250	150			
	1240	T-15521	4	ON	Printing				9120	3.5	0.36
	1315	T-15521	4	ON	Printing			130			
	1322-1332	T-15521	4	ON	Printing	130	170				
	1355	T-15521	4	ON	Printing			135			
	1400-1406	T-15521	4	ON	Printing	140					
	1447			OFF	Line down. Cleaning heads				6690[e]	3	0.22
3-23-81	0923	T-15516	5	ON	Printing			105			
	0925	T-15516	5	ON	Printing				8510	3	0.29
	1015	T-15516	5	ON	Printing				9420	2	0.21
	1022-1028	T-15516	5	OFF	Line down briefly	130		135			
	1340	T-15519	3	ON	Printing				7300	3	0.25
	1417	T-15519	3	ON	Printing			70			
	1420-1430	T-15519	3	ON	Line up and down	100					
	1548	T-15519	3	ON	Trimming problems			90			
	1610				Line down				8816	3	0.30
	1630-1640				Printing. Testing leader	95	210				

[a] Average of measurements made at 5 feet above the floor, throughout printroom. Does not include measurements made near open doorways.
[b] Average of measurements made 2 to 5 feet from print heads at 5 feet above the floor.
[c] Average of measurements made about 2 feet in front of the embosser at 5 feet above the floor.
[d] OH door open about 10 inches.
[e] Print head fans were off during these doorway measurements
* Measured in Doorway D.
** Measured in Doorway B.

TABLE 2-5 (Continued)

SUMMARY OF PRINT ROOM AMBIENT AIR SURVEYS AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Time	Print-Line Operations: Order No.	No. Print Heads	Embosser	General	Average MEK Concentration (ppm): Print Room[a]	Print-Line[b]	Embosser[c]	Doorway E Flowrate (SCFM)	MEK Concentration Outside Doorway E (ppm)	MEK Mass Flowrate Into Print Room (Pounds/Hour)
3-24-81				ON	Embossing all day						
3-25-81	0910	T-15511	4	OFF	Printing			170			
	0950	T-15511	4	OFF	Printing				6690	2	0.15
	0955	T-15511	4	OFF	Printing			125			
	0958-1006	T-15511	4	OFF	Printing	110	225				
	1046	T-15511	4	ON	Printing			150			
	1105	T-15511	4	OFF	Line down			130			
	1240-1257			OFF	Line down. Floor cleaning with MEK	50	60	170			
	1422			ON	Embossing only			32			
	1450			ON	Embossing. Wall fan on				21300	2.5	0.60
3-26-81	0950-1024	T-15508	5	ON	Color matching and printing	85	250				
	0952	T-15508	5	ON	Color matching			200			
	1023	T-15508	5	ON	Printing			190			
	1026	T-15508	5	ON	Printing				10000	2	0.22
	1115-1125	T-15508	5	ON	Line up and down	120	175	95	10300	2	0.23
	1138	T-15508	5	ON	Printing			120			
	1159	T-15508	5	ON	Printing			100			
	1355	T-15507	5	OFF	Line down			65			
	1426	T-15507	5	ON	Printing			125			
	1445-1456	T-15507	5	ON	Printing	110	200	110			
	1532	T-15507	5	ON	Printing			80			

[a] Average of measurements made at 5 feet above the floor, throughout print room. Does not include measurements made near open doorways.
[b] Average of measurements made 2 to 5 feet from print heads at 5 feet above the floor.
[c] Average of measurements made about 2 feet in front of the embosser at 5 feet above the floor.

TABLE 2-6

DUCT AND AMBIENT AIR VOC MEASUREMENTS AT THE EMBOSSER
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Time	Embosser Operation	VOC Concentrations (ppm as MEK) Ambient	Duct[a]	Duct Flowrate Measurements[b] Time	SCFM
3-18-81	1506	On	140	173	1500	3200
3-19-81	0853	On	105	245	0930	3270
3-20-81	1037	Off	130	168	1015	3370
	1115	Off	150	118		
	1155	On	125	309		
	1215	On	150	320		
	1315	On	130	309	1340	3430
	1355	On	135	316		
3-23-81	0923	On	105	198	1020	3390
	1026	Off	135	178		
	1417	On	70	110	1225	3260
	1548	On	90	121	1700	2790

[a] Measurements made in embosser ESP inlet. No duct measurements at this location were made 3-25 and 3-26.

[b] See Table 2-1.

was observed either horizontally or vertically up to 8 feet above the floor and within the cage surrounding the embosser. At both times the embosser was operating. These vane anemometer readings and the low in-duct VOC concentrations observed at 0925 on March 25 indicated that air flow into the embosser hood is localized at the level of the hood. At this height VOC concentrations may be lower than at 5 feet above the floor; the VOC concentrations measured at 1115 on March 20 support this hypothesis (Table 2-6).

2.4.3 Doorway Flowrates

Air speed through open print room doorways were measured with a hot-wire anemometer and a vane anemometer. Average speed was multiplied by the doorway area to obtain flowrate. The results of the air flow measurements are shown in Table 2-5.

Doorway E (at the northeast corner of the print room, connecting the print room to the main plant) was fully open during the entire measurement program. All other doorways were closed, except for doorways B and D on March 18 which were partially open during that day. The wall fan was off except for the afternoon of March 19, and except for occassional brief periods when the print-line was down and the print room needed ventilation.

Air flowrates through doorway E ranged from about 2430 SCFM to 21300 SCFM. Excluding the flowrate measurement on March 18 (when doorways B and D were also open), the low measurement of 2430 SCFM (when the overhead door was open 10 inches), and the flowrates measured when the wall fan was on (20100 SCFM and 21300 SCFM), the air flowrate through doorway E ranged from 6080 SCFM to 10300 SCFM. During all measurement periods the direction of air flow was into the print room.

Considering measured flows into and out of the print room, with the wall fan both on and off, a general flow balance does exist (see Tables 2-1 and

2-5). During the times the wall fan was on and doorway E flow measurements were made (1400 on March 19 and 1450 on March 25), measured flow into the print room was about 21000 SCFM. Measured flow out of the print room at this time was about 3300 SCFM at the embosser plus about 10000 SCFM at the wall fan plus about 7500 SCFM at the CA inlet, or a total of about 20800 SCFM. During the times when the wall fan was off, flow at the embosser still averaged about 3300 SCFM and flow at the CA inlet averaged about 8500, for a total flow of approximately 11800 SCFM out of the print room. Air flow into the print room when the wall fan was off ranged from 6080 SCFM to 10300 SCFM, as noted above. These latter flowrates indicate that miscellaneous air flows into the print room (around other closed doors and general building leakage) are significant when the wall fan is off.

During each flow measurement period, the ambient air VOC concentration at approximately 5 feet outside doorway E (in doorways E, B and D on March 18) was measured about 5 feet above the floor with the portable hydrocarbon analyzer. These concentrations ranged from 2 to 5 ppm (as MEK) in doorway E. Higher concentrations were measured in doorways B and D probably because these doorways connect the print room directly to areas of the main plant where inks are mixed. The VOC mass flowrate into the print room through open doorways was estimated by multiplying these doorway concentrations by the measured doorway flowrates. These mass flowrates are shown in Table 2-5.

In general a steady north-to-south air flow of about 300-400 feet per minute existed just outside doorway E. Air drawn into the print room had to make a sharp right turn, so the highest air speeds were usually measured at the south end of doorway E.

2.4.4 Eight-Hour Exposure Sampling

Continuous eight-hour VOC sampling was performed at four locations near

the print-line using battery-operated personal samplers and charcoal tubes. The four sampling locations were:

1. on the cage in front of the embosser, about 5 feet above the floor and 3 feet from the embosser;
2. same as location 1 but in back of the embosser;
3. in front of print head No. 6, on the side of the stairs leading to a catwalk above the print-line, about 6 feet above the floor;
4. above print head No. 2, about 2 feet below the fan air intake, about 17 feet above the floor.

Eight-hour samples were taken on March 23, 25 and 26 at these four locations. During each eight-hour period, charcoal tubes were replaced every two hours. The results of the charcoal tube solvent analyses are shown in Table 2-7. Sampler malfunctions on March 23 led to poor data recovery on that day, so only the samples from March 25 and 26 were analyzed.

The results from the carbon tube analyses indicate generally lower concentrations than the room air survey results made with the portable hydrocarbon analyzer. There is no definitive explanation for this difference. However, the carbon tube samples were taken over a continuous eight-hour period. The print-line was not always operating during these times, so lower carbon tube concentration could be expected. Also, VOC was found in most back-up sections of the carbon tubes. This indicates that VOC break-through may have occurred with the result that the reported data may be lower than actual values.

2.5 Carbon Bed Wastewater Samples

Wastewater samples from the carbon absorption unit were collected periodically on March 25 and 26 during the continuous VOC monitoring at the CA unit inlet and outlets. Nine samples were taken from a common drain at the base of the carbon beds (bed condensation samples) and 12 samples were taken from a

TABLE 2-7

EIGHT-HOUR SAMPLING DATA IN THE PRINT ROOM AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Sampling Location	Time Start	Time End	Total Time (minutes)	Volume of Air Sampled (liters)	MEK mg	MEK ppm(v/v)	MIBK mg	MIBK ppm(v/v)	Toluene mg	Toluene ppm(v/v)
3-23-81	Front Embosser	0907	1107	120							
		1107	1307	120							
		1307	1507	NM							
		1507	1707	NM							
		0907	1307	240							
	Back Embosser	0909		NM							
	Ladder	0903	1103	120		SAMPLES NOT ANALYZED					
		1103	1304	121							
		1304	1507	123							
		1507	1730	143							
		0903	1730	527							
	Above PH 2	0911	1111	120							
		1111	1311	120							
		1311	1511	120							
		1511	1732	141							
		0911	1732	521							

NM - No measurement due to sampler malfunction.

TABLE 2-7 (Continued)

EIGHT-HOUR SAMPLING DATA IN THE PRINT ROOM AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Sampling Location	Time Start	Time End	Total Time (minutes)	Volume of Air Sampled (liters)	MEK mg	MEK ppm(v/v)*	MIBK mg	MIBK ppm(v/v)*	Toluene mg	Toluene ppm(v/v)*
3-25-81	Front Embosser	0841	1037	116	91.6	1.39	5.16	0.50	1.34	0.42	1.22
		1037	1237	120	94.7	8.48	30.47	0.71	1.84	0.58	1.63
		1237	1437	120	97.9	11.86	41.33	0.69	1.73	0.54	1.47
		1437	1637	120	82.8	6.30	25.89	1.44	4.26	1.13	3.63
		0841	1637	476	367.0	28.03	25.99	3.34	2.23	2.67	1.94
	Back Embosser	0845	1039	114	97.8	17.41	60.58	1.79	4.48	1.30	3.54
		1039	1239	120	116.1	14.91	43.70	1.79	3.78	1.35	3.10
		1239	1439	120	116.1	1.56	4.57	0.62	1.31	0.49	1.12
		1439	1639	120	109.6	3.97	12.23	1.32	2.95	1.05	2.55
		0845	1639	474	439.6	37.85	29.30	5.52	3.07	4.19	2.54
	Ladder	0834	1030	116	140.6	14.54	35.19	2.04	3.55	1.41	2.67
		1030	1230	120	156.5	8.97	19.50	0.94	1.47	0.85	1.45
		1230	1430	120	156.5	10.12	22.00	0.57	0.89	0.60	1.02
		1430	1630	120	151.0	3.77	8.50	0.85	1.37	0.54	0.95
		0834	1630	476	604.6	37.40	21.05	4.40	1.78	3.40	1.50
	Above pH 2	0830	1033	123	41.0	3.77	31.29	0.85	5.08	0.55	3.57
		1033	1233	120	40.0	2.18	18.55	0.42	2.57	0.50	3.33
		1233	1433	120	40.0	1.02	8.68	0.38	2.32	0.47	3.13
		1433	1633	120	40.0	0.68	5.78	0.38	2.32	0.47	3.13
		0830	1633	483	161.0	11.42	24.14	2.03	3.09	1.99	3.29

* 25C, 760 mm Hg.

TABLE 2-7 (Continued)

EIGHT-HOUR SAMPLING DATA IN THE PRINT ROOM AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Sampling Location	Time Start	Time End	Total Time (minutes)	Volume of Air Sampled (liters)	MEK mg	MEK ppm(v/v)*	MIBK mg	MIBK ppm(v/v)*	Toluene mg	Toluene ppm(v/v)*
3-26-81	Front Embosser	1007	1212	125	116.3	21.18	61.92	1.54	3.24	1.00	2.29
		1212	1403	111	95.6	14.01	49.87	1.07	2.74	0.68	1.89
		1404	1602	118	93.5	10.75	39.12	0.06	0.16	0.04	0.11
		1604	1803	119	82.1	5.46	22.63	0.31	0.93	0.18	0.58
		1007	1803	473	387.5	51.40	45.10	2.98	1.88	1.90	1.31
	Back Embosser	1011	1214	123	115.0	5.84	17.28	1.05	2.24	0.81	1.88
		1214	1406	112	96.1	10.26	36.33	1.57	4.00	1.23	3.41
		1406	1608	122	104.7	10.98	35.69	2.69	6.29	1.26	3.49
		1608	1806	118	101.2	8.80	29.59	1.10	2.93	0.63	1.66
		1011	1806	475	417.0	35.88	29.28	6.41	3.77	3.93	2.51
	Ladder	1001	1207	126	189.0	11.03	19.86	0.58	0.75	0.40	0.56
		1207	1409	122	176.0	2.61	5.05	0.76	1.06	0.47	0.71
		1409	1610	121	170.6	9.33	18.61	1.23	1.76	0.90	1.40
		1610	1808	118	162.8	1.78	3.72	0.76	1.14	0.46	0.75
		1001	1808	487	698.4	24.75	12.04	3.33	1.17	2.23	0.85
	Above PH 2	1004	1210	126	42.0	2.74	22.20	0.32	1.86	0.28	1.78
		1210	1412	122	40.6	2.48	20.79	0.24	1.45	0.20	1.31
		1412	1615	123	41.0	3.43	28.47	0.39	2.33	0.33	2.14
		1615	1815	120	40.0	0.99	8.42	0.14	0.85	0.13	0.87
		1004	1815	491	163.6	9.64	20.05	1.09	1.63	0.94	1.53

* 25 C, 760 mmHg

drain at the base of the water/solvent distillation column (bottom product samples). Under the direction of the EPA task manager, twelve representative samples were selected out of the 21 samples and were analyzed for MEK, MIBK, toluene, and total organic carbon (TOC) content. The results of these analyses are shown in Table 2-8.

The TOC results are always greater than the sum of the individual component results (MEK, MIBK and toluene). This difference may be because two different analysis procedures were used and because the solvents may begin to break down during the CA steam regeneration and distillation processes.

2.6 Fabric Solvent Residue

Four different wallcoverings were sampled from March 23 to March 25, 1981. The fabric solvent residue analysis results are summarized in Table 2-9. The time lag from sample collection to start of recovery, pattern duplication information and paired sample identification information are presented in Table 2-10.

The purpose of this part of the test program was to determine the embosser emissions indirectly from the product samples collected before and after being embossed. The analysis procedure used was a preliminary procedure still in the development stage. The results do not compare well with the embosser emissions measured in the embosser ESP inlet duct with Methods 2 and 25A, and were therefore not used to estimate emissions.

