



## *Project Summary*

# Frequency of Leak Occurrence For Fittings in Synthetic Organic Chemical Plant Process Units

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**This report summarizes the results of a study of the frequency of leak occurrence in the synthetic organic chemical manufacturing industry (SOCMI). The work was funded by the Environmental Protection Agency and carried out by four contractors: Acurex Corp.; PEDCo Environmental, Inc.; Radian Corp.; and TRW, Inc.**

**The frequency of occurrence of fugitive emissions was determined by instrumental screening. The screening process is defined as the measurement of the volatile organic compounds (VOC) concentration as close as possible to the point of suspected leakage, such as at the valve stem, pump seal, etc. The screening value is the maximum repeatable VOC concentration detected for any given source, expressed in parts per million by volume (ppmv).**

**A total of 24 process units in the SOCMI were tested by the four contractors. The frequency of fugitive emission sources with screening values equal to or greater than 10,000 ppmv was tabulated for all units combined, for each type of chemical process, and for each process unit.**

***This Project Summary was developed by EPA's Industrial Environmental Research Laboratory in Research Triangle Park, N.C., to announce key findings of the research project that is fully documented in a separate report***

***of the same title (see Project Report ordering information at back).***

### **Introduction**

The U.S. EPA Industrial Environmental Research Laboratory (IERL), Research Triangle Park, N.C., has coordinated a study to develop information about fugitive emissions; i.e., unintentional discharges or leaks, of volatile organic compounds from equipment sources in the synthetic organic chemical manufacturing industry. The results of this study will be used by EPA in the evaluation of regulatory strategies for the control of fugitive emissions from SOCMI process units (the SOCMI is defined as those process units which produce, as intermediate or final products, any of the chemicals listed in the draft Background Information Document (BID) for fugitive emission control standards). Fugitive emission sources studied include process valves, pump seals, compressor seals, flanges, relief valves, open-ended lines, process drains, and agitator seals.

The objective of the program was to develop data on the frequency of occurrence of fugitive emissions from various sources in the SOCMI. This objective was met by a two-fold approach:

- The acquisition of fugitive emission data by the four participating contractors listed here with re-

spective EPA contract numbers: — Acurex Corporation (68-02-3176-01, 06)—PEDCo Environmental, Inc. (68-02-3173-02, 11)—Radian Corporation (68-02-3171-01)—TRW, Inc., Energy Systems Group (68-02-3174-04)

- Coordination of the program, administration of quality control checks, data processing, and preparation of the final report by Radian Corporation.

For this program, "screening" refers either to the measurement of fugitive emissions at a single source or to the overall sampling of a process unit. "Screening value" refers to the maximum repeatable concentration of total hydrocarbons detected at a source with a portable hydrocarbon detector, expressed in parts per million by volume. "Screening data" refers to the information recorded for each screened source, including the type of source, the screening value, line temperature and pressure, ambient conditions, etc.

The frequency of occurrence of component leaks was investigated for 14 types of chemical process units. A total of 24 process units were screened by four contractors. The screening took place over a six-month period (1/22/80 to 8/1/80); an average of about one week was spent in each process unit. Table 1 presents the process unit identi-

fication (ID) number, the type of process, and the contractor for each of the 24 process units.

The screening procedures began with the definition of the process unit boundaries. All feed streams, reaction/separation facilities, and product and by-product delivery lines were identified on process flow diagrams and in the process unit. Process data, including stream composition, line temperature, and line pressure, were obtained for all flow streams.

Each process stream was then traced in the field. In most cases, plant personnel assisted the screening team in obtaining process data and identifying sources to be screened. Accessible sources were screened by a two-person team (one person operating the VOC detector and one person recording data) as the sources were encountered along the stream. Tags or markings were placed on screened sources to prevent inadvertent rescreening.

The Century Systems Models OVA-108 and OVA-128 VOC detectors were used for screening. The HNU Systems, Inc., Model PI 101 Photoionization Analyzer was also used to screen sources at the formaldehyde process unit. The detector probe of the instrument was placed directly on those areas of the sources where leakage would typically occur. For example, gate valves were

screened along the circumference of the annular area around the valve stem where the stem exits the packing gland and at the packing gland/valve bonnet interface.

The maximum concentration reading (in ppmv) on the instrument was recorded for each source. For some sources, the reading fluctuated considerably. In these cases, the maximum reading repeated at least once was recorded as the screening value.

All accessible sources of the following source types were screened:

- process valves
- pump seals
- compressor seals
- agitator seals
- relief valves
- process drains
- open-ended lines.

