Note: This is a reference cited in *AP 42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the reference number, the AP42 chapter and section. The file name "ref02_c01s02.pdf" would mean the reference is from AP42 chapter 1 section 2. The reference may be from a previous version of the section and no longer cited. The primary source should always be checked.

POLYSTYRENE
AP-42
Section 5.13.3
Reference Number
8

Gulf Oil Chemicals Company

P. O. Box 3766
Houston, TX 77001

November 11, 1982

Mr. Jack R. Farmer
United States Environmental Protection Agency
Chemicals and Petroleum Branch
Office of Air Quality Planning and Standards
Research Triangle Park, NC 27711

Dear Mr. Farmer:

This is in response to your letter of September 22 requesting certain information after your visit to our polystyrene facility at Marietta, Ohio.

Your request included a summary (attached) of five (5) items covering the additional information needed by EPA. We have enclosed reports of vent emissions tests conducted by IHI-KEMRON and a styrene mass balance diagram which should satisfactorily answer Items 1 and 4. The information requested under Items 2, 3, and 5 is proprietary in nature and therefore cannot be provided.

Gulf Oil Chemicals Company appreciates the opportunity to work with the EPA in the development of the New Source Performance Standards for the polymers and resin industry.

If we can be of further assistance in this matter, please do not hesitate to call me at 713/754-3841.

Sincerely,

J. R. Strausser

J. R. Strausser

JRS/sm
[redacted]
Attachment

Gulf
A DIVISION OF GULF OIL CORPORATION

3 HOUSTON CENTER
909 FANNIN STREET

TELEPHONE: (713) 750-2000

SUMMARY OF INFORMATION NEEDED

1. Vacuum system discharge vent emissions test report prepared by KEMRON. (If possible, please supply any additional supporting data that would be useful in evaluating the test results and determining the representativeness of the operating conditions at the time the test was performed.)

2. Engineering calculations made to estimate emissions from the vacuum discharge system. (These were computed in order to compare with the test results obtained by KEMRON.) If possible, please identify any assumptions used in arriving at the estimated emissions.

3. The capital expenditure justification associated with the central vacuum pump system. (We would like to be able to allocate the portion of the total cost not borne by improvements in capacity or product quality that could be properly attributed to air pollution control. Any assistance you can provide would be most helpful.)

4. Styrene mass balance through the process. If possible, please include the styrene monomer content of the pellets entering the dryer and that of the pellets stored or shipped unless some measurement has been made of the mass organic emission from the dryer exhaust.

5. In connection with 3 above, a flow sheet identifying the planned central vacuum system and indicating key operating parameters (e.g., operating temperatures and pressures of the condensers and reactors) would be extremely helpful. Also, the temperature range of coolants used in each condenser would be helpful.

ANSWER TO ITEM 1

GOCHEM, MARIETTA, OHIO
POLYSTYRENE PLANT
VENT EMMISSIONS TEST REPORTS

An Air Emmission Test Program using Kemron Environmental Services was begun by GOCHEM on August 27, 1981 after technical improvements in the Vacuum System were implemented, ie; Vacuum pumps replaced Steam Jets.

The First tests took place on three vacuum pumps during a process upset with an organic odor present and visible emmissions evident from the pumps tested. Each pump discharge was tested twice. The plant was operating at 50% capacity.

The second series of tests were conducted on February 16 and 17, 1982 with 67% of the process lines on stream. All pump units and emergency vacuum systems in service were tested at that time.

The attached data shows test results, testing methods and laboratory techniques employed by Kemron to obtain the data.

Supportive data for comparing test results to operating conditions center around relative process vapor loads, ambient process cooling water temperatures and heat transfer efficiency condition of condensing equipment. August, 1981 water temperature was 85° F. February, 1982 water temperature was 32° F.

Actual numbers to support the heat transfer efficiency condition of condensing equipment are not available other than the ambient cooling water temperature differential in August as compared to February.

The suspended solids load in the process cooling water in February, 1982 was lower than it was in August of 1981.