In general, the weights are fairly consistent and reproducibility within a given set of samples is good. Only two samples (29 and 30) had any bleedthrough to the backup tube. The first set of samples (order no. 15516) does not exhibit substantial differences before and after embossing. This may be because the "before" samples were run through the heated embosser area

TABLE 2-8

CARBON ADSORPTION UNIT WASTEWATER ANALYSIS RESULTS AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Sample No.	Time	Carbon Bed Adsorbing	Bed Condensation Samples (mg/ℓ) MEK	MIBK	Toluene	TOC	Bottom Product Samples (mg/ℓ) MEK	MIBK	Toluene	TOC
3-25-81	1	1021	3	-	-	-	-				
	2	1029	3					41.2	n.d.	n.d.	65.4
	3	1030	3					-	-	-	-
	4	1035	3					-	-	-	-
	5	1050	3					-	-	-	-
	6	1052	3	-	-	-	-				
	7	1102	3	-	-	-	-				
	8	1106	3					-	-	-	-
	9	1214	1					15.3	0.3	n.d.	68.4
	10	1421	3					-	-	-	-
3-26-81	11	1030	1	1.3	0.2	n.d.	7.2				
	12	1105	1	n.d.	0.1	n.d.	10.9				
	13	1135	3	2.5	0.1	n.d.	17.6				
	14	1140	3					14.5	0.1	n.d.	55.3
	15	1201	3	-	-	-	-				
	16	1203	3					-	-	-	-
	17	1240	1	4.8	0.2	n.d.	11.6				
	18	1240	1					-	-	-	-
	19	1320	1	6.2	0.2	n.d.	13.9				
	20	1328	1					38.7	n.d.	n.d.	63.9
	21	1525	1					-	-	-	-

n.d. = not detectable
- = sample not analyzed

TABLE 2-9 (Continued)

SUMMARY OF WALLCOVERING SOLVENT RESIDUES
GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS
MARCH 23-25, 1981

Sample No.	Order No.	Condition	Sample Size (sq. inches)	mg MEK Sample	mg MIBK Sample	mg Toluene Sample	lb MEK (sq. yd.)	lb MIBK (sq. yd.)	lb Toluene (sq. yd.)
26A[b]	14796	After embosser	28.41	0.40	0.10	0.07	4.02×10^{-5}	1.01×10^{-5}	7.00×10^{-6}
26B				0	0	0			
29A[c,d]	15511	Before embosser	28.16	27.02	3.55	2.20	3.78×10^{-3}	3.60×10^{-4}	2.23×10^{-4}
29B				10.21	0	0			
30A[c,d]	15511	Before embosser	31.30	35.83	2.25	1.37	3.92×10^{-3}	2.05×10^{-4}	1.25×10^{-4}
30B				7.10	0	0			
33A	15516	Unprinted	36	3.49	0.32	0.26	2.77×10^{-4}	2.54×10^{-5}	2.06×10^{-5}
33B									
34A	15516	Unprinted	36	2.12	0.32	0.11	1.68×10^{-4}	2.54×10^{-5}	8.70×10^{-6}
34B									
35A	15511	Unprinted	36	1.54	0.12	0.12	1.22×10^{-4}	9.50×10^{-6}	9.50×10^{-6}
35B									
36A	15511	Unprinted	36	1.62	0.19	0.14	1.29×10^{-4}	1.51×10^{-5}	1.11×10^{-5}
36B									
37A	14796	Unprinted	36	1.60	0.11	0.10	1.27×10^{-4}	8.73×10^{-6}	7.90×10^{-6}
37B									
38A	14796	Unprinted	36	1.80	0.11	0.11	1.43×10^{-4}	8.70×10^{-6}	8.70×10^{-6}
38B									
39A	15519	Unprinted	36	0.04	0.005	0.002	3.17×10^{-6}	3.97×10^{-7}	1.59×10^{-7}
40A	15519	Unprinted	36	0.03	0.004	0.002	2.38×10^{-6}	3.18×10^{-7}	1.59×10^{-7}

[a] Samples 1 and 2, "before embosser" samples, were not embossed, but were run through the heated embosser area. These two samples were brought back to the recovery room, cut and loaded within ten minutes.

[b] These samples were placed in Wheaton jars while awaiting the availability of the drying tubes.

[c] These samples were collected, cut and loaded directly into the drying tubes.

[d] These samples have very high area counts and they are fairly consistent with each other. Although the wallcovering does not have especially heavy coverage, it is possible that the inks used on this covering (order no. 15511) have a particularly high solvent content. There are no "after embosser" samples. This was the last day of ES's field testing and GTR was only printing that day, intending to emboss that night.

TABLE 2-9 (Continued)

SUMMARY OF WALLCOVERING SOLVENT RESIDUES
GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS
MARCH 23-25, 1981

Sample No.	Order No.	Condition	Sample Size (sq. inches)	mg MEK Sample	mg MIBK Sample	mg Toluene Sample	lb MEK (sq. yd.)	lb MIBK (sq. yd.)	lb Toluene (sq. yd.)
41A	15511	Unprinted	36	0.01	0.005	0.001	7.94×10^{-7}	3.97×10^{-7}	7.94×10^{-8}
42A	15511	Unprinted	36	0.03	0.001	0.001	2.38×10^{-6}	7.94×10^{-8}	7.94×10^{-8}

a Samples 1 and 2, "before embosser" samples, were not embossed, but were run through the heated embosser area. These two samples were brought back to the recovery room, cut and loaded within ten minutes.

b These samples were placed in Wheaton jars while awaiting the availability of the drying tubes.

c These samples were collected, cut and loaded directly into the drying tubes.

d These samples have very high area counts and they are fairly consistent with each other. Although the wallcovering does not have especially heavy coverage, it is possible that the inks used on this covering (order no. 15511) have a particularly high solvent content. There are no "after embosser" samples. This was the last day of ES's field testing and GTR was only printing that day, intending to emboss that night.

TABLE 2-9

SUMMARY OF WALLCOVERING SOLVENT RESIDUES
GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS
MARCH 23-25, 1981

Sample No.	Order No.	Condition	Sample Size (sq. inches)	mg MEK Sample	mg MIBK Sample	mg Toluene Sample	lb MEK (sq. yd.)	lb MIBK (sq. yd.)	lb Toluene (sq. yd.)
1A[a]	15516	Before embosser	36	3.57	1.16	0.48	2.83×10^{-4}	9.21×10^{-5}	3.81×10^{-5}
1B				0	0	0			
2A[a]	15516	Before embosser	36	3.37	0.89	0.38	2.68×10^{-4}	7.06×10^{-5}	3.02×10^{-5}
2B				0	0	0			
5A[b]	15516	After embosser	36	3.11	0.99	0.42	2.47×10^{-4}	7.86×10^{-5}	3.33×10^{-5}
5B				0	0	0			
6A[b]	15516	After embosser	36	2.75	0.90	0.37	2.18×10^{-4}	7.14×10^{-5}	2.94×10^{-5}
6B				0	0	0			
9A[b]	15519	Before embosser	33	4.35	1.57	0.68	3.77×10^{-4}	1.36×10^{-4}	5.89×10^{-5}
9B				0	0	0			
10A[b]	15519	Before embosser	36.56	5.00	1.88	0.81	3.91×10^{-4}	1.47×10^{-4}	6.33×10^{-5}
10B				0	0	0			
13A[c]	15519	After embosser	38.88	1.25	0.44	0.02	9.19×10^{-5}	3.23×10^{-5}	1.50×10^{-6}
13B				0	0	0			
14A[c]	15519	After embosser	40.06	1.53	0.46	0.19	1.09×10^{-4}	3.28×10^{-5}	1.36×10^{-5}
14B				0	0	0			
19A[c]	14796	Before embosser	32.87	0.57	0.41	0.26	4.95×10^{-5}	3.56×10^{-5}	2.26×10^{-5}
19B				0	0	0			
20A[c]	14796	Before embosser	27.25	0.26	0.45	0.20	2.73×10^{-5}	4.72×10^{-5}	2.10×10^{-5}
20B				0	0	0			
25A[b]	14796	After embosser	23.51	0.26	0.18	0.12	3.16×10^{-5}	2.19×10^{-5}	1.46×10^{-5}
25B				0	0	0			

[a] Samples 1 and 2, "before embosser" samples, were not embossed, but were run through the heated embosser area. These two samples were brought back to the recovery room, cut and loaded within ten minutes.

[b] These samples were placed in Wheaton jars while awaiting the availability of the drying tubes.

[c] These samples were collected, cut and loaded directly into the drying tubes.

[d] These samples have very high area counts and they are fairly consistent with each other. Although the wallcovering does not have especially heavy coverage, it is possible that the inks used on this covering (order no. 15511) have a particularly high solvent content. There are no "after embosser" samples. This was the last day of ES's field testing and GTR was only printing that day, intending to emboss that night.

TABLE 2-10

SUMMARY OF TIME LAG AND PATTERN
DUPLICATION OF WALLCOVERING SAMPLES
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Sample No.[a]	Date	Time Lapse From Collection to Start of Recovery
1A, B[b]	3/23	10 minutes
2A, B[b]	3/23	10 minutes
5A, B[b]	3/23	49 minutes
6A, B[b]	3/23	49 minutes
9A, B[c]	3/23	2 minutes
10A, B[c]	3/23	2 minutes
13A, B[c]	3/23	4 minutes
14A, B[c]	3/23	4 minutes
19A, B[c]	3/24	2 minutes
20A, B[d]	3/24	2 minutes
25A, B[d]	3/24	2 hours, 28 minutes
26A, B[d]	3/24	2 hours, 28 minutes
29A, B[c]	3/25	1 minute
30A, B[c]	3/25	1 minute
33A, B	3/27	Samples 33-42 were re-
34A, B	3/27	covered in the ES lab
35A, B	3/27	
36A, B	3/27	
37A, B	3/27	
38A, B	3/27	
39	4/21	
40	4/21	
41	4/21	
42	4/21	

a Every two numbers represents a pair of samples which were recovered simultaneously.

b These samples were cut attempting to duplicate the patterns. Samples numbers 1 and 2 are a pair, and 5 and 6 are a pair.

c These samples were loaded directly into the drying tubes in the print room in less than two minutes.

d These samples were placed in the Wheaton jars immediately after being cut in the print room, while awaiting the drying tubes.

causing some solvent to be driven off. The next set of samples (order no. 15519) shows a considerable difference between the before and after embosser samples. The third set (order no. 14796) was a different wallcovering from the others and was know to be far less absorbent. The resulting data reflect this. The fourth set (order no. 15511) contains only before embosser samples.

During the field test, there was considerable "down" time in the print room. Also during these three days, GTR experienced problems with some wallcovering which was expanding with the heat of the process and, therefore, could not be trimmed properly. When this occured, GTR printed the wallcovering and waited until later in the day or at night to the embossing. These factors account for the small number of samples collected.

The data indicate that some solvent is driven off by the heat of the embosser and some remains on the wallcovering and is going out with the product. For example, sample 5A retained 2.47×10^{-4} pounds of MEK per square yard. A hypothetical run of 5,000 square yards would then retain 1.24 pounds (0.7 liter) of MEK.

The unprinted wallcovering samples contained a significant amount of solvent material. This may be because one or more of the solvents may be used in the manufacturing of the vinyl or the fabric web. To check for sample container contamination, samples of unprinted wallcovering were stored at room temperature in a manila folder and analyzed one month after the original analyses. Small amounts of solvent were detected in these delayed analyses.

2.7 FID Analyzer Audit Results

Two standard concentrations of propane and one standard concentration of MEK were supplied by EPA and analyzed by TRC in order to assess the accuracy of the FID analyzers. These standard concentrations (audit samples) were an-

alyzed in the TRC laboratory before and after the measurement program and in the field periodically during the program. The results of these audit sample analyses are shown in Table 2-11. Details are presented in Appendix C.3.

The average error for each analyzer was within the specified criterion of ±10 percent for both propane and MEK. The analysis results for the one MEK audit sample exhibit error considerably larger than the propane audit error. The MEK results for the analyzer used at the CA inlet were consistently high (averaging +5.2%) while the MEK results for the wall fan/CA outlet and embosser were consistently low (averaging -5.7% and -7.0%, respectively). The reason for the difference between the CA inlet analyzer and the other two analyzers is not evident. This difference may be attributable to the unique response characteristics of each analyzer, since a similar though less pronounced pattern is evident in the propane results.

The larger errors in the MEK results compared to the propane results are probably due to the MEK bag standards used to calibrate the analyzers. These bag standards were prepared as described by EPA Method 110. Very small amounts of liquid MEK (0.5 microliters to 100 microliters) were vaporized in 1 cubic foot of air and contained in 30-liter Tedlar bags. The difficulties inherent in measuring out those small amounts of MEK with syringes, and in accounting for other variables such as the volume, temperature and pressure of the diluting air, contribute significantly to error. The potential adsorption and desorption of MEK onto and from the bag walls, while controlled through the use of pre-conditioned bags, can also contribute to error.

MEK calibrations were not performed on March 17 and March 23 (except for the CA inlet analyzer), so propane/MEK relationships specific for these two days could not be calculated. On these two days analyzer responses to the MEK audit sample were converted to propane concentrations (since propane calibra-

TABLE 2-11

AUDIT SAMPLE ANALYSIS RESULTS AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Analyzer	Sampling Location	Date	Audit Sample MEK 38.7 ppm	Audit Sample Propane 309 ppm	Audit Sample Propane 10.01 ppm
Bendix 1	TRC Lab	3-11-81	37.7	297	10.2
	CA Inlet	3-17-81	39.3	302	*
		3-18-81	NA	298	10.0
		3-23-81	49.1[a]	301	10.3
		3-24-81	41.7	NA	NA
		3-25-81	34.8	301	9.6
		3-26-81	42.5	303	9.9
	TRC Lab	3-31-81	40.1	291	10.3
		Average	40.7	299	10.0
		Error (%)	5.2	-3.2	0.0
Bendix 2	TRC Lab	3-11-81	33.8	283	9.7
	Wall Fan	3-17-81	37.7[a]	294	9.9
	CA Outlet	3-25-81	33.7	292	10.0
		3-26-81	37.8	303	10.3
	TRC Lab	3-31-81	39.7	303	10.0
		Average	36.5	295	10.0
		Error (%)	-5.7	-4.5	0.0
Scott 1	TRC Lab	3-11-81	33.2	304	10.7
	Embosser	3-17-81	37.6[a]	298	10.0
		3-23-81	35.8[a]	294	9.1
	TRC Lab	3-31-81	37.3	294	9.6
		Average	36.0	298	9.8
		Error (%)	-7.0	-3.6	-2.0
Weighted Average Error (%)			-1.3	-3.7	-0.5

* Analyzer attenuation was not low enough to yield proper resolution.

[a] Measured as propane and converted to MEK using propane/MEK relationships developed on nearest days.

tions were performed daily), and then converted to MEK using propane/MEK relationships developed on the nearest days. All FID analyzer calibration procedures are discussed further in Section 5.3 and in Appendix C.

3.0 PROCESS DESCRIPTION

Emission tests were conducted at the GTR vinyl-coated fabric plant in Reading, Massachusetts during March 1981. The tests were designed to quantify controlled and uncontrolled VOC emissions from the printing of vinyl wallcoverings. An overhead diagram of the printing operation facilities is shown in Figure 3-1. A schematic of the printing operation is shown in Figure 3-2.

The print-line tested by EPA was housed in a room separate from the main plant. The print room ventilation system consisted of a room air exhaust fan, a room air supply fan, a carbon adsorption unit inlet fan, an embosser exhaust fan, and several doors. The print room itself and the room air supply fan are designed to accomodate three print-lines. At the time of these tests only one print-line, PE-3, was in the print room.

3.1 General Description

The vinyl wallcovering manufacturing process at this GTR plant consists of three operations: the calendering operation (preparation of the substrate), the ink mixing operation and the printing operation. The calendering operation works five days per week, eight hours per day, with an occasional shift on Saturday and Sunday. The printing operation (print-line) works as a batch operation five days per week, 24-hours per day.

The substrate is prepared by mixing plasticizers in three banburies. The mixed plasticizers are fed into a feed mill for further mixing before being transported to the calendering operation. Emissions from the three banburies are manifolded and exhausted through a roof fan to the atmosphere. The feed mill is vented by a canopy hood which is exhausted through a roof fan to the atmosphere.