Also, a randomly selected subset of flanges was screened. Originally, only five percent of all flanges were screened. The subset was increased to 20 percent of all flanges when initial results indicated a higher frequency of measurable emissions than had been encountered in previous programs. For the purposes of this program, "flange" referred to any pipe-to-pipe or tubing-to-tubing connection, excluding welded joints.

The following data were recorded for each identified source:

- source ID number
- source type
- screening value (ppmv) if the source was accessible
- type of service (gas, light liquid, or heavy liquid)
- composition of material in the line (identities and mole fractions of the two major organic components)
- line temperature (°F)
- line pressure (psig)
- ambient air temperature (°F)
- source elevation (number of landings above ground level)

Only those sources containing at least one weight percent VOC were screened or identified as inaccessible. Fittings in steam and cooling water service were thus eliminated from consideration. Wastewater and process water fittings were screened if they contained at least one weight percent VOC.

The sources in this study were screened at an average rate of 1.7 minutes per source for a two-person team (or 3.4 person-minutes per source). This average screening rate includes

**Table 1.** Chemical Process Units Screened for Fugitive Emissions

Unit No.	Unit Type	Contractor
1	Vinyl Acetate	Radian
2	Ethylene	Radian
3	Vinyl Acetate	Radian
4	Ethylene	Radian
5	Cumene	Radian
6	Cumene	Radian
11	Ethylene	TRW
12	Acetone/Phenol	TRW
20	Ethylene Dichloride	PEDCo
21	Vinyl Chloride Monomer	PEDCo
22	Formaldehyde	PEDCo
28	Ethylene Dichloride	PEDCo
29	Vinyl Chloride Monomer	PEDCo
31	Methyl Ethyl Ketone	Acurex
32	Methyl Ethyl Ketone	Acurex
33	Acetaldehyde	Acurex
34	Methyl Methacrylate	Acurex
35	Adipic Acid	Acurex
60	Trichloroethylene/Perchloroethylene	PEDCo
61	1, 1, 1-Trichloroethane	PEDCo
62	Ethylene Dichloride	PEDCo
64	Adipic Acid	PEDCo
65	Acrylonitrile	PEDCo
66	Acrylonitrile	PEDCo

time spent for instrument calibration and repair.

A three-part quality control strategy was used to ensure experimental consistency within the acquired fugitive emission data base. These three procedures were as follows:

- daily instrument calibrations.
- determinations of screening repeatability.
- replicate screening by Radian quality control personnel.

## Conclusions

The overall fugitive emission frequencies for fittings in the 24 process units are summarized in Table 2. The following information is shown for the total population of each source type:

- The number of sources screened (Column 1)
- the percentage of the total identified sources that were not screened (Column 2)
- the percentage of screened sources with screening values greater than or equal to 10,000 ppmv (Column 3)
- the 95 percent confidence interval for the percentage of screened

sources with screening values greater than or equal to 10,000 ppmv (Column 4)

The 95 percent confidence interval, denoted by the upper and lower limits in Column 4, is the interval of percentage values that can be said, with 95 percent certainty, to include the true percentage value.

The sources are further categorized by phase of the material contained by the source. For this program, "gas" refers to gas phase at process conditions. Liquids were classified based on their most volatile component present at 20 weight percent or more. If that component had a vapor pressure equal to or greater than 0.04 psi (0.3 kPa) at 20°C, the material was classified as a "light liquid" if not, the material was classified as a "heavy liquid" (1 kPa = 0.145 psi = 7.50 mmHg).

The detailed results of the screening program are presented in Fugitive Emission Profile tables. Each of these tables presents overall data on a type of chemical process, as well as the individual units of that type tested.

An example of a Fugitive Emission Profile table is Table 3, which presents

data for adipic acid process units 35 and 64. Three data entries, comprising a "cell," are presented for various source/service combinations. The first cell in Table 3 is 0.0%/(0.0, 7.2)/49. The first data entry in the cell, 0.0%, represents the combined percentage of flanges in gas service in units 35 and 64 that had measured screening values of greater than or equal to 10,000 ppmv. The second data entry in the cell, (0.0, 7.2), is the 95 percent confidence interval. This means that it can be stated with 95 percent certainty that the *true* percentage of sources with screening values greater than or equal to 10,000 ppmv in this population of screened flanges lies within the interval of 0.0 percent and 7.2 percent. The uncertainty in the estimated percentage of sources with screening values greater than or equal to 10,000 ppmv, reflected by the confidence interval, stems from random fluctuations in source emission rates, instrument operation, weather conditions, and other factors. The third data entry in the cell, 49, is the number of flanges in gas service screened at units 35 and 64. As indicated in Table 3, the confidence interval narrows with increasing number of screened sources.