IHI-KEMRON

235 Second Street, Marietta, Ohio 45750 (614) 374-2222

GULF OIL CHEMICALS

Emission Tests

Vacuum Recovery Systems

February, 1982

IHI-KEMRON
901 Highland Avenue
Williamstown, WV 26187

INTRODUCTION

On February 16 and 17, a series of emissions tests were performed at Gulf Oil Chemicals, Marietta, Ohio, by IHI-KEMRON. These tests were designed to provide baseline data on emission levels of organic vapors from a series of vacuum recovery systems. The sampling procedures involved collecting samples volumetrically on charcoal absorption tubes and measuring exhaust gas flow rates. The samples were extracted with carbon disulfide and analyzed by gas chromatography/mass spectrometry (qualification) and flame ionization gas chromatography (quantification).

RESULTS

The tests indicate the presence of toluene and styrene in the exhaust gases. Lower concentrations of benzene and xylene were detected. Due to the low volumetric gas flow rates, mass emissions are relatively low.

Complete results are presented in Table 1. Supporting data is included in Table 2.

TEST LOCATION

	867	868	Line 11	1066-9N	1067-9S	1069-ION	EMERG. AUTOCLAVE
Date	2/16/82	2/16/82	2/16/82	2/17/82	2/17/82	2/17/82	2/16/82
Time	1153-1235	1142-1231	1347-1415	0935-1030	0926-1020	0956-1055	1443-1515
µg/l of Air							
Benzene	1,429	1,020	1,571	727	407	712	250
Toluene	20,000	18,367	24,286	14,545	4,815	7,797	5,688
Xylene	219	4,082	1,429	727	29.6	10.2	10.6
Styrene	38.1	6,939	12,143	3,636	5,185	1,864	8,750
Pounds/Hour							
Benzene	3.54×10^{-5}	3.02×10^{-5}	8.61×10^{-5}	1.45×10^{-5}	3.87×10^{-5}	2.11×10^{-5}	1.43×10^{-5}
Toluene	4.96×10^{-4}	5.45×10^{-4}	1.33×10^{-3}	2.89×10^{-4}	4.58×10^{-4}	2.31×10^{-4}	3.26×10^{-4}
Xylene	5.43×10^{-6}	1.21×10^{-4}	7.84×10^{-5}	1.45×10^{-5}	2.81×10^{-6}	3.02×10^{-7}	6.06×10^{-7}
Styrene	9.43×10^{-7}	2.06×10^{-4}	6.66×10^{-4}	7.23×10^{-5}	4.93×10^{-4}	5.53×10^{-5}	5.01×10^{-4}
Pounds/Year*							
Benzene	0.31	0.26	0.75	0.13	0.34	0.18	0.13
Toluene	4.34	4.77	11.65	2.53	4.01	2.02	2.86
Xylene	0.048	1.06	0.69	0.13	0.025	0.0026	0.0053
Styrene	0.0083	1.80	5.83	0.63	4.32	0.48	4.39

* Assumes continuous operation

TABLE 1

TEST RESULTS

TEST LOCATION

	867	868	Line 11	1066-9N	1067-9S	1069-ION	EMERG. AUTOCLAVE
Time (Minutes)	42	49	28	55	54	59	32
T (^{o}F)	58	64	66	68	64	76	80
Sample Volume (Liters)	2.10	2.45	1.40	2.75	2.70	2.95	1.60
Velocity (Feet/Min)	61	73	135	49	234	73	141
Flow (f^3/hour)	318.6	381	704.4	255.6	1,221.6	381	736.2
Parts per Million (v/v)							
Benzene	451	322	496	229	128	225	79
Toluene	5,222	4,796	6,341	3,798	1,257	2,036	1,485
Xylene	49.5	924	323	164	6.7	2.3	2.4
Styrene	8.8	1,603	2,804	840	1,197	430	2,021

TABLE 2

TEST PARAMETERS

DISCUSSION

The sampling was largely uneventful. Some variations in apparent emission concentrations were noted by odor changes. The pump vents were extended with 4" I.D. aluminum pipe with sample ports. Velocity was measured along two 90° traverses, 4 points per traverse located at the centroids of equal areas. A calibrated Kurz Model 441 Air Velocity Meter was used. This is a hot-wire anemometer type instrument. Temperature was measured using a bimetallic thermometer. Velocity was measured prior to each test. Sampling was carried out using low-flow Personnel Sampling pumps calibrated with two charcoal tubes to 50 cc/min flow. One sample was collected on each of the seven vents tested. The back-up charcoal tube was analyzed separately to determine if sample breakthrough occurred. No breakthrough was found on any samples.