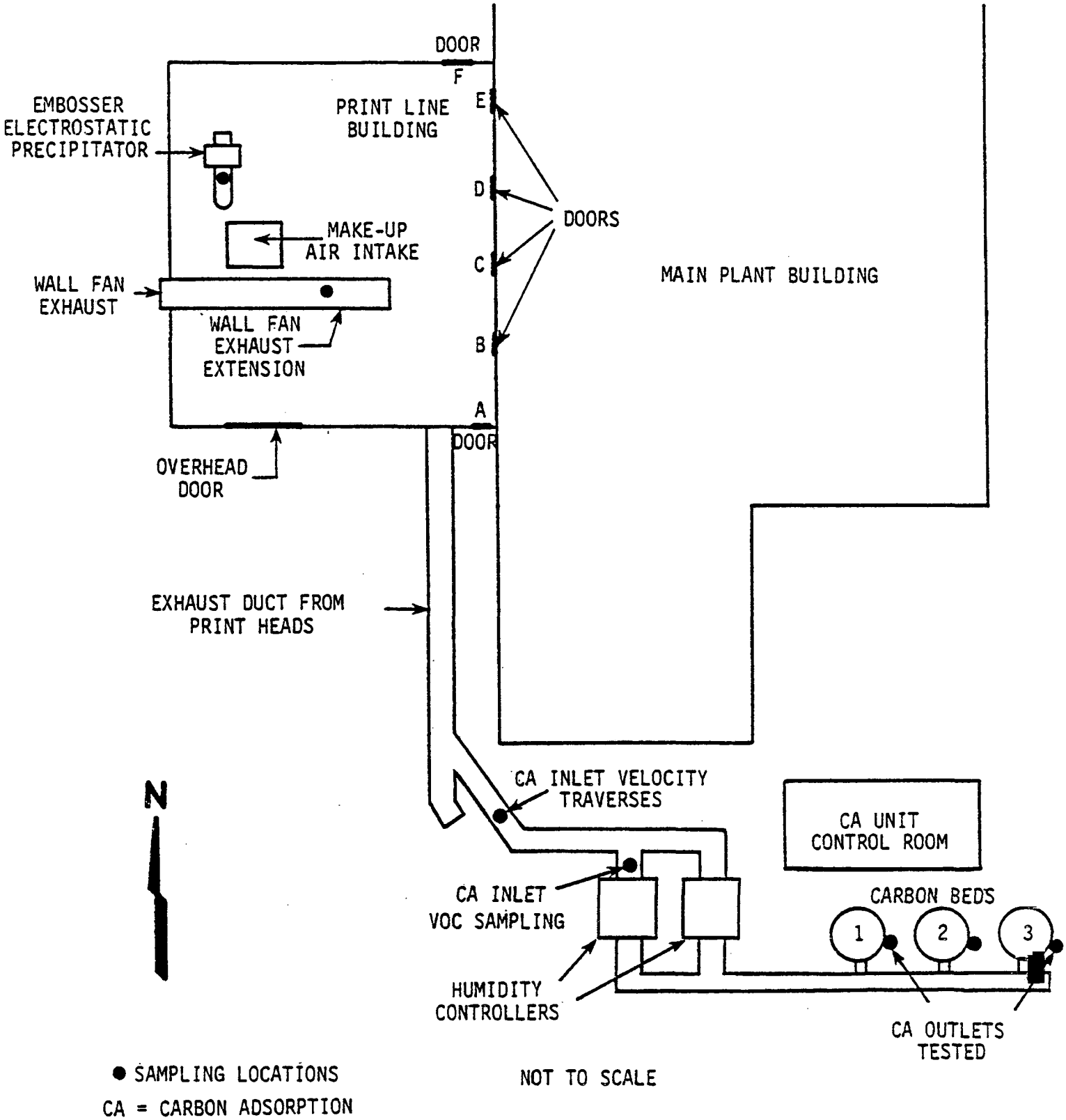
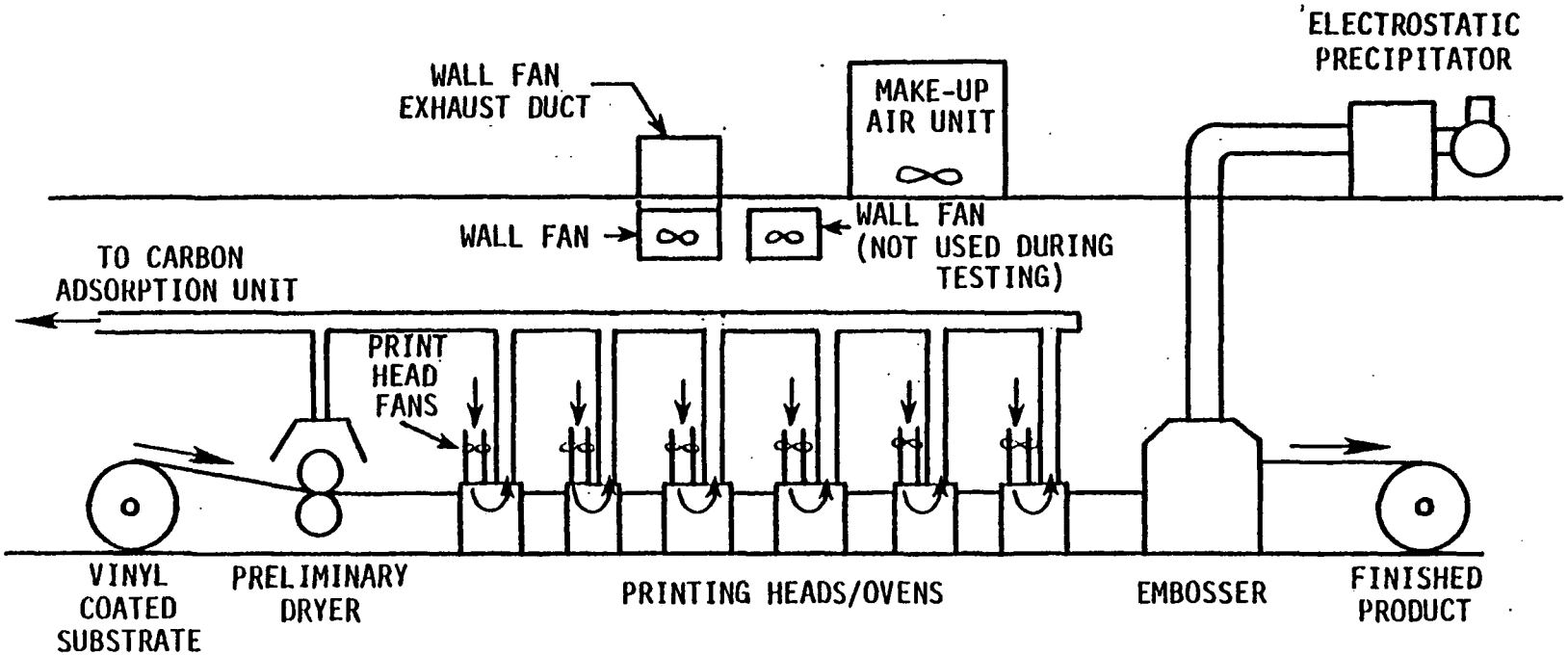


FIGURE 3-1: OVERHEAD DIAGRAM OF PRINTING OPERATION FACILITIES AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS



NOT TO SCALE

FIGURE 3-2: SCHEMATIC OF PRINT-LINE OPERATION AT GENERAL TIRE AND RUBBER COMPANY READING, MASSACHUSETTES

In the calendering operation, the mixed plasticizers from the feed mill are coated onto a fabric web. The heated rollers of the calender volatilize the plasticizers, producing a light smoke over the calender stand. This smoke is vented by a canopy hood and is exhausted directly to atmosphere through two exhaust fans located on the roof. The finished product from the calendering operation is rolled and transported to the print-line.

Inks for the printing operation are prepared by mixing ink base, color pigments and solvents. Inks are transported to the print-line in 55-gallon drums. During most times of the year, methyl ethyl ketone (MEK) makes up approximately 95 percent of the solvents used to prepare the inks. Emissions from the substrate preparation and ink-mixing operations were not investigated in this test program.

3.2 Printing Operation Description

The print-line is located in a new building, separated from the calendering area and ink mixing area. A Baker-Perkins rotogravure printing machine with an in-line embossing unit utilizes six printing heads capable of printing up to six different colors on the substrate. Depending on the type of printing required for the substrate, one to six print heads can be utilized at any one time.

The pre-mixed ink is transferred manually from drums to a pump tank located next to each print head. When filled, a pump tank is connected to the print head, and ink is pumped from the pump tank to a tray within the print head. A print roller, half-submerged in the tray, transfers ink from the tray to the substrate. Excess ink is gravity fed back to the pump tank.

After ink charging, the print-line is ready for the color matching procedure whereby the operator compares the colors of the new product with a

standard sample. This is done by threading a leader substrate through the entire print-line with a 4-foot square sample of the actual substrate taped to the printed surface. This avoids wasting large quantities of new substrate during the matching process. After the sample has passed through all the print heads, it is removed from the leader and compared to the standard. If the test sample fails to match the standard, inks, ink base or solvent are added to the pump tanks as needed. The sample printing is repeated until all colors adequately match the standards. At the conclusion of color matching, the leader substrate is drawn through the print-line and the actual product substrate is threaded behind it to start the print run.

During the print run, operators will occasionally add MEK solvent or ink base to the pump tanks to make up liquid that has evaporated in order to maintain the required ink viscosity. Each addition is made manually using five-gallon pails which are filled from 55 gallon drums located near the print-line.

During a printing operation a roll of substrate is fed through a preliminary dryer, the six print heads, and an embosser. The inked substrate is dried in an oven contained within each print head and is further heated within the embosser. The final product is re-rolled as it emerges from the embosser.

Periodic line shuts-downs are common during each run due to problems with color matching, registration, the embosser, printers and ink circulation systems. During the down periods, print rollers are often cleaned with small quantities of tetrahydrofuran (THF) and a stiff brush.

To minimize the number of times the pump tank and ink circulation system must be cleaned with solvents, operators will often schedule a series of runs using similar colors. When this occurs, a new color is added to a pump tank without removing the residual ink from the previous run. However, solvent cleaning is necessary if the new color contrasts significantly with the pre-

vious color. Cleaning is done by disassembling all ink circulation system components and rinsing them with MEK solvent. The resulting solvent/ink waste mixture is placed into the original ink mixing drum and removed. The rinsed circulation components, including the used pump tank, are sent out for additional cleaning and a new pump tank and circulation system is installed.

3.3 Printing Operation Emission Controls

VOC emissions are generated by the vaporization of solvents used in the print-line. The print-line emissions are captured by a hooding system that allows the captured emissions to be drawn into the individual print hood ovens. The print-line gaseous emissions which are not captured enter the print room atmosphere and are removed through the other ventilation equipment.

Emissions from the preliminary dryer and the forced-air drying ovens within each print head are manifolded and ducted to a carbon adsorption (CA) unit before being released to the atmosphere. The CA unit is located approximately 300 feet from the print-line building. The unit was designed and installed by Sutcliffe-Speakman, Leigh of Lancashire, England.

There are now three carbon beds associated with the carbon adsorption system. As one carbon column is removing the organic compounds from the air/vapor mixture (adsorption), another is being steam regenerated (desorption). The adsorption/desorption cycle lasts for approximately 120 minutes. The solvent/water mixture recovered from the desorption process is treated by azeotropic distillation and dehydration with calcium chloride. During this measurement program only carbon beds 1 and 3 were operating.

After leaving the sixth print head, the printed substrate passes through a heated embossing unit. The embossing operation further volatilizes the plasticizer, resin, and solvents. Some portion of these plasticizers condense and

form an aerosol. VOC emissions are also generated during embossing. Embosser generated emissions as well as print room ambient emissions are exhausted by the embosser fan. The embosser emissions are exhausted to an electrostatic precipitator (ESP) manufactured by United Air Specialists, Cincinnati, Ohio. The ESP removes the aerosols but does not control the VOC emissions.

3.4 Print-Line Building Air Circulation

Air circulation within the print-line building is affected by four factors:

1. Two wall exhaust fans on the west wall;
2. A make-up air fan on the roof;
3. An overhead door and two small doors opening to the outside; and
4. Four sliding doors connecting the print-line building to the adjacent plant building.

The wall fans are designed to exhaust the fugitive emissions generated by the print-line to the atmosphere. The overhead door is generally open during the summer and closed during the winter. The make-up air fan supplies outside air to the print-line building at the rate of approximately 35000 SCFM, as estimated by plant personnel.

3.5 Operation Parameters Controlled During this Testing Program

The make-up fan remained off during this testing program primarily because plant personnel had determined that the turbulence it generates adversely affects drying within the print head ovens and the embosser. Since it introduces air from a single point about 20 feet above the floor, air distribution is nonhomogeneous along the print-line. In addition, it was shown in the previous EPA test program at this GTR plant that with the make-up fan on, there is a net air flow out of the print-line building through open doorways (1). To maximize the VOC loading to the CA unit, the make-up fan was kept off.

A duct to contain exhaust air from one of the two wall fans was installed on the roof of the print-line building prior to the first EPA testing program in order to facilitate monitoring of wall fan exhausts. During this second test program both wall fans remained off except during the afternoon of March 19, 1981. Prior to this time the fan belt on the ducted fan had been slipping and no flow was detectable in the duct even though the fan motor was on. At approximately 1330 on March 19 the belt was tightened and this one fan remained on the rest of the afternoon. Subsequently the wall fan remained off except for brief periods when the print-line was down. During these times the ducted wall fan was turned on to ventilate the print room.

During the color matching and actual printing process steps, the print head fans were all on to remove the VOC emissions from the ovens and ink wells. Often during the switching and clean up steps, the print head fans were turned off to reduce noise levels in the area. When the print head fans are off, emissions around the print-line are reduced because of lower air circulation around the print-line and because no printing is occurring.

Generally, all but one print room doorway remained closed during the testing program in order to control the amount of air flowing into the print room. The open door was doorway E at the northeast corner of the print room, opening to the main plant. An exception to this occurred on March 18, 1981, when doorways D and B, also opening to the main plant, remained partially open. During the remainder of the testing program other doorways were occasionally opened and usually closed immediately.

Immediately prior to this test program, the carbon adsorption system had been down for repairs and a third carbon bed had just been added as part of a planned expansion. Trained operators were not yet available for night shift operation so the system was operated only on the day shift. At the end of each day the carbon adsorption system was completely shutdown. The carbon

beds were regenerated two times to prevent any remaining solvent from causing fires. This extra regeneration of the beds each evening would make the carbon bed system somewhat more efficient the next day, compared with normal 24-hour per day operation.

3.6 Monitoring of Process Operations

Print-line operations were continuously monitored and recorded by Radian personnel during the testing program. A copy of this process log is shown in Appendix H.

4.0 DESCRIPTION OF SAMPLING LOCATIONS

This section presents descriptions of the sampling locations used during the VOC emission testing program conducted at the GTR vinyl-coated, fabric plant in Reading, Massachusetts, during March 1981. An overhead diagram of the printing operation facilities and approximate sampling locations is shown in Figure 1-1.