**Table 2. Summary of SOCFI Process Unit Emissions**

Source Type	Service	(1) Number Screened	(2) % Not Screened	(3) % of Screened Sources with Screening Values ≥ 10,000 ppmv	(4) 95% Confidence Interval for Percentage of Sources ≥ 10,000 ppmv
Flanges	Gas	1,443	4.6	4.6	(3.6, 5.8)
	Light Liquid	2,897	2.6	1.2	(0.9, 1.8)
	Heavy Liquid	607	2.4	0.0	(0.0, 0.6)
Process Drains	Gas	83	23.1	2.4	(0.3, 8.4)
	Light Liquid	527	1.9	3.8	(2.3, 5.8)
	Heavy Liquid	28	0.0	7.1	(0.9, 23.5)
Open Ended Lines	Gas	923	17.5	5.8	(4.4, 7.5)
	Light Liquid	3,603	10.4	3.9	(3.3, 4.6)
	Heavy Liquid	477	21.5	1.3	(0.5, 2.8)
Agitator Seals	Gas	7	46.1	14.3	(0.4, 57.9)
	Light Liquid	8	11.1	0.0	(0.0, 36.9)
	Heavy Liquid	1	66.7	0.0	(0.0, 97.5)
Relief Valves	Gas	85	72.7	3.5	(0.7, 10.0)
	Light Liquid	69	40.5	2.9	(0.3, 10.1)
	Heavy Liquid	3	66.7	0.0	(0.0, 70.8)
Valves	Gas	9,668	17.5	11.4	(10.8, 12.1)
	Light Liquid	18,294	12.2	6.4	(6.1, 6.8)
	Heavy Liquid	3,632	9.9	0.4	(0.2, 0.7)
Pumps	Light Liquid	647	4.3	8.8	(6.6, 11.1)
	Heavy Liquid	97	40.5	2.1	(0.3, 7.3)
Compressors	Gas	29	9.4	6.9	(0.9, 22.8)
Other <sup>1</sup>	Gas	19	9.5	21.0	(6.0, 45.6)
	Light Liquid	33	19.5	6.1	(0.7, 20.2)
	Heavy Liquid	2	33.3	0.0	(0.0, 84.2)

<sup>1</sup>Includes filters, vacuum breakers, expansion joints, rupture disks, sight glass seals, etc.

**Table 3. Fugitive Emission Profile With Confidence Intervals - Adipic Acid**

Source	Service	Weighted Average	Unit #35	Unit #64
Flanges	Gas	0.0%/(0.0, 7.2)/49	0.0%/(0.0, 21.8)/15	0.0%/(0.0, 10.3)/34
	Light Liquid	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2	—
	Heavy Liquid	0.0%/(0.0, 1.2)/320	0.0%/(0.0, 1.7)/218	0.0%/(0.0, 3.6)/102
Process Drains	Heavy Liquid	0.0%/(0.0, 30.8)/10	0.0%/(0.0, 30.8)/10	—
Open Ended Lines	Gas	0.0%/(0.0, 17.6)/19	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 18.5)/18
	Light Liquid	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 97.5)/1	—
	Heavy Liquid	0.0%/(0.0, 1.8)/214	0.0%/(0.0, 3.6)/102	0.0%/(0.0, 3.2)/112
Relief Valves	Gas	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2	—
	Valves	Gas	0.0%/(0.0, 3.8)/95	0.0%/(0.0, 7.9)/45
Valves	Light Liquid	0.0%/(0.0, 19.5)/17	0.0%/(0.0, 19.5)/17	—
	Heavy Liquid	0.0%/(0.0, 0.3)/1478	0.0%/(0.0, 0.3)/1163	0.0%/(0.0, 1.2)/315
	Pumps	Heavy Liquid	0.0%/(0.0, 11.6)/30	0.0%/(0.0, 97.5)/1
Compressors	Gas	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1
Other <sup>1</sup>	Gas	0.0%/(0.0, 84.2)/2	—	0.0%/(0.0, 84.2)/2
	Heavy Liquid	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

<sup>1</sup>Includes rotary drum seal and tank hatch.

## Recommendations

This study developed a significantly larger data base on the occurrence of fugitive emissions in the SOCM1 than was previously available. It also provided valuable information about the effort required for complete monitoring of a process unit. When combined with the results of a closely related study of the effectiveness of maintenance on fugitive emissions from valves and pumps in SOCM1 process units, these data will provide a sound basis for structuring regulatory requirements and for assessing the net cost of a monitoring and maintenance program.