A nominal sampling period of 30-60 minutes was used based on visual and olfactory observation of the vents to limit the effects of factors such as:

- Normal process variability
- Abnormal or upset conditions
- Sample breakthrough on sample tubes

No indications of process variability, such as gas flow rate changes, were observed during the tests. During the tests, line #867 was in the stripping train vacuum header position and line #868 was in the recovery vacuum system configuration.

In addition to the values reported, several minor constituents were present in all samples, including silicone oil isomers.

IHI - KEMRON

32740 Northwestern Highway, Farmington Hills, Michigan 48018 (313) 626-2426

Kemron Report No. 23626
Date 3-8-82

TO: IHI-KEMRON
Attn: David L. Bumgarner
235 Second Street
MARIETTA, OH 45750

The following results were obtained on samples received on 2-19-82 and identified as shown.

TYPE OF SAMPLE: Charcoal Tubes

ANALYSIS REQUESTED: Substituted Benzenes

KEMRON Lab No.	Your Identification Number	Name or Sample Description		Results of analysis	
	Gulf Oil Chemicals	Total µg		Total µg	
		Benzene *	Toluene	Xylenes	Styrene
27820	867 A & B	3000	42000	460	80
27821	868 A & B	2500	45000	10000	17000
27822	Line 11	2200	34000	2000	17000
27823	1066-9n	2000	40000	2000	10000
27824	1067-9s	1100	13000	80	14000
27825	1069-10n	2100	23000	30	5500
27826	Emerg. Autoclave	400	9100	17	14000
27827	Blank	<10	<10	<10	<10

* Other alkyl benzenes were seen by GC/MS ranging to C_9 in small quantities.

L. Mavis
Analyst

Cecil L. Smith
Cecil L. Smith, Manager

Kemron

Kemron Environmental Services

GULF OIL CHEMICALS

Emission Tests

Vacuum Recovery Systems

August, 1981

KEMRON Environmental Services
Borg-Warner Corporation
235 Second Street
Marietta, Ohio 45750

INTRODUCTION

On August 27, 1981 a series of emissions tests were performed at Gulf Oil Chemicals, Marietta, Ohio by KEMRON Environmental Services, Borg-Warner Corporation. These tests were designed to provide baseline data on emission levels of organic vapors from a series of vacuum recovery systems. The sampling procedures involved collecting samples volumetrically on charcoal absorption tubes and measuring exhaust gas flow rates. The samples were extracted with carbon disulfide and analyzed by gas chromatography/mass spectrometry (qualification) and flame ionization gas chromatography (quantification).

RESULTS

The tests indicate high concentrations of toluene, xylene and styrene in the exhaust gases. Lower concentrations of benzene and silicone oil isomers were detected. Due to the low volumetric gas flow rates, mass emissions are relatively low.

Complete results are presented in Table 1. Supporting data is included in Table 2. Figure 1 is a typical GC/MS scan for these samples.

Kemron

Kemron Environmental Services

Test	Location	ug/l of air emitted benzene	toluene	xylene	styrene	#/hour benzene	toluene	xylene	styrene
7612-1	8S	6.3	95.8	55.3	129.9	7.9×10^{-4}	1.2×10^{-2}	6.9×10^{-3}	1.6×10^{-2}
7612-2	8S	9.5	306.4	1326.	1515.5	1.3×10^{-3}	4.2×10^{-2}	1.8×10^{-1}	2.1×10^{-1}
7612-6	8N	22.2	2298.	7072.	2598.	9.1×10^{-4}	9.4×10^{-2}	2.9×10^{-1}	1.1×10^{-1}
7612-7	8N	15.9	1118.4	184.3	288.9	1.0×10^{-3}	7.2×10^{-2}	1.2×10^{-2}	1.9×10^{-2}
7612-8	11	17.4	93.8	601.1	236.	8.6×10^{-5}	4.6×10^{-4}	3.0×10^{-3}	1.2×10^{-3}
7612-9	11	13.3	100.7	583.4	913.6	6.5×10^{-5}	5.0×10^{-4}	2.9×10^{-3}	4.5×10^{-3}