4.1 Carbon Adsorption (CA) Unit Inlet

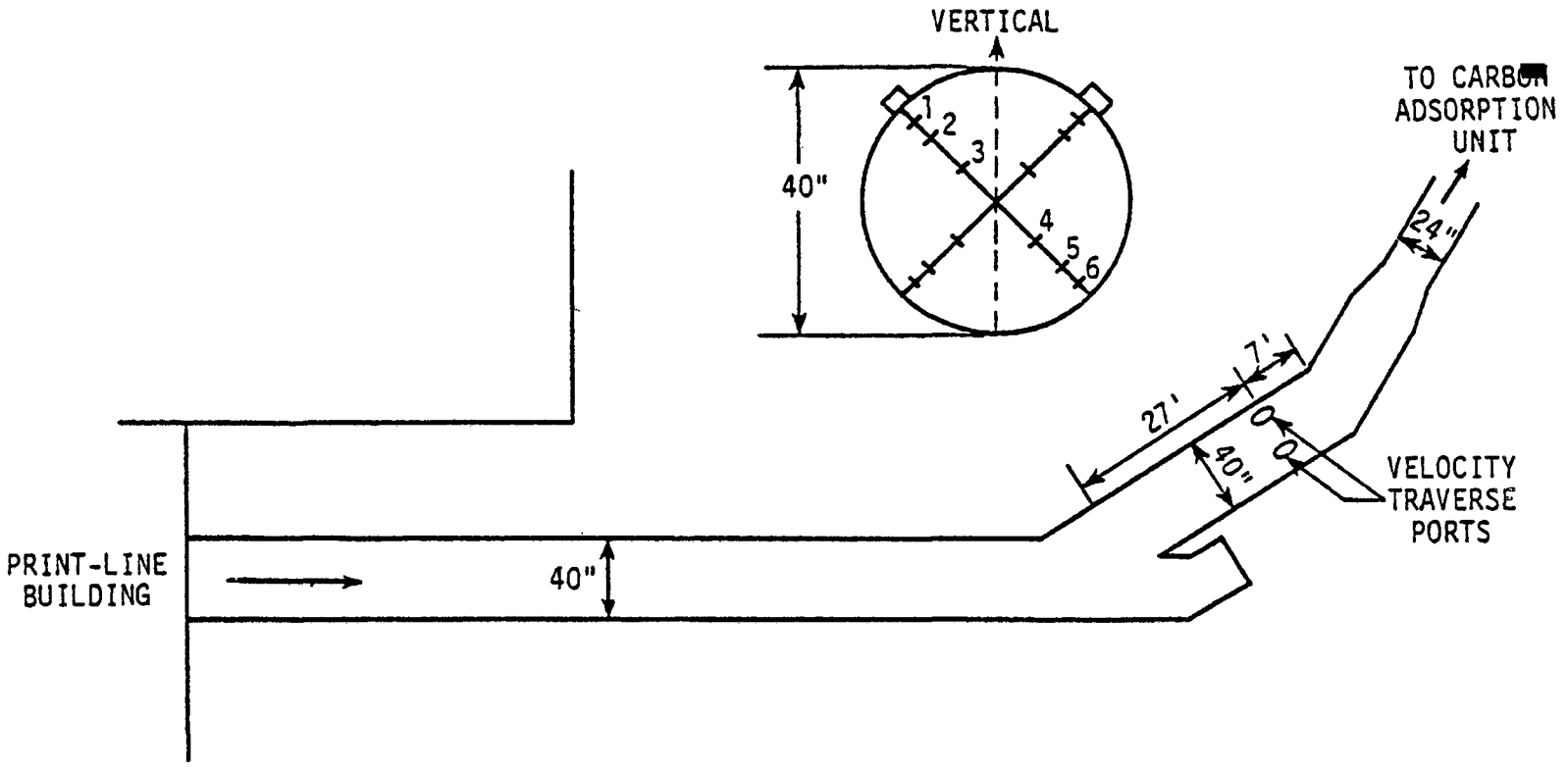
4.1.1 Flowrate Measurements

The CA unit inlet flowrate sampling location was located in a 40-inch i.d. horizontal section of metal duct. A schematic of this location is shown in Figure 4-1. This sampling location was approximately 20 feet above the ground and was reached by erecting temporary scaffolding.

Two 2-inch capped sampling ports were located approximately 40 feet upstream from the carbon unit. The ports were positioned 90 degrees apart in a vertical plane, each 45 degrees on either side of the top of the duct. The ports were approximately 7 feet (2.1 duct diameters) upstream and 27 feet (8.1 duct diameter) downstream from bends in the duct. Since this location did meet the eight-and-two diameters criteria of EPA Method 1, six sampling points were used on each traverse axis, for a total of 12 sampling points.

4.1.2 VOC Sampling

The CA unit inlet VOC sampling location was located at the center of a 90 degree bend in a 24-inch i.d. section of metal duct. The continuous FID samples and NMO Method 25 samples were drawn from the center of the duct using a stainless steel probe inserted through one 2-inch port located approximately



OVERHEAD VIEW

TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM DUCT WALL (INCHES)
1	1.8
2	5.8
3	11.8
4	28.2
5	34.2
6	38.2

FIGURE 4-1: CARBON ADSORPTION UNIT INLET VELOCITY TRAVERSE LOCATION AT GENERAL TIRE AND RUBBER COMPANY, READING, MASS.

36 inches upstream from the newer of the two CA unit humidity controllers. The FID samples were drawn through 20 feet of heated 1/4-inch Teflon tubing to the FID analyzer. This sampling location is shown in Figure 4-2.

The VOC samples were not taken at the flowrate measurement sampling location for the following reasons. EPA Method 1 criteria for sampling site selection are not applicable and not required for VOC sampling. The flowrate measurement sampling location was inconvenient because it was about 20 feet above ground and 60 feet from the sheltered CA unit control room where the FID analyzer was located. Instead, the VOC sampling location provided representative samples and was more accessible. The VOC sampling site was only 5 feet above ground and within 20 feet of the FID, thus less heated sampling line was needed.

4.2 CA Unit Outlets

4.2.1 Flowrate Measurements

The CA unit outlet flowrate sampling locations were located in 24-inch i.d. vertical metal ducts. A schematic of these locations is shown in Figure 4-3.

On each of the two carbon bed outlet stacks (carbon beds 1 and 3), two 2-inch sampling ports were positioned 90 degrees apart in a horizontal plane. The ports were located approximately 4 feet upstream from the top of the stack, and approximately 16.5 feet downstream from where a 6-inch steam bypass duct attaches to the stack. Since these sampling locations did meet the eight-and-two-diameters criteria of EPA Method 1, six sampling points were used on each traverse axis, for a total of 12 sampling points.

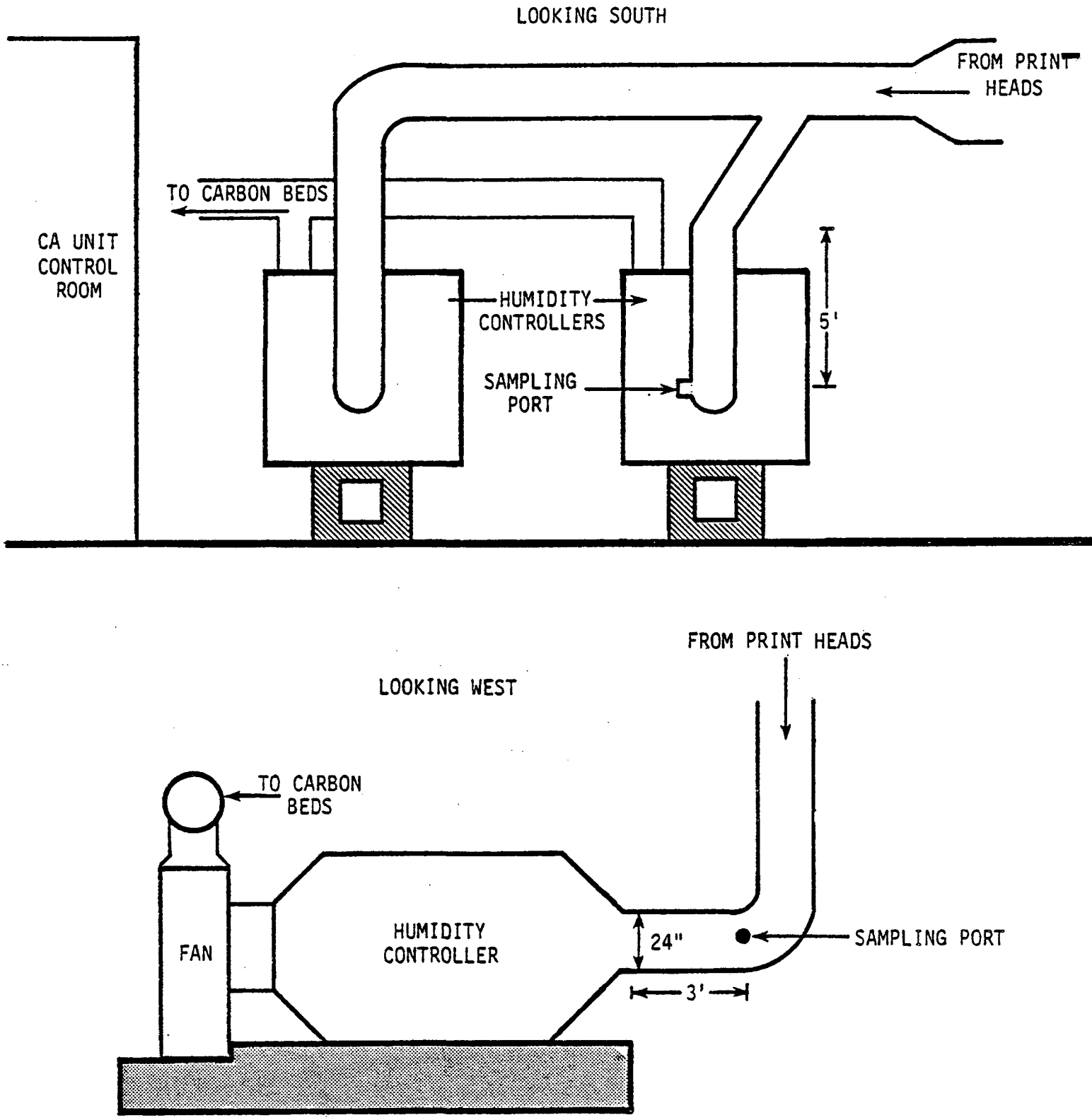
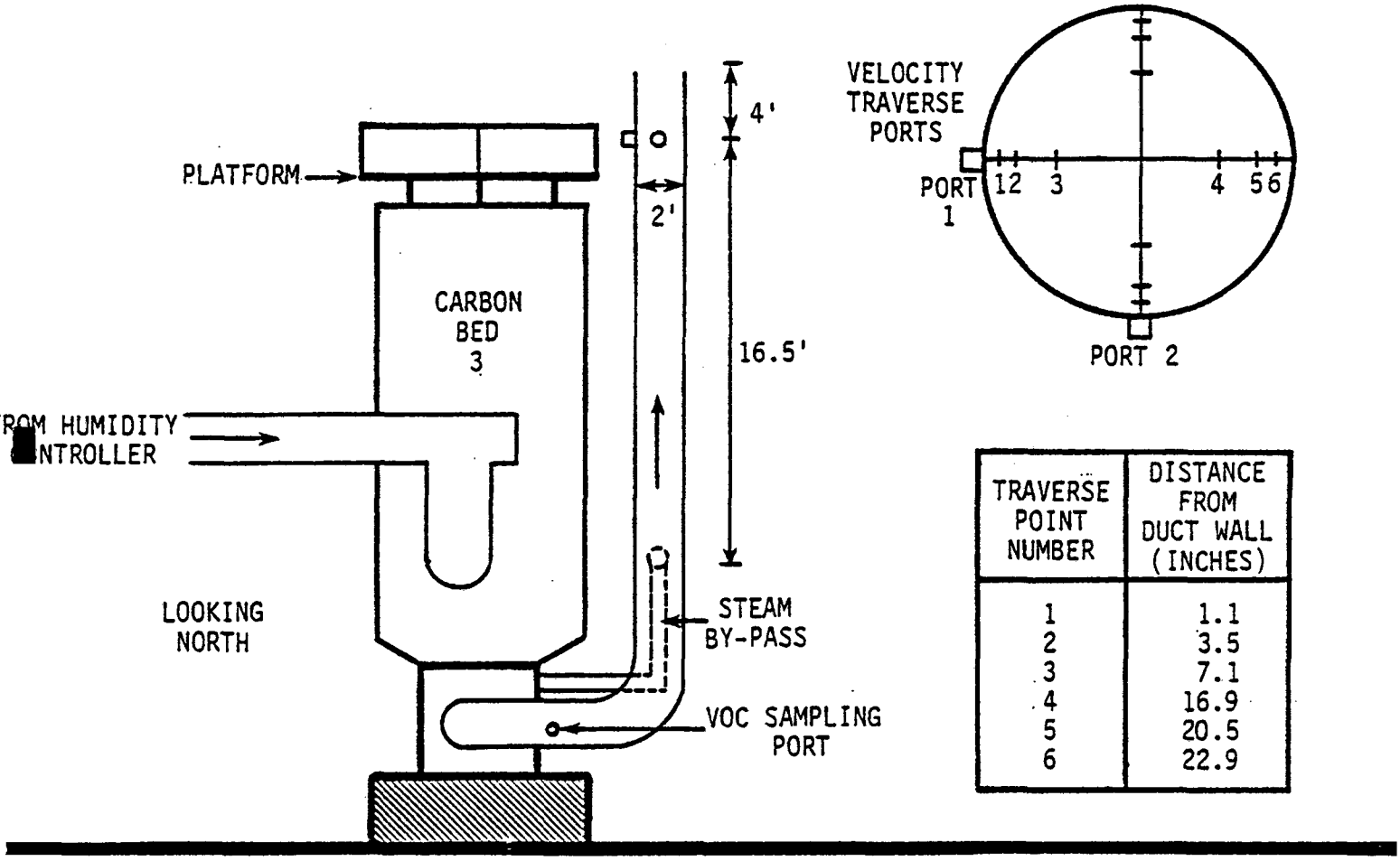


FIGURE 4-2: CARBON ADSORPTION UNIT INLET VOC SAMPLING LOCATION AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS



TRAVERSE POINT NUMBER	DISTANCE FROM DUCT WALL (INCHES)
1	1.1
2	3.5
3	7.1
4	16.9
5	20.5
6	22.9

FIGURE 4-3: CARBON ADSORPTION UNIT OUTLET SAMPLING LOCATIONS (CARBON BED 3) AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS.

4.2.2 VOC Measurements

The CA unit outlet sampling locations were located approximately 20 inches downstream from where the outlet stacks emerge from the base of the carbon beds. The VOC samples (continuous FID and NMO Method 25) were drawn from the center of the duct using a stainless steel probe inserted through a 2-inch port. The continuous FID samples were drawn through 40 feet of heated 1/4-inch Teflon tubing to the FID analyzer. This sampling location is shown in Figure 4-3. The VOC sampling location was different from the flowrate measurement location because the VOC sampling location was more convenient and EPA Method 1 criteria are not required for VOC sampling.

4.3 Embosser Electrostatic Precipitator (ESP) Inlet

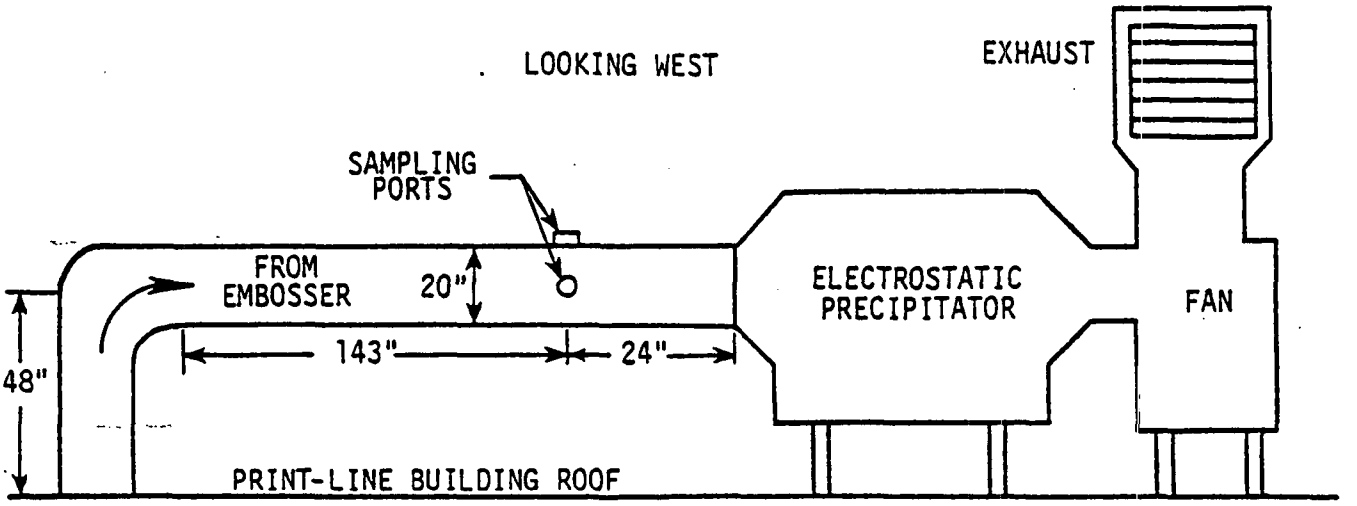
4.3.1 Flowrate Measurements

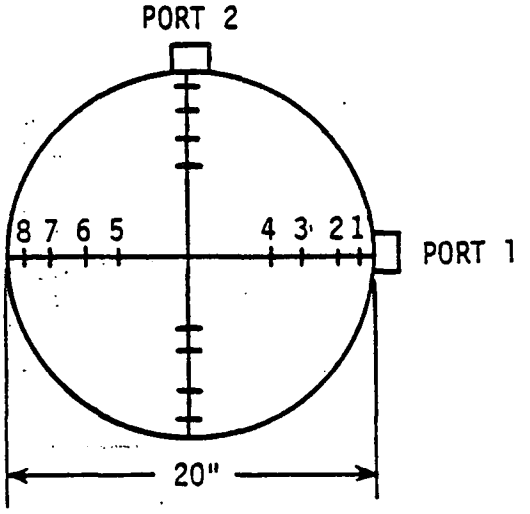
The embosser ESP inlet sampling location was in a 20-inch i.d. horizontal section of metal duct. A schematic of this location is shown in Figure 4-4.

Two 1.5-inch capped ports were positioned 90 degrees apart in a vertical plane. The ports were located 24 inches (1.2 duct diameters) upstream from the ESP and 143 inches (7.2 duct diameters) downstream from a 90 degree bend. Since this location did not meet the eight-and-two diameters criteria of Method 1, eight sampling points were used on each traverse axis, for a total of 16 sampling points.

4.3.2 VOC Sampling

FID and NMO sampling was performed at the same location used for the flowrate measurements. VOC samples were drawn from the center of the duct with a stainless steel probe inserted through one port. The continuous FID samples were drawn through 60 feet of heated 1/4-inch Teflon tubing to the FID analyzer.





TRAVERSE POINT NUMBER	TRAVERSE POINT LOCATION FROM DUCT WALL (INCHES)
1	0.6
2	2.1
3	3.9
4	6.5
5	13.5
6	16.1
7	17.9
8	19.4

FIGURE 4-4: EMBOSSER ELECTROSTATIC PRECIPITATOR INLET SAMPLING LOCATION AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS.

4.4 Wall Fan Exhaust Duct

4.4.1 Flowrate Measurements

The print-line building wall fan exhaust sampling location was located in a 48-inch i.d. square horizontal section of metal duct. A schematic of this location is shown in Figure 4-5. The exhaust extension was applied to only one of the two wall fans. The other fan was not operated during the testing program.

Three 3-inch capped sampling ports were positioned on the north side of the duct in a vertical plane. The ports were located 96 inches (2.0 equivalent duct diameters) upstream from the end of the duct and 384 inches (8.0 equivalent duct diameters) downstream from a 180 degree bend. Since this location did meet the eight-and-two-diameters criteria of EPA Method 1, four sampling points were used on each of the three traverse axes, for a total of 12 sampling points.

4.4.2 VOC Sampling

FID and NMO sampling was performed at the same location used for the flowrate measurements. VOC samples were drawn from the center of the duct with a stainless steel probe inserted through the center port (Port B). The continuous FID samples were drawn through 20 feet of heated 1/4-inch Teflon tubing to the FID analyzer.

4.5 Print-Line Building Ambient Air Measurements

Ambient air VOC measurements were made with a portable hydrocarbon analyzer in the immediate vicinity of the print heads and embosser and at locations throughout the print-line building. Near the print heads measurements were made at the center of the print-line, 2 feet from the print-line and 5 feet from the print-line. Near the embosser measurements were made approximately

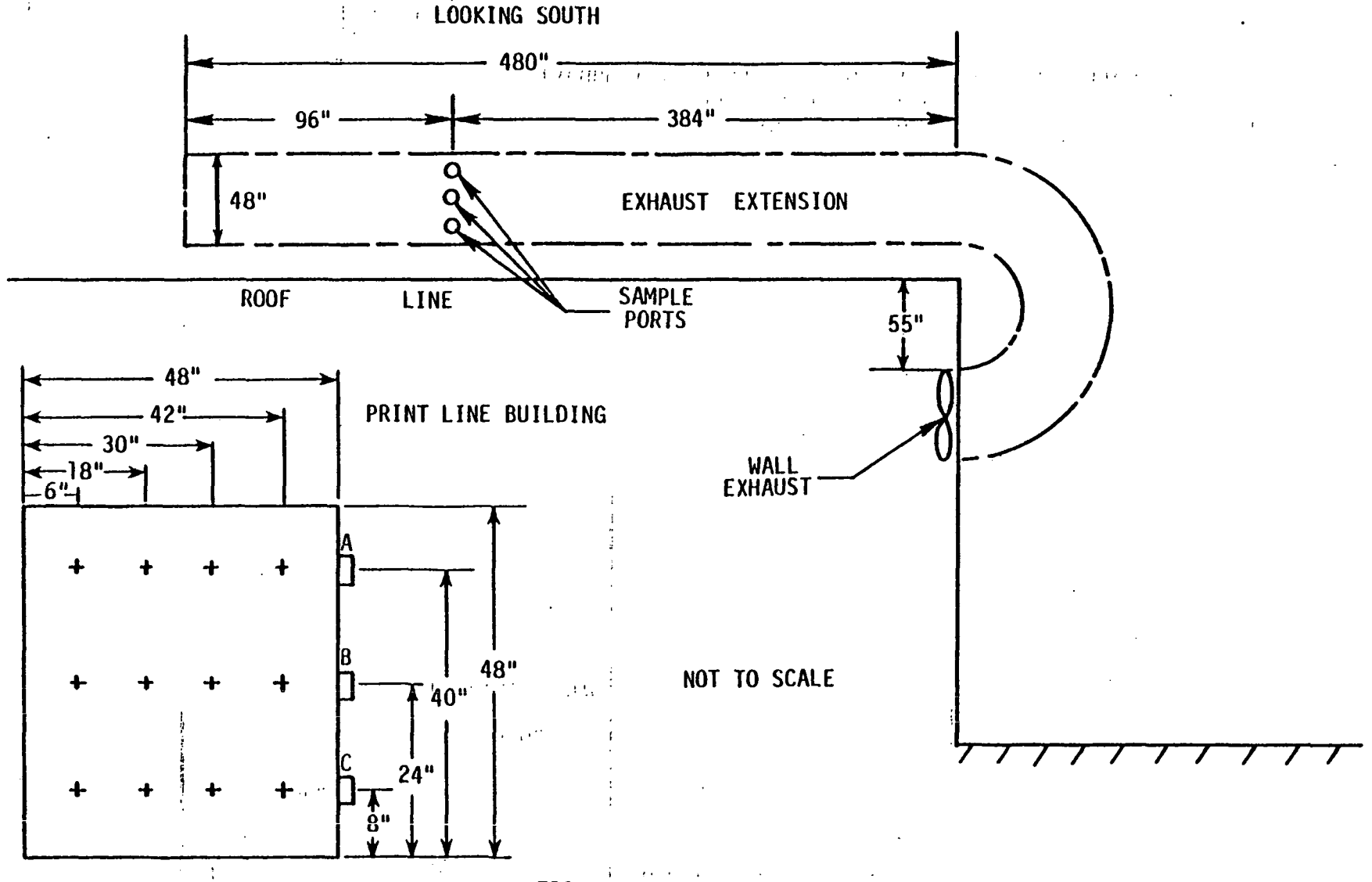


FIGURE 4-5: WALL FAN EXHAUST SAMPLING LOCATION AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS.

2 feet from the cage surrounding the embosser. During the first two ambient surveys, sampling was done at three levels: 1, 5 and 8 feet above the floor. All later sampling was done at only one level, approximately 5 feet above the floor (breathing level). The VOC measurement positions shown in Figure 4-6 represent approximate locations and were not precisely dimensioned. Figure 4-7 shows the VOC measurement site around the embosser.

Air flow measurements were made in open doorways with a hand-held hot-wire anemometer and a vane anemometer. These approximate measurement locations are shown in Figure 4-6. Nearly all air flow measurements were made in doorway E which was always completely open. Nine measurement points were used in doorway E. Six measurement points were used (three rows of two) in doorway D and nine measurement points were used in doorway B when these two doorways were partially open on March 18.

4.6 Wastewater Sampling Locations

Wastewater samples from the carbon adsorbtion unit were collected from a common drain at the base of the carbon beds and from a drain at the base of the water/solvent distillation column.

4.7 Wallcovering Product Sampling Locations

Wallcovering samples were collected from the print-line immediately before and after the embosser.

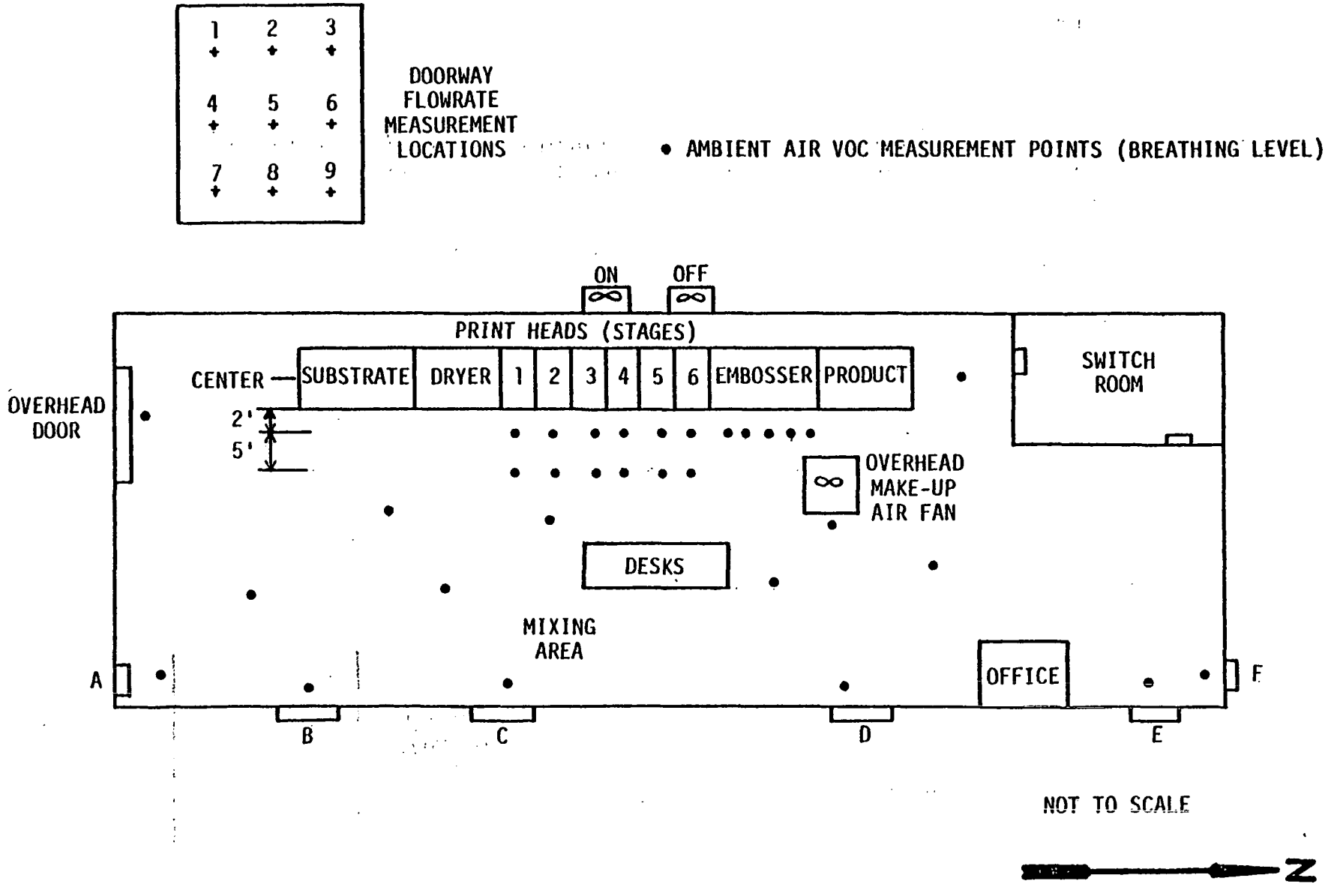


FIGURE 4-6: PRINT-LINE BUILDING AMBIENT AIR MEASUREMENT LOCATIONS AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS

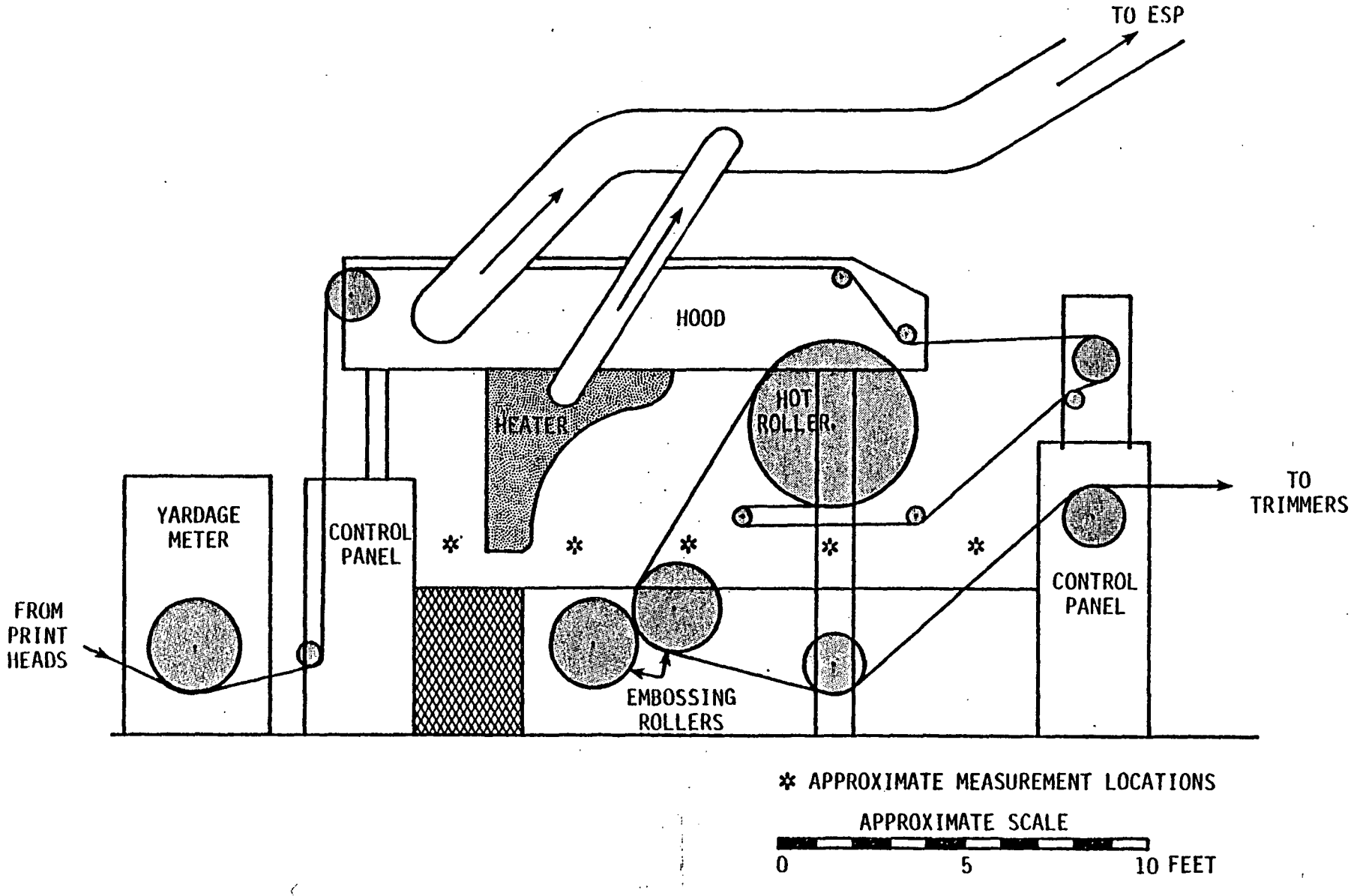


FIGURE 4-7: AMBIENT AIR MEASUREMENT LOCATIONS ALONG THE EMBOSSER AT GENERAL TIRE AND RUBBER COMPANY, READING, MASSACHUSETTS.