Test	Location	POUNDS PER YEAR benzene	toluene	xylene	styrene
7612-1	8S	6.9	105.1	60.4	140.2
7612-2	8S	11.4	367.9	1576.8	1839.6
7612-6	8N	8.0	823.4	2540.4	963.6
7612-7	8N	8.8	630.7	105.1	166.4
7612-8	11	0.75	4.0	26.3	10.5
7612-9	11	.57	4.4	25.4	30.4

TABLE 1 TEST RESULTS

ADDENDUM

Emissions Tests - Vacuum Recovery Tests

Original Report for Gulf Oil Chemicals, dated August, 1981, prepared by KEMRON Environmental Services.

The values reported for emissions in pounds per hour, (Table I), when assumed to represent 24 hour per day, 365 days per year of operation, translate into the following annual emissions:

		Pounds per Year			
TEST #		Benzene	Toluene	Xylene	Styrene
7612-1)	L-8 N	6.9	105.1	60.4	140.2
7612-2)		11.4	367.9	1576.8	1839.6=3795.7
7612-6)	L-8 S	8.0	823.4	2540.4	963.6=3595.4
7612-7)		8.8	630.7	105.1	166.4
7612-8)	L-11	0.8	4.0	26.3	10.5
7612-9)		0.6	4.4	25.4	39.4= 38.8
					7429.9 #/Y

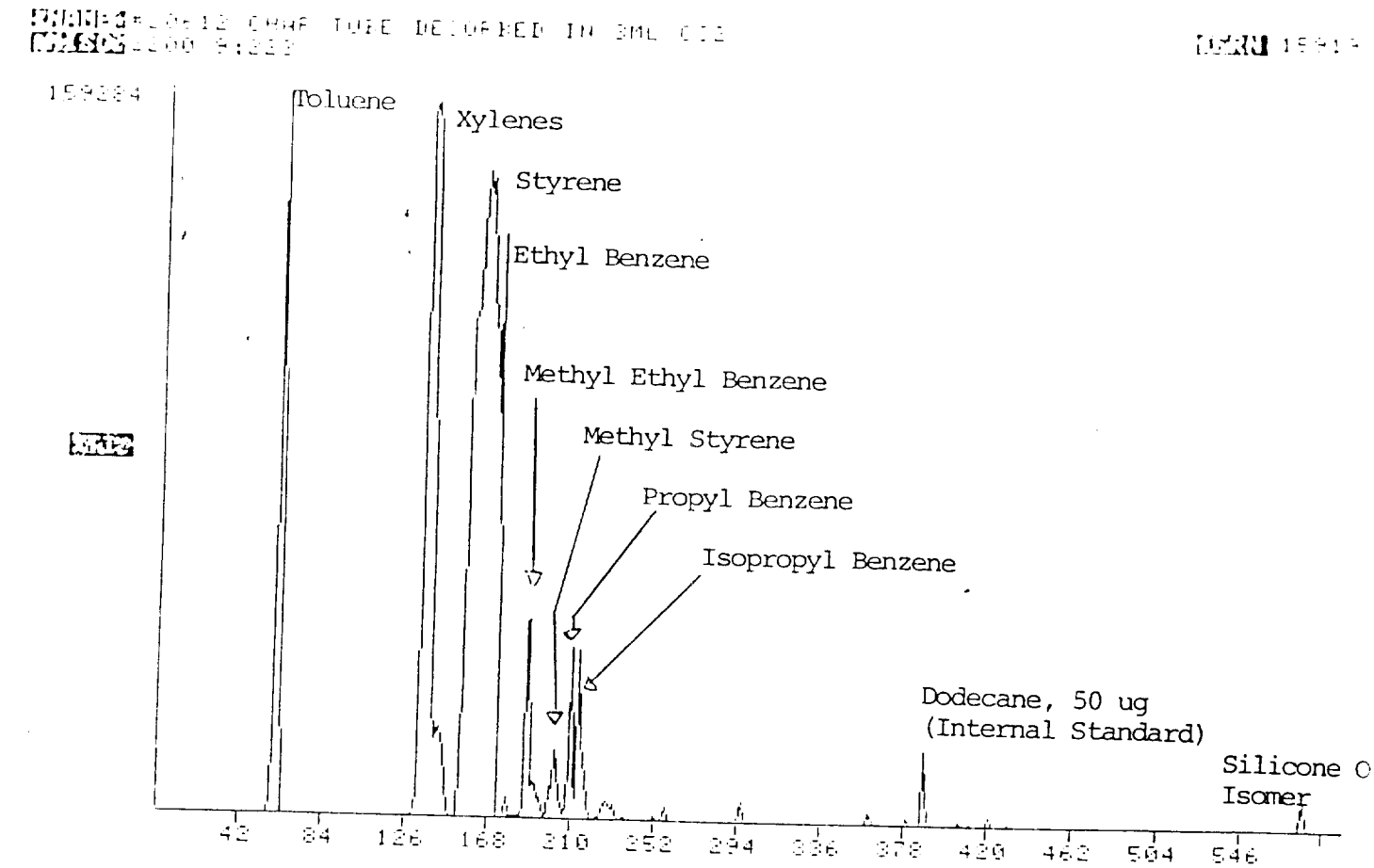
Tests 1 and 2 were duplicates as were 6-7 and 8-9.
This was during a period of severe emission from the two Line 8 Vacuum pumps in August of 1981 - a worst condition situation; the cooling tower was at its hottest and it must be assumed many condensers were fouled with mud.