5.0 SAMPLING AND ANALYSIS METHODS

This section presents descriptions of the sampling and analysis procedures used during the VOC emission testing program conducted at the GTR vinyl-coated fabric plant in Reading, Massachusetts during March 1981.

5.1 EPA Reference Methods Used During this Program

Method 1 - Sample and Velocity Traverses for Stationary Sources (2)

This method specifies the number and location of sampling points within a duct, taking into account duct size and shape and local flow disturbances.

Method 2 - Determination of Stack Gas Velocity and Volumetric Flowrate (2)

This method specifies the measurement of gas velocity and flowrate using a pitot tube, manometer, and temperature sensor. The physical dimensions of the pitot tube and its spatial relationship to the temperature sensor and any sample probe are also specified.

Proposed Method 25A - Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer (3)

This method describes how VOC are continuously sampled and analyzed using an FID analyzer.

Method 25 - Determination of Total Gaseous Non-Methane Organic Emissions as Carbon (4)

This method describes how gaseous non-methane organic compounds are sampled and analyzed. An emission sample is drawn through a condensate trap and into an evacuated tank. Trap and tank contents are oxidized to CO_2, reduced to methane and analyzed by FID.

Proposed Method 110 - Determination of Benzene from Stationary Sources (5)

This method describes how to prepare standard gas mixtures (benzene or other solvents) in Tedlar bags.

5.2 Duct Flowrate Measurements

Velocity traverses were performed in accordance with EPA Methods 1 and 2 at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets periodically during each testing day. The primary purpose of these

measurements was to determine representative flowrates through these ducts when the print-line was operating.

Traverses were performed at each location with a standard pitot tube for velocity head measurements and a Thermo-Electric Digimite model 31160 electronic thermocouple for temperature measurements. Some temperature measurements were made with an ASTM thermometer when one of the two Digimites brought to the field broke. A 5-foot standard pitot with a 0-10-inch water manometer was used at the CA inlet. A 3-foot standard pitot was used with a 0-10-inch manometer at the embosser ESP inlet and the CA outlets. A 5-foot standard pitot was used with a 0-0.25-inch manometer at the wall fan exhaust duct. A more sensitive manometer was used at the wall fan exhaust duct because of the very small velocity heads expected at this location, based on the results of the previous measurement program at GTR (1).

A measurable flow (about 5000 SCFM) was expected in the wall fan exhaust duct with the one ducted wall fan on. However, velocity traverses performed on March 17 and 18 indicated no flow in this duct, even though the fan motor was on. Plant personnel discovered on March 19 that the fan belt was slipping, and when this was corrected at about 1330 on March 19, flow in this duct was about 10000 SCFM. As a result, air flow in the CA inlet duct decreased by about 7 percent (from about 8200 SCFM to about 7600 SCFM), air flow in the embosser ESP inlet remained unchanged, and air flow into the print room through doorway E approximately tripled (from about 6100 SCFM to about 20000 SCFM). In order to maximize the VOC loading to the CA unit, Radian personnel decided to continue the measurement program after March 19 with the wall fan off when the print-line was operating.

VOC measurements were made at the CA unit outlets on March 25 and 26 only, so flowrate measurements at the CA outlets were made only on those two days. At any given time, VOC and flowrate measurements were made at either carbon

bed 1 outlet or carbon bed 3 outlet, depending on which bed was in operation (adsorbing).

To calculate flowrate (SCFM) from the velocity head and temperature data, moisture contents were estimated. Wet bulb and dry bulb temperature measurements were made daily in the print room with a Bendix Psychron. These measurements indicated a moisture content in the print room of between 0.2 percent and 0.5 percent. Air in the CA inlet, embosser ESP inlet and wall fan exhaust ducts was assumed to be dry (molecular weight 28.8). The moisture content in the CA outlet ducts was assumed to be 5 percent (molecular weight 28.3). This assumption is based on the fact that air with a moisture content of 5 to 6 percent is nearly saturated at the CA outlet stack temperatures (about 110°F). Barometric pressures were obtained daily from Logan Airport in Boston.

5.3 VOC Measurements with FID Analyzers

5.3.1 Sampling with FID Analyzers

VOC concentrations at the CA unit inlet, embosser ESP inlet and wall fan exhaust duct were measured continuously during each day (daytime shift) from March 18 to March 20, 1981. Since there was no flow in the wall fan exhaust duct, monitoring at this location was discontinued on March 23 (Monday). No sampling was performed on March 24 because no printing was done this day. A large backlog of printed but un-embossed wallcovering was accumulated on March 23 because of embosser problems this day. Consequently, March 24 was dedicated to embossing only. VOC concentrations were measured continuously only at the CA unit inlet and CA unit outlets on March 25 and March 26.

The FID analyzers were operated concurrently at each sampling location. A schematic of the sampling equipment is shown in Figure 5-1. A stainless steel probe was inserted through one port and samples were drawn from the center of

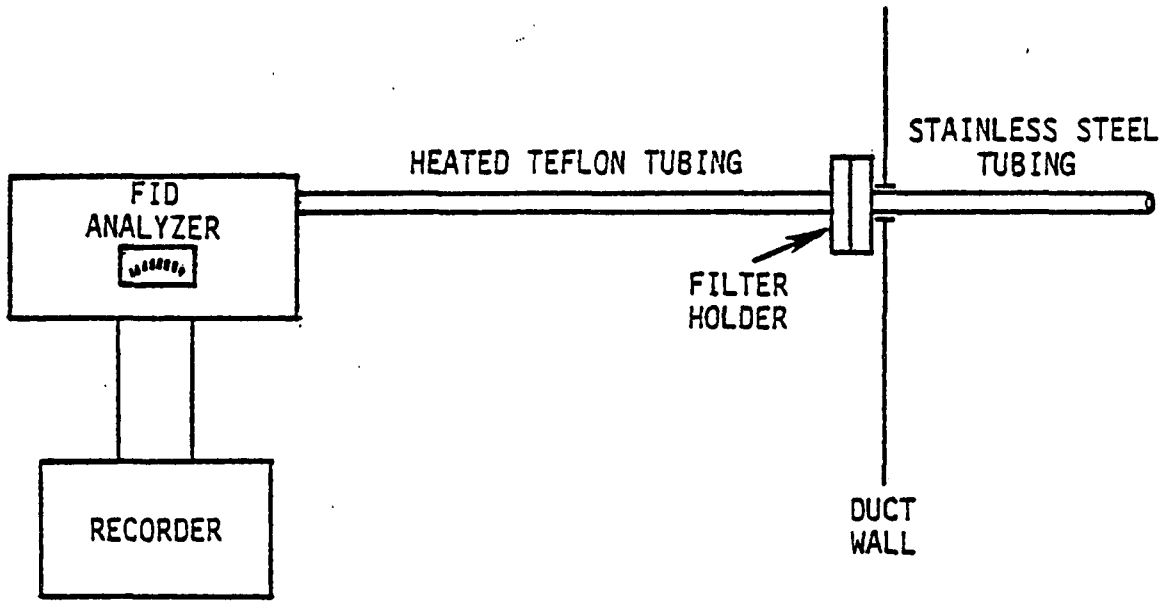


FIGURE 5-1: FLAME IONIZATION DETECTION SAMPLING SYSTEM

the duct. A 2-inch glass fiber filter was positioned between the probe and a heated Teflon sample line to remove particulate matter. This filter was replaced each day, though no significant particulate accumulation was ever observed. The sample line was heated to at least 10°F above stack temperature to prevent condensation of water and organics within the line, and the line was attached directly to the FID analyzer. The continuous analyzer output was recorded on a strip chart recorder.

The analyzers monitoring emissions at the embosser ESP inlet and wall fan exhaust duct were housed in heated fiberglass shelter atop the print-line building. The analyzers monitoring emissions at the CA unit inlet and outlets were housed in the CA unit control room.

Each monitoring day the analyzers were turned on at about 0700, allowed to warm up for about one hour and then calibrated. Sampling continued until the end of the work day or earlier if printing operations ended before the end of the day. Calibrations were repeated at the end of each monitoring day.

Three FID analyzers were used during this measurement program. The sampling locations for each analyzer were as follows:

FID ANALYZER	SAMPLING LOCATION	DATES
Bendix 8402, TRC-1	CA unit inlet	March 18-20,23,25,26
Bendix 8402, TRC-2	Wall Fan Exhaust	March 18-20
	CA unit outlets	March 25-26
Scott 415, TRC-1	Embosser	March 18-20,23

5.3.2 Calibration of the FID Analyzers

During the week prior to and the week following the field work, the three FID analyzers were calibrated at the TRC laboratory with both propane and MEK standards. The primary purpose of these calibrations was to determine that the analyzers were operating satisfactorily. In addition, a preliminary

relationship between the response to propane and the response to MEK was established for each analyzer. With this relationship, the total hydrocarbon (THC) field measurements (based on propane calibrations) could be converted to THC measurements expressed as MEK. Calibrations were performed with six propane compressed gas mixtures and eight MEK bag standards. The MEK standards were prepared by diluting known amounts of MEK in a known volume of hydrocarbon-free air, following the general procedure presented in EPA proposed Method 110. The propane and MEK standards used during these calibrations are shown in Table 5-1.

In the field each analyzer was calibrated at the beginning and end of each monitoring day with propane standards. Because of the difficulty in carrying the compressed gas cylinders onto the roof of the print-line building, propane bag standards were prepared every other day and were used to calibrate the analyzer at the embosser ESP inlet and wall fan exhaust duct. The propane bag standards were prepared by half-filling 30-liter Tedlar bags with the propane mixtures. When a bag was filled for the first time, it was labelled and set aside for an hour to allow for adsorption onto the bag wall. The bag was then emptied and immediately refilled with the same propane mixture. Subsequently a given bag was refilled with the same propane mixture previously used in it.

In addition to the calibrations performed with several propane concentrations at the beginning and end of each day, a one-point calibration was performed one or more times each day as a check on the response of the analyzer. A propane concentration near the highest expected concentration was used for this one-point (span) check. The propane standards used at each sampling location during the field program are shown in Table 5-1. To save time, all six propane standards were not always used with each analyzer. Four or five standards were identified as the base standards for each analyzer, depending on the concentration range expected at each sampling location.

TABLE 5-1

FID ANALYZER CALIBRATION CONCENTRATIONS
USED DURING THE VOC MEASUREMENT PROGRAM AT
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Sampling Location	Measured Concentration Range (ppm as propane)	Propane Standards (ppm)	MEK Standards (ppm)*
[redacted]eneral		0, 5.4, 9.7, 75.1, 274, 499, 949	0, 4.7, 9.5, 18.9, 47.3, 94.5, 189, 473, 945
[redacted]A Inlet	7.5 - 820	0, 9.7, 75.1, 274, 499, 949	**
[redacted]A Outlet	1.3 - 13.0	0, 5.4, 9.7, 75.1, 274	**
Embosser ESP	15.2 - 362	0, 5.4, 9.7, 75.1, 274	**
[redacted]all Fan	1.1 - 146	0, 5.4, 9.7, 75.1, 274	**

* These MEK concentrations are approximate; exact concentrations varied each time MEK bag standards were prepared, depending on temperature and pressure.

** The same MEK bag standards were used at all sampling locations.

Each analyzer was calibrated with MEK standards periodically during the measurement program. These calibrations were performed with one of the twice-daily propane calibrations in order to establish propane-to-MEK response relationships. MEK bags were prepared every day or every other day, and the set of seven or eight bags so prepared were used at all sampling locations. Each bag was labeled and reused with the same approximate MEK concentrations. The approximate MEK concentrations used in the field are the same as those used during the laboratory calibrations, as shown in Table 5-1. The exact concentrations varied from day to day depending on temperature and pressure of the dilution air as it was metered into the bags.

When a given calibration gas was introduced into an analyzer, the analyzer response was recorded on as many attenuations as would fit on the strip chart or as would give a readable response. In this way a calibration curve could be prepared for each attenuation.

5.3.3 Audit Sample Analysis of FID Analyzers

Three audit samples (one MEK and two propane) were provided by EPA. These compressed gas mixtures were introduced to each FID analyzer during the calibrations before and after the field program, and periodically during the field program. As with the propane standards, Tedlar bags were filled with the audit gases in order to avoid carrying the gas cylinders to the print-line building roof. The response (in chart divisions) of each analyzer to the audit samples on a given day was converted to concentration through the propane and MEK calibration curves calculated from the propane and MEK calibration data of that day. Details of the audit results are presented in Appendix C.3.

5.3.4 Data Reduction and Calculations for FID Analyzers

Calibration equations relating analyzer response (chart divisions) to total hydrocarbon (THC) concentration were calculated for each day that calibrations were performed. Calibration equations were calculated for each analyzer and for each attenuation used for the measured duct concentrations and audit sample analyses.

Propane and MEK calibration equations were calculated for each day that MEK calibrations were performed. For each analyzer and attenuation the two calculated relationships were:

$$CD = M_p X_p + B_p \quad (5\text{-}1)$$

$$CD = M_{MEK} X_{MEK} + B_{MEK} \quad (5\text{-}2)$$

Where:
- CD = chart divisions measured from zero offset
- M_p = slope of propane response line
- M_{MEK} = slope of MEK response line
- X_p = total hydrocarbon propane concentration (ppm)
- X_{MEK} = total hydrocarbon MEK concentration (ppm)
- B_p = intercept of propane response curve
- B_{MEK} = intercept of MEK response curve

By combining equations (1) and (2), the MEK concentration equivalent to a given propane concentration was expressed as follows:

$$X_{MEK} = X_p \, (M_p/M_{MEK}) + K \quad (5\text{-}3)$$

where: K is a constant equal to $(B_p - B_{MEK})/M_{MEK}$.

A summary of equations 5-1, 5-2 and 5-3 for each calibration day is shown in Table 5-2. These equations were used only to produce the propane/MEK relationships. A propane/MEK relationship calculated for a given day was also used for the nearest days for which no MEK calibrations were performed. The pre-field-program and post-field-program calibration data were not used to reduce field data.

TABLE 5-2

PROPANE AND MEK CALIBRATION EQUATIONS USED TO ESTABLISH PROPANE-TO-MEK CONVERSION EQUATIONS
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Analyzer	Sampling Location	Calibration Date[a]	Dates Used[b]	Attenuation	Propane[c]			MEK[c]			Propane/MEK Relationship[d]	
					r	M	B	r	M	B	A	K
Bendix 8402	CA Inlet	3-20	3-20,19,18	10000	0.9999	0.032	-0.50	0.9999	0.031	0.06	1.03	-18.7
TRC-1		3-25	3-25	10000	0.9908	0.033	-0.48	0.9999	0.030	0.26	1.10	-24.7
		3-20	3-20, 19	3000	0.9999	0.098	-0.3	0.9976	0.106	-0.6	0.92	2.8
		3-24	3-23	3000	0.9999	0.096	-0.9	0.9990	0.105	-0.7	0.91	-1.9
		3-25	3-25	3000	0.9999	0.096	-0.3	0.9957	0.097	1.0	0.99	-13.7
		3-26	3-26	3000	0.9978	0.095	-0.4	0.9991	0.099	-0.5	0.96	0.7
		3-20	3-20,19,18	1000	0.9999	0.292	-1.1	0.9957	0.317	-2.0	0.92	2.8
		3-24	3-23	1000	0.9993	0.269	-1.1	0.9970	0.304	-1.5	0.89	1.3
		3-26	3-26	1000	0.9983	0.282	-1.1	0.9992	0.292	-1.4	0.97	1.0
		3-24	3-23	300	0.9982	0.793	-1.8	0.9986	0.927	-2.7	0.86	1.0

[a] Day when MEK and propane calibrations were performed.

[b] Days when the indicated propane/MEK relationship was used (because MEK/propane calibrations were not performed every day).

[c] CD = MX + B where CD = chart divisions, M = slope, X = concentration (ppm), B = intercept, r = correlation coefficient.

[d] MEK concentration (ppm) = [A * propane concentration (ppm)] + K. This equation is calculated by combining the propane and MEK calibration equations. See Section 5.3.4.

TABLE 5-2 (Continued)

PROPANE AND MEK CALIBRATION EQUATIONS USED TO
ESTABLISH PROPANE-TO-MEK CONVERSION EQUATIONS
GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Analyzer	Sampling Location	Calibration Date[a]	Dates Used[b]	Attenuation	Propane[c]			MEK[c]			Propane/MEK Relationship[d]	
					r	M	B	r	M	B	A	K
Bendix 8402 TRC-2	Wall Fan	3-20	3-20,19,18	1000	0.9985	0.324	-1.1	0.9964	0.341	-1.9	0.95	2.3
	Wall Fan	3-20	3-20,19,18	300	0.9999	0.969	0.3	0.9983	0.976	1.1	0.99	-0.8
	Wall Fan	3-20	3-20,19,18	100	0.9808	3.033	-1.5	0.9988	3.066	0.4	0.99	-0.6
	CA Outlet	3-26	3-26,25	100	0.9921	2.219	-0.7	0.9981	2.377	1.1	0.93	-0.8
	Wall Fan	3-20	3-20,19,18	30	1	7.037	0	1	11.064	0	0.64	0*
	CA Outlet	3-26	3-26,25	30	0.9928	7.416	-2.2	0.9904	8.838	3.3	0.84	-0.6
Scott 415 TRC-1	Embosser	3-20	3-20,19,18	1000	0.9980	0.245	-0.1	0.9975	0.276	-0.7	0.89	2.0
		3-24	3-23	1000	0.9997	0.248	-0.3	0.9999	0.274	-0.1	0.91	-0.7
		3-20	3-20,19,18	500	0.9968	0.463	1.4	0.9963	0.497	0.5	0.93	1.8

* Only one non-zero calibration point could be used for the propane and MEK equations.

[a] Day when MEK and propane calibrations were performed.

[b] Days when the indicated propane/MEK relationship was used (because MEK/propane calibrations were not performed every day).

[c] CD = MX + B where CD = chart divisions, M = slope, X = concentration (ppm), B = intercept, r = correlation coefficient.

[d] MEK concentration (ppm) = [A * propane concentration (ppm)] + K. This equation is calculated by combining the propane and MEK calibration equations. See Section 5.3.4.

Strip charts were divided into time intervals according to the consistency of the trace and according to times corresponding to significant process operations. An average VOC-as-propane (X_p) concentration was calculated for each time interval, using a cursor to determine chart divisions (CD) and then using a daily propane calibration equation, calculated from the combined beginning-of-day and end-of-day calibration data, to determine X_p. These daily propane calibration equations (calculated for each attenuation) have the same form as Equation 5-1, and are shown in Appendix C.3. With X_p and the measured flowrates the following parameters were then calculated:

- VOC-as-MEK concentration (X_{MEK}), using equation (5-3);
- mass as MEK emitted during each time interval (lb);
- mass emission rate during each time interval (lb/hour); and
- total mass emitted during each print run (lb).

The mass as MEK emitted during each time interval was calculated by multiplying the VOC concentration for that time interval by the average flowrate for the run and by the length of the time interval:

$$Mass_{MEK} = X_{MEK} \cdot Q \cdot T \cdot F \qquad (5\text{-}4)$$

Where: X_{MEK} = total hydrocarbon concentration as MEK (ppm)
Q = average flowrate for the run (SCFM)
T = time interval (minutes)
F = units conversion factor

Details of these calculation procedures are presented in Appendix C.

Since flowrates were not measured continuously, judgements were made on what flowrates should be assigned to which time intervals, as discussed in Section 2.2. When two or more consecutive measured flowrates did not change significantly (approximately $\pm$ 10%), these flowrates were averaged. Using the process log and the consistency of the strip chart traces as guides, flowrates were then assigned to time intervals. The flowrate assignments are shown on the work sheets in Appendix B.

5.4 NMO Sampling with Method 25

5.4.1 Preparation for Method 25

The NMO sampling train condensate traps and evacuated tanks were prepared at TRC in accordance with Method 25 guidelines. Detailed preparation procedures are shown in Appendix D.

Each uniquely identified trap was connected to a source of hydrocarbon-free (HCF) air and a CO_2 analyzer and placed in a furnace. While heated to 600°C the trap was purged with HCF air until CO_2 concentrations were below 10 ppm.

Each uniquely identified tank (each with a volume of approximately 4800 cc) was purged with HCF air and evacuated three times. Twenty percent of the tanks were then analyzed to ensure they contained less than 10 ppm hydrocarbons.

Six flow control assemblies were adjusted to a nominal flowrate of approximately 50 cc/minute. The evacuated tank was connected to the flow assembly and the on/off value was then opened. Flow into the tank was adjusted with the flow control valve, and the flow assembly was then sealed.

5.4.2 Sampling for Method 25

Prior to assembly of the sampling train, tank vacuum pressure was checked with a mercury U-tube manometer to ensure no change had occurred since laboratory preparation. At each sampling location two Method 25 sampling trains were assembled, as shown in Figure 5-2, except without the glass fiber filter, and each train was leak checked. The sampling plan was to collect duplicate samples at each location only while the print-line was operating and concurrently with the continuously operating FID analyzers. At the embosser ESP

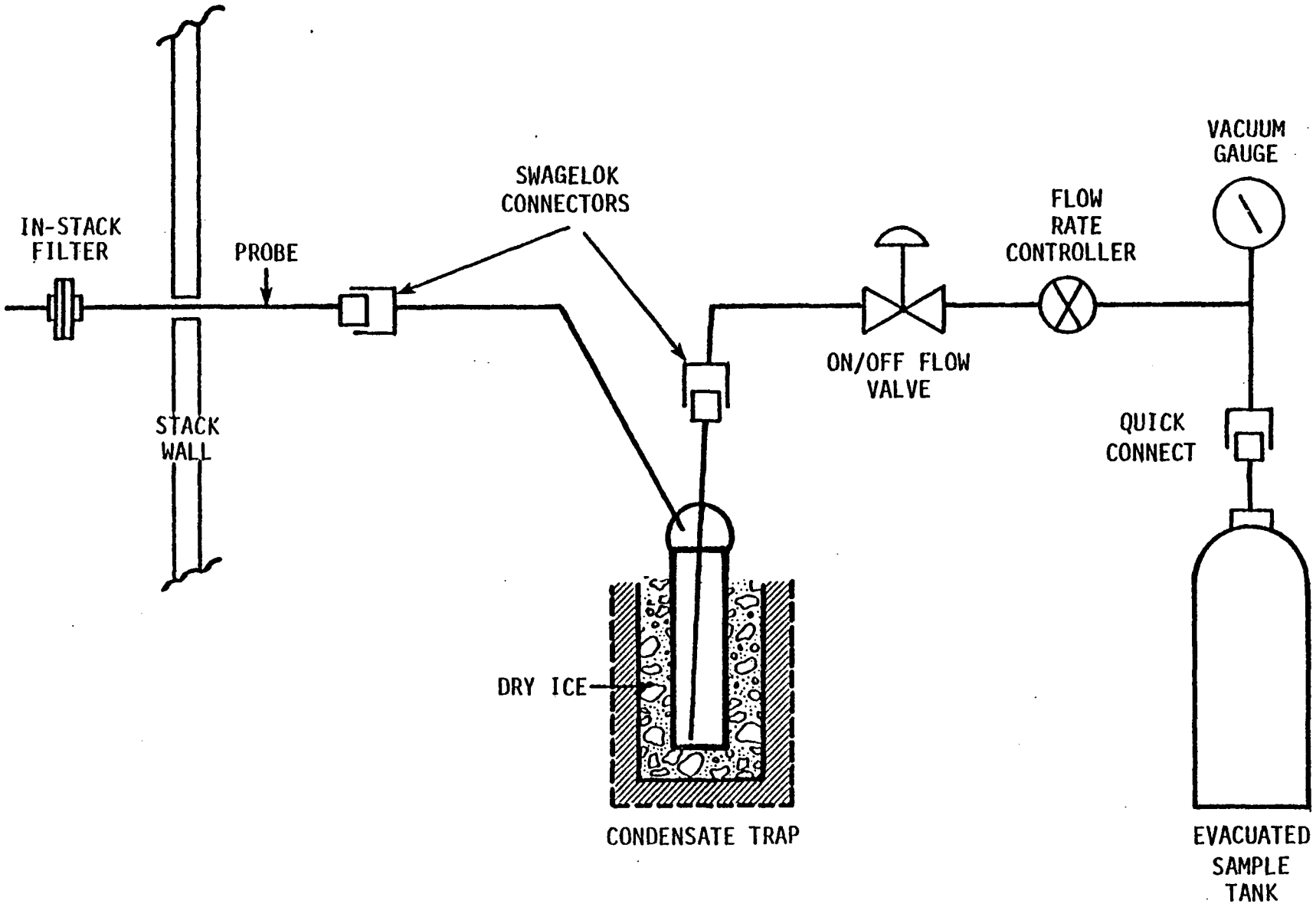


FIGURE 5-2: METHOD 25 SAMPLING TRAIN

inlet on March 19 and 20, one train was assembled with a glass fiber in-stack filter in order to assess the effects of the filter on the collected sample.

The probes were inserted through the sampling port to the center of the duct. If conditions were favorable (i.e., the print-line was operating) the on/off valves were opened on all sampling trains at a pre-arranged time and sampling continued for 45 minutes. If the print-line went down before 45 minutes had elapsed, sampling was stopped and then re-started when the print-line came back up. All stop and start times were recorded. Because of the unpredictable operation of the print-line, 45 minutes of sampling was not always achieved. Actual sampling times ranged from 18 to 56 minutes. An additional sampling tank was used at the CA outlets on March 26 on both sampling trains to draw a larger sample because of the low duct concentrations.

During sampling, tank vacuum pressure was recorded every five or ten minutes. At the conclusion of sampling the final tank vacuum pressure was recorded, the probe was removed from the duct and the probe tip was plugged. The trains were then leak checked and dissassembled. The two ends of the condensate trap were sealed and the trap was kept packed in dry ice until analysis at the TRC laboratory.

5.4.3 Analysis for Method 25

Tanks and traps were analyzed at the TRC laboratory within 30 days of sample collection, following the EPA Method 25 procedures modified as described in the February 1981 TRC report "EPA Method 25 Collaborative Report" (6). Details of the analysis procedures are presented in Appendix D.

Each trap was first purged with nitrogen at ambient temperature to sweep any CO_2 in the trap into its associated tank and to bring the tank pressure from vacuum to positive (15-20 inches Hg). The tank contents were then passed

through a Varian model 2800 gas chromatograph and flame ionization detector (GC/FID). When CO, CH_4 and CO_2 eluted, the GC column was backflushed and all other organic compounds in the tank were passed through oxidation catalysts (converting everything to CO_2) and then through reduction catalysts (converting everything to CH_4) and finally through the FID for measurement of non-methane organics (NMO_{tank}) as CH_4.

The trap was then heated and purged with air or oxygen to volatilize all heavy (condensable) organics. These organics were passed through the oxidation catalyst and collected as CO_2 in a clean, evacuated intermediate tank. The intermediate tank contents were then passed through a reduction catalyst and analyzed in the FID as CH_4 (NMO_{trap}). The sum of NMO_{tank} plus NMO_{trap} equals the total non-methane organics sampled by the Method 25 train.

The GC/FID was calibrated with propane standards that were first passed through the oxidation and reduction catalysts and then measured as methane.

5.5 Print Room Ambient Air Measurements

Measurements of ambient air VOC concentrations were made in the immediate vicinity of the print-line and throughout the print room periodically during each day of the measurement program. In addition, air flowrate measurements were made in the open doorways of the print room. The purpose of these measurements was to determine typical VOC concentrations in the print room during times of print-line operation, and to estimate the amount of VOC drawn into the print room from other plant areas through the open doorways.

VOC measurements were made with a portable H-NU model PI 101 Photoionizer hydrocarbon analyzer. The operating principle of this analyzer is that sampled organics are ionized with ultra-violet light within an electric field, producing a current proportional to concentration. At each location in the

print room the analyzer probe was held at breathing level (about 5 feet above the floor) until an average concentration at that location could be estimated on the meter readout (approximately 10-15 seconds). Measurements were made at pre-determined representative locations throughout the print room, at the center of the print-line (in the spaces between the print heads) and at locations 2 feet and 5 feet from two print heads. Frequent measurements were also made directly in front of the embosser (approximately 2 feet from the cage surrounding the embosser). The purpose of these latter measurements was to estimate the VOC concentration of air being drawn into the embosser exhaust hood intake.

The H-NU photoionizer was calibrated daily with the same MEK bag standards used to calibrate the FID analyzers. These bags were prepared every one or two days.

Eight-hour exposure sampling was performed March 23, 25 and 26 at four locations in the print room. Sampling was performed with Bendix model BDX 44 personal samplers using 7-cm glass charcoal tubes. All four samplers were set out, turned on and turned off at the same time. Charcoal tubes were changed every two hours. Sampler flowrates were approximately one liter per minute and flowmeter readings were recorded each time the samplers were attended. All exposed charcoal tubes were refrigerated until analysis at the TRC laboratory, in order to minimize any possible breakdown of captured MEK at room temperatures.

The tubes were analyzed at the TRC laboratory within 30 days after the end of the measurement program. Analysis consisted of extraction in carbon disulfide and then injection into a Perkin-Elmer Sigma 1B gas chromatograph (GC). The GC was calibrated with standard solutions of MEK, MIBK and toluene.

Air speed measurements were made in open print room doorways with a portable TSI model 1650 hot-wire anemometer and a Davis model 23B vane anemometer. The only open doorway was doorway E (opening into the main plant at the northeast corner of the print room), except on March 18 when in addition doorways B and D were partially open. Measurements were made at six to nine equally spaced points in each doorway, with air speed averaged over 30 seconds at each point. An average air speed for the entire doorway was then calculated and multiplied by the area of the doorway to determine flowrate.

The TSI hot-wire and the Davis vane anemometer were calibrated prior to the field program in the TRC wind tunnel. Further details of the ambient air measurements and instrument calibrations are presented in Appendix F.

5.6 Wastewater Sampling

Wastewater samples from the carbon adsorption unit were collected periodically during March 25 and 26, 1981. Nine samples were collected from the common drain at the base of the carbon beds and twelve samples were collected from a drain at the base of the water/solvent distillation column (bottom product). Each sample was collected in a 400-ml glass jar with Teflon-lined cap.

The nine samples from the carbon beds were collected during each phase of the carbon bed cycle (desorption, drying, adsorption). The duration of this cycle for each bed is approximately 120 minutes. The distillation column operates independently from the carbon beds, and samples from this column were collected throughout each day as time allowed.