Test #	Process	Time	T(°F)	Sample Volume (liters)	Velocity Feet/min.	Flow f^3/hour	Parts per million (V/V)[2]. benzene	toluene	xylene	styrene
7612-1	8S-Autoclave vacuum system	0841-0901	80	20	378	1985	2	25	13	30
7612-2		0905-0915	82	10	416	2184	3	80	300	350
7612-6	8N-Recovery & autoclave vacuum system	0945-0955	82	10	125	656	7	600	1600	600
7612-7		0959-1005	80	6	197	1034	5	292	42	67
7612-8	11-Mill vacuum header	1025-1036	78	11	15	79	6	25	136	55
7612-9		1041-1100	78	19	15	79	4	26	132	211

1. August 27, 1981
2. All values equal to or greater than values reported. See discussion.

TABLE 2

TEST PARAMETERS



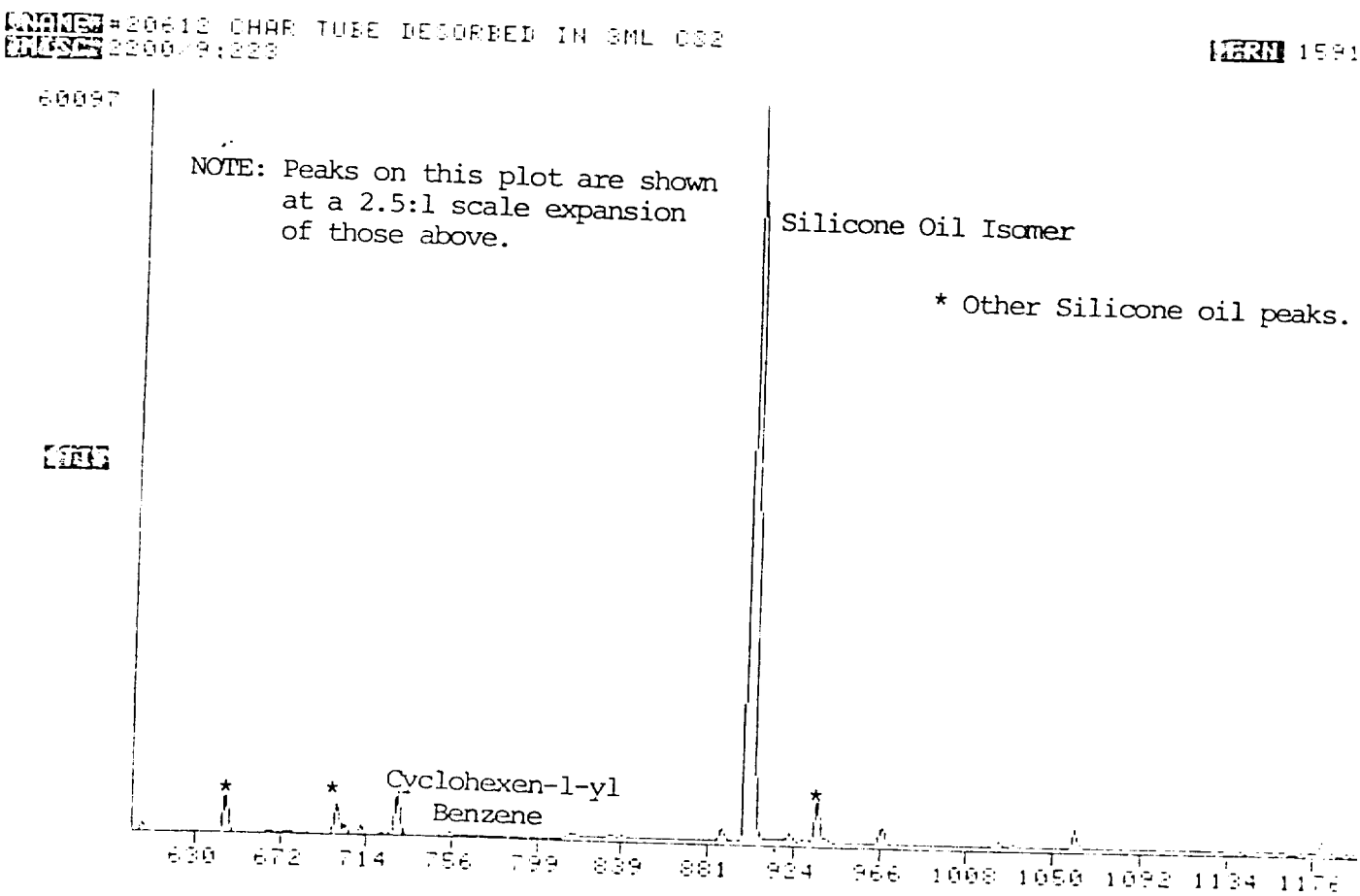


FIGURE 1
TYPICAL MASS PLOT

DISCUSSION

The sampling was largely uneventful. Some variations in apparent emission concentrations were noted by odor changes and visible vapor condensation intensity. The pump vents were extended with 4" I.D. aluminum pipe with sample ports. Velocity was measured along two 90° traverses, 4 points per traverse located at the centroids of equal areas. A calibrated Kurz Model 441 Air Velocity Meter was used. This is a hot-wire anemometer type instrument. Temperature was measured using a bimetallic thermometer. Velocity was measured prior to each test. Sampling was carried out using MSA Personnel Sampling pumps calibrated with charcoal tubes to 1 lpm flow. Three samples were collected on each of the three vents tested. They were low, medium and high volume samples. The middle volume sample was analyzed initially. Due to the high concentrations found, the low volume samples were then analyzed. Although the tubes were not saturated, they were in every case loaded heavily enough to indicate at least some breakthrough. Thus, all reported values are biased low.

The relatively high variability among test runs suggests that one or more of the following factors was involved:

- Normal process variability
- Abnormal or upset conditions
- Varying degree of sample breakthrough on samples tubes