The water samples were analyzed for MEK, MIBK, toluene and total organic carbon (TOC) at the TRC laboratory within 30 days of sample collection. MEK, MIBK and toluene analyses were performed with the purge-and-trap method, using a Tekmar model LSC-2 liquid sample concentration. Nitrogen carrier gas was

bubbled through a small aliquot of each sample for about 10 minutes. The carrier picked up the organic solvents in the sample and then passed into a gas chromatograph for solvent analysis. The GC was calibrated with prepared standards containing known amounts of MEK, MIBK and toluene. TOC analyses were performed using an Ionics model 445 Total Organic Carbon analyzer. Details of the wastewater sample analyses are presented in Appendix F.

5.7 Fabric Solvent Residue

The embossing operation heats the wallcovering and may drive off solvents remaining from the printing operation. Printed wallcovering samples were collected before and after the embosser to estimate solvent evaporation in the heated embosser area. Unprinted samples were also collected to determine the background solvent content of the wallcovering.

The sampling and analytical procedure is summarized as follows:

1) Pieces of printed and unprinted wallcovering were cut and the area of each sample was measured;

2) the samples were placed in drying tubes and heated in a small oven for a predetermined amount of time;

3) while heating, the tubes were purged with hydrocarbon-free air to help remove residual solvent;

4) solvents in the air stream were collected in charcoal tubes, desorbed with carbon disulfide, and analyzed on a gas chromatograph.

Details of this procedure are presented in Appendix G. The sample purging system is shown in Figure 5-3.

5.8 Effects of Process Operations on VOC Emission Measurements

The amount and distribution of VOC emitted from the printing operations at this plant, as measured at the sampling locations used during this program, is

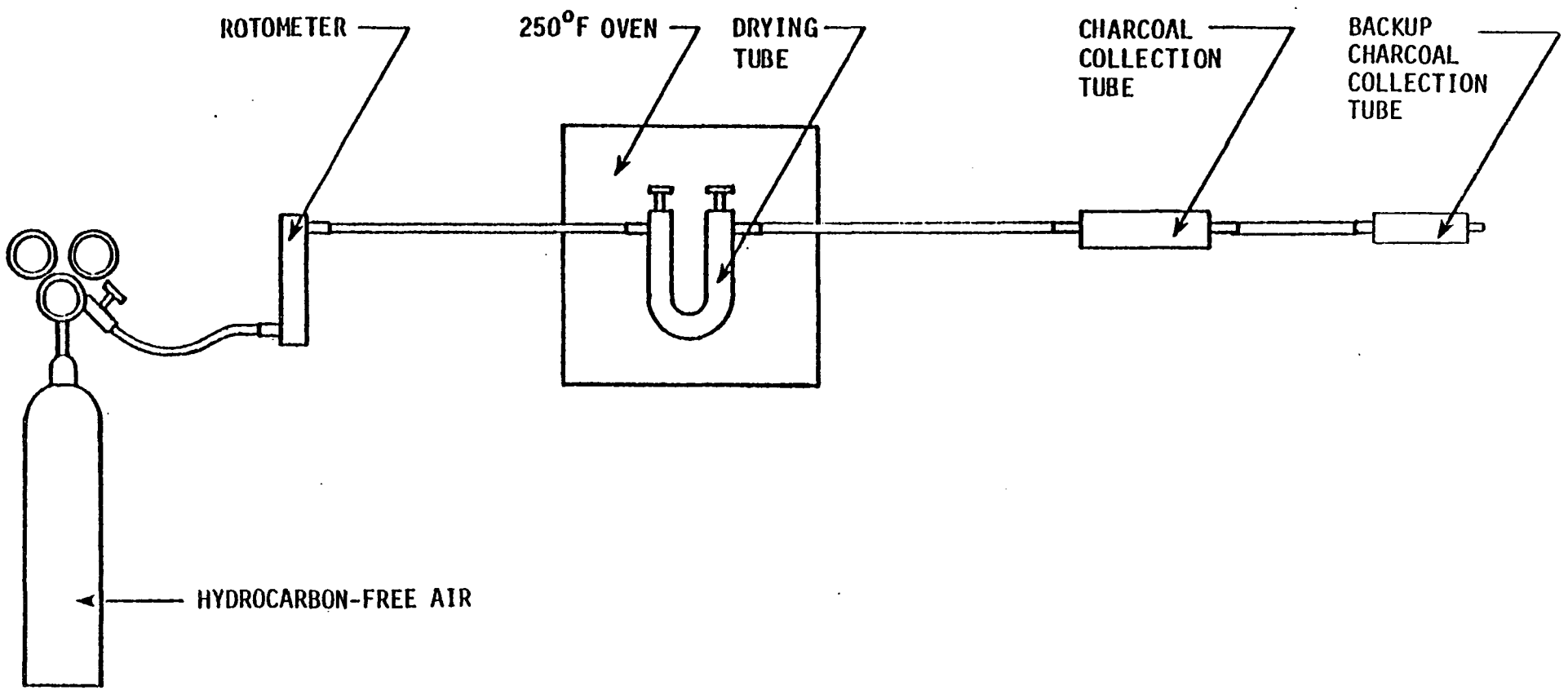


Figure 5-3. Residual solvent in fabric purging system.

affected by several factors related directly and indirectly to the process. Factors directly related to the process include the number of print heads operating, line speed, amount of ink used in the pattern, whether the embosser is on or off, whether the door-hoods on each print head are open or closed, and the frequency and extent of equipment and floor cleaning with MEK. Indirect factors include the number of print head fans operating, whether the make-up fan is operating, whether the wall fans are operating, and how many print room doors are open.

As noted in Section 3.5, the indirect factors were considered prior to the beginning of this measurement program. The make-up fan remained off because of its effects on substrate drying within the print heads and its effects on air flow to the CA unit and into the print room. The adjusted wall fan (fan belt tightened) was found to draw more air out of the print room than either the embosser ESP or the CA unit collection system. The air flow to the CA unit from the print room is affected by the number of print head fans operating. In order to maximize the VOC loading to the CA unit the wall fan was therefore kept off, and all six print head fans were kept on whenever possible. Only one of the print room doors was kept open during the measurement program in order to control the amount of VOC entering the print room from other areas of the plant.

Control of the direct factors by the measurement team was, of course, not possible. Changes in the operation of the print-line were recorded in the process log, shown in Appendix H.

REFERENCES

(1) "Process Emission Tests at the General Tire and Rubber Company Vinyl-Coated Fabric Plant in Reading, Massachusetts. September and October, 1980." EPA report 80-VNC-1A. Prepared by TRC Environmental Consultants, Inc., under EPA Contract 68-02-3543, Work Assignment 2.

(2) CFR 40, July 1, 1980, Part 60, "Standards of Performance for New Stationary Sources," Appendix A, pp. 183 ff.

(3) Federal Register, Volume 45, No. 194, Wednesday, December 17, 1980, pp. 83149ff.

(4) Federal Register, Volume 45, No. 194, Friday, October 3, 1980, pp. 65959 ff.

(5) Federal Register, Volume 45, No. 77, Friday, April 18, 1980, pp. 26677 ff.

(6) "EPA Method 25 Collaborative Study", dated February 1981. Prepared by TRC Environmental Consultants, Inc., for Midwest Research Institute. TRC project 1503-K80.

United States
Environmental Protection
Agency

Office of Air Quality
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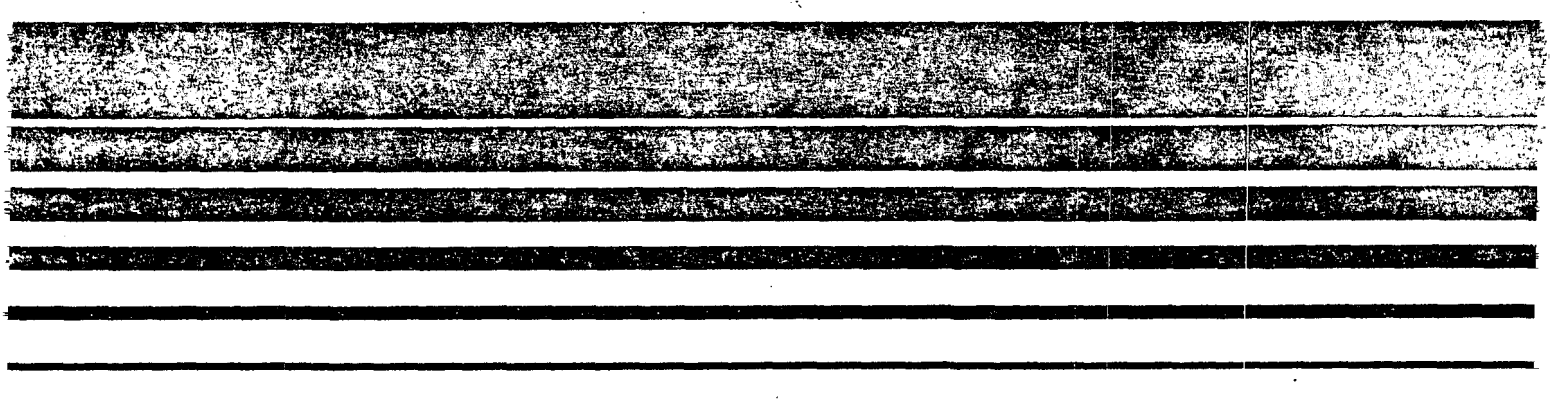

1.2 Brief Process Description

Figure 1-1 presents an overhead view of the plant facilities associated with the printing operation, and Figure 1-2 presents a schematic of the printing operation. This process is described very basically in the following paragraphs.

The printing operation consists of a Baker-Perkins rotogravure printing machine utilizing six printing heads. The vinyl-coated substrate is fed through a preliminary dryer, the six print heads, and an embossing unit. Premixed ink is supplied to each print head from a pump tank located next to each print head. Ink is pumped from the pump tank to a tray within the print head where a print roller, half-submerged in the tray, transfers ink from the tray to the substrate. The inked substrate is dried in an oven contained within each print head. Excess ink is gravity fed back to the pump tank. During a print run, solvent or ink base is occasionally added manually to the pump tanks to maintain the required ink viscosity. The solvent used in the inks is primarily methyl ethyl ketone (MEK) with some methyl isobutyl ketone (MIBK) and toluene.

Emissions from the preliminary dryer and print head ovens are manifolded and ducted to a carbon adsorption (CA) unit before being released to the atmosphere. The CA unit has three carbon beds, but only beds 1 and 3 were used during the test program. Emissions from the embosser are controlled with an electrostatic precipitator (ESP). Fugitive emissions within the print-line building are vented to the atmosphere through a pair of wall exhaust fans and through the embosser exhaust system.
Air is supplied to the print-line building by a make-up fan on the roof and from seven doors that open to the outside and to other areas of the plant. During the test program only one wall fan was operated and then only briefly. The make-up fan was off at all times. All doors but one were closed.

2.0 SUMMARY AND DISCUSSION OF RESULTS

This section presents the results of the VOC emission tests conducted during March 1981 at the GTR vinyl-coated fabric plant in Reading, Massachusetts. The purpose of these tests was to measure the controlled and uncontrolled VOC emissions from the wallcovering printing and embossing operations.

VOC measurements were performed with flame ionization detection (FID) analyzers at five ducted locations: carbon adsorption (CA) unit inlet, CA outlets to beds 1 and 3, embosser electrostatic precipitator (ESP) inlet, and wall fan exhaust. In addition, ambient air VOC sampling was performed in the print-line building with a portable photoionizer hydrocarbon analyzer.

VOC sampling was performed at the embosser ESP inlet, wall fan exhaust duct and CA unit inlet on March 18, 19, 20, and 23, 1981. Surveys of the ambient VOC concentrations in the print room, near the print line, and near the embosser hood intake were conducted each testing day. VOC sampling was performed at the CA unit inlet and outlets on March 25 and 26, 1981, to determine the control efficiency of the CA unit. No measurement work was performed on March 24 because no wallcovering was printed that day.

2.1 Summary of Results

VOC concentrations and air flowrates were measured at the embosser ESP inlet, wall fan exhaust duct, CA unit inlet and CA unit outlets during print-line operations. Ambient air VOC measurements were made inside the print-line building (print room). The results of this measurement program showed that:

1. Under the operating conditions of this measurement program (make-up air fan and wall exhaust fans off), the majority of print-line VOC emissions is ducted to the CA inlet.

2. The VOC ducted to the embosser ESP inlet is a combination of embosser-generated VOC and ambient print room VOC.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-20-81	T-15521	Completing Previous Run	0740	0744	4	0.67	0	NM	--
		Completing Previous Run	0744	0814	30	3.42	0	19.4	22.8
		Preparation for T-15521	0814	0958	104	4.56	0	14.7	19.3
		Color Matching	0958	1019	21	1.91	0	31.2	33.1
		Printing Start/Stop for Repairs	1019	1148	89	7.97	0	35.6	43.6
		Printing, Embosser On	1148	1150	2	0.233	0	1.16	1.39
		1000 Yards Printing	1150	1212	22	4.32	0	18.2	22.5
		Printing Start/Stop for Repairs	1212	1256	44	6.76	0	29.5	36.3
		1000 Yards Printing	1256	1318	22	4.27	0	17.27	21.5
		1000 Yards Printing	1318	1340	22	4.25	0	17.6	21.8
		1000 Yards Printing	1340	1402	22	4.37	0	18.93	23.3
		Run Completed	1402	1410	8	1.26	0	5.61	6.87
		Cleaning Print Heads	1410	1426	16	2.09	0	7.49	9.58
		Clean Up	1426	1532	66	6.06	0	NM	--
		TOTAL PRINT TIME	1019	1410	231	33.4	0	143.8	177.2
		TOTAL RUN TIME	0958	1410	252	35.3	0	175.0	210.3

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.

TABLE 2-2 (Continued)

SUMMARY OF FID VOC EMISSIONS FROM PRINTING OPERATIONS
AT GENERAL TIRE AND RUBBER COMPANY
READING, MASSACHUSETTS

Date	Production Order Number	Process Operations	Time Interval Start[a]	Time Interval End	Total Minutes	VOC Emissions (Pounds as MEK) Embosser	Wall Fan	CA Inlet	Total
3-23-81	T-15516	Printing in Progress	0850	0909	19	1.92	Sampling	10.51	12.43
		1000 Yards Printing	0909	0931	22	2.60	Discontinued	13.06	15.7
		1000 Yards Printing	0931	0953	22	2.78		14.70	17.5
		1000 Yards Printing	0953	1015	22	3.12		14.20	17.3
		Run Completed	1015	1025	10	1.48		7.15	8.63
		TOTAL PRINT TIME	0850	1025	95	11.9		59.6	71.5
		TOTAL RUN TIME	0850	1025	95	11.9		59.6	71.5
	T-15519	Threading Leader	1025	1037	12	1.41		24.60	26.0
		Cleaning. PH Fans off. Wall Fan on	1037	1239	122	5.25		4.17	9.42
		Color Matching, Web Alignment	1239	1244	5	0.070		0.180	0.250
		Wall Fan Off. Color Matching	1244	1324	40	0.85		10.3	11.2
		Printing Line Down Once	1324	1351	27	1.88		9.90	11.8
		1000 Yards Printing	1351	1413	22	1.56		9.02	10.6
		Printing	1413	1423	10	0.64		4.17	4.81
		Line Up and Down. Trimming Problems	1423	1605	102	6.07		35.8	41.9
		Problems Persist. Run Ended	1605	1628	23	1.14		10.5	11.6
		Repairs	1628	1633	5	0.27		1.16	1.43
		Repairs	1633	1636	3	NM		1.93	--
		TOTAL PRINT TIME	1324	1605	161	10.2		58.9	69.1
		TOTAL RUN TIME	1239	1628	229	12.2		69.6	81.8

NM: Not measured - analyzer problems or calibrations in progress.
[a] Start time for the initial time interval is the time when FID monitoring began that day.