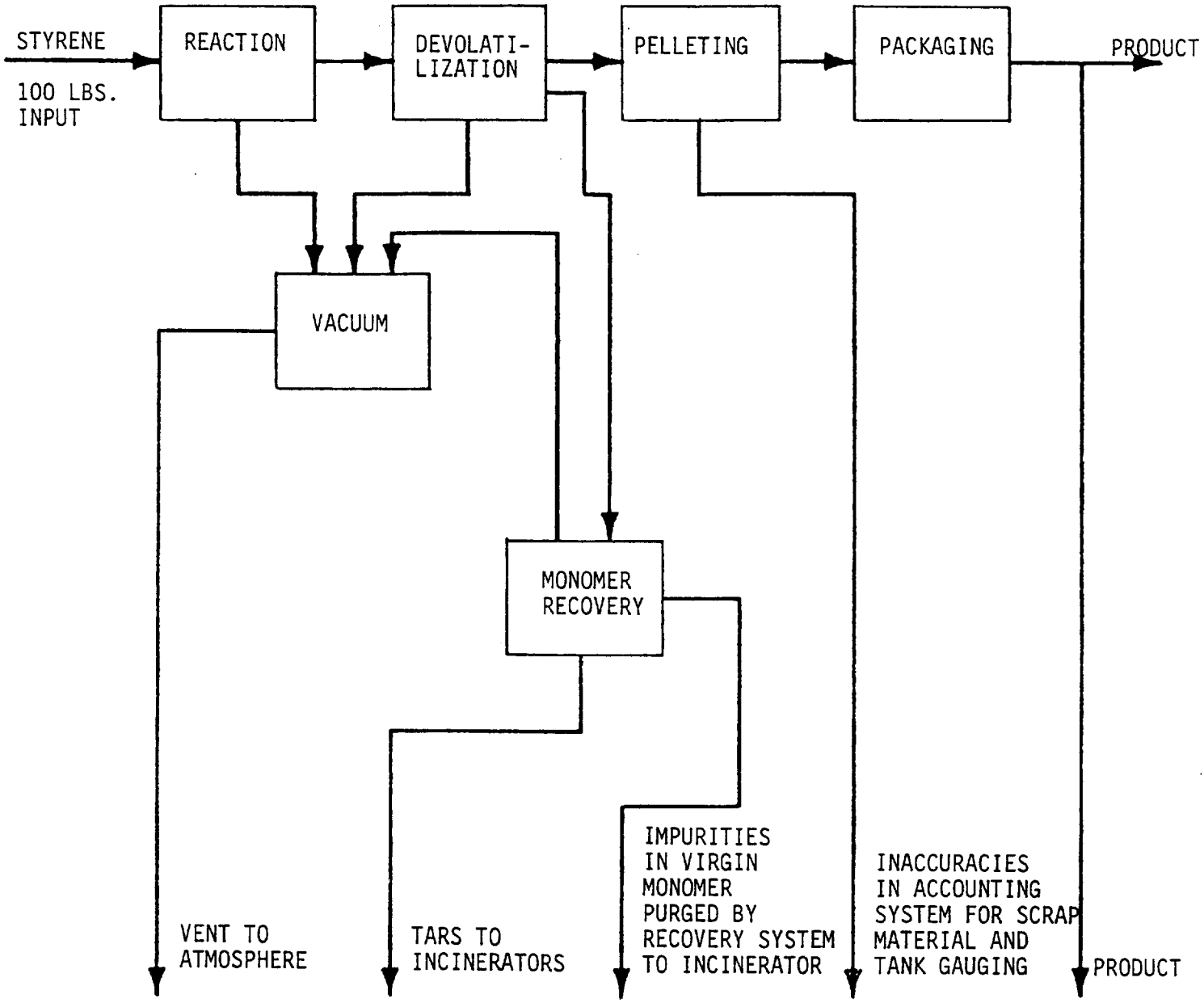
Some indications of process variability, such as gas flow rate changes, were observed during the tests carried out on 8N and 8S push vacuum pumps. In addition, a change in operating configuration was carried out at approximately 0915-0930. In addition, the analytical value for xylene on test 7612-6 may be an anomaly; but the limited number of tests and other variables preclude a definitive determination.

In addition to the values reported, several minor constituents were present in all samples, including silicone oil isomers.

Any future sampling should be carried out using lower sample flow rates and/or larger capacity charcoal tubes to preclude sample breakthrough. Longer sampling times are essential to minimize the effects of process variability.

ANSWER TO ITEM 4

GOCHEM MARIETTA, OHIO
POLYSTYRENE PLANT
STYRENE MASS BALANCE



100 LBS. = 0.03 LBS. + 0.60 LBS. + 0.20 LBS. + 0.67 LBS. + 98.50 LBS.

IN VERY CAREFULLY CONTROLLED SITUATIONS GOCHEM HAS REACHED 98.9% PRODUCT YIELD. HOWEVER, 98.50% IS TYPICAL.

PELLET MONOMER CONTENT BEFORE AND AFTER THE DRYER REMAINED CONSTANT. MONOMER CONTENT WAS MEASURED TO THE NEAREST 0.01%.

10/26/82