**Table 4. Fugitive Emission Profile With Confidence Intervals - Acetaldehyde**

Source	Service	Unit #33
Flanges	Gas	0.0%/(0.0, 10.9)/32
	Light Liquid	0.0%/(0.0, 2.5)/144
Process Drains	Light Liquid	41.7%/(15.2, 72.3)/12
Open Ended Lines	Gas	8.8%/(1.9, 23.7)/34
	Light Liquid	5.1%/(2.2, 9.8)/158
Relief Valves	Gas	0.0%/(0.0, 60.2)/4
	Light Liquid	0.0%/(0.0, 70.8)/3
Valves	Gas	4.5%/(1.9, 8.7)/178
	Light Liquid	0.5%/(0.1, 1.6)/551
Pumps	Light Liquid	9.4%/(2.0, 25.0)/32

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

**Table 5. Fugitive Emission Profile With Confidence Intervals - Acetone/Phenol**

Source	Service	Unit #12
Flanges	Light Liquid	0.0%/(0.0, 4.4)/82
	Heavy Liquid	0.0%/(0.0, 11.6)/30
Process Drains	Light Liquid	20.0%/(2.5, 55.6)/10
Open Ended Lines	Gas	0.0%/(0.0, 84.2)/2
	Light Liquid	1.5%/(0.7, 3.0)/518
	Heavy Liquid	0.0%/(0.0, 3.4)/107
Relief Valves	Light Liquid	0.0%/(0.0, 17.7)/19
	Heavy Liquid	0.0%/(0.0, 70.8)/3
Valves	Gas	0.0%/(0.0, 36.9)/8
	Light Liquid	0.3%/(0.1, 0.7)/1818
	Heavy Liquid	0.0%/(0.0, 0.8)/488
Pumps	Light Liquid	2.3%/(0.3, 8.2)/86
	Heavy Liquid	0.0%/(0.0, 9.7)/36

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

**Table 6. Fugitive Emission Profile With Confidence Intervals - Acrylonitrile**

Source	Service	Weighted Average	Unit #65	Unit #66
Flanges	Gas	1.4%/(0.2, 5.0)/142	1.3%/(0.0, 7.2)/75	1.5%/(0.0, 8.0)/67
	Light Liquid	0.0%/(0.0, 1.0)/382	0.0%/(0.0, 3.1)/117	0.0%/(0.0, 1.4)/265
	Heavy Liquid	0.0%/(0.0, 12.3)/28	0.0%/(0.0, 12.3)/28	—
Process Drains	Light Liquid	12.5%/(0.3, 52.7)/8	100.0%/(2.5, 100.0)/1	0.0%/(0.0, 41.0)/7
	Heavy Liquid	100.0%/(2.5, 100.0)/1	100.0%/(2.5, 100.0)/1	—
Open Ended Lines	Gas	0.9%/(0.0, 4.7)/116	0.0%/(0.0, 6.3)/57	1.7%/(0.0, 9.1)/59
	Light Liquid	2.5%/(1.3, 4.3)/486	3.7%/(1.3, 8.0)/160	1.8%/(0.7, 4.1)/326
	Heavy Liquid	10.5%/(2.9, 24.8)/38	10.5%/(2.9, 24.8)/38	—
Valves	Gas	2.4%/(1.0, 4.3)/396	4.4%/(2.0, 8.3)/203	0.0%/(0.0, 1.9)/193
	Light Liquid	1.9%/(1.2, 2.7)/1494	2.5%/(1.4, 4.1)/591	1.4%/(0.8, 2.4)/903
	Heavy Liquid	0.0%/(0.0, 3.8)/95	0.0%/(0.0, 3.8)/95	—
Pumps	Light Liquid	8.2%/(2.7, 18.1)/61	5.3%/(0.1, 26.0)/19	9.5%/(2.7, 22.6)/42
	Heavy Liquid	25.0%/(3.2, 65.1)/8	25.0%/(3.2, 65.1)/8	—
Compressors	Gas	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2	—
Other <sup>1</sup>	Gas	12.5%/(0.3, 52.7)/8	12.5%/(0.3, 52.7)/8	—
	Light Liquid	0.0%/(0.0, 60.2)/4	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2
	Heavy Liquid	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 97.5)/1	—

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

<sup>1</sup>Includes rupture disk, head gasket, mixer, and atmospheric vent.

**Table 7. Fugitive Emission Profile With Confidence Intervals - Chlorinated Ethanes**

Source	Service	Unit #60	Unit #61	Unit #62
		Trichloroethylene/ Perchloroethylene	1, 1, 1-Trichloroethane	Ethylene Dichloride
Flanges	Gas	0.0%/(0.0, 28.5)/11	—	0.0%/(0.0, 52.2)/5
	Light Liquid	0.0%/(0.0, 0.7)/525	0.0%/(0.0, 4.9)/73	—
	Heavy Liquid	0.0%/(0.0, 84.2)/2	—	—
Process Drains	Light Liquid	0.0%/(0.0, 33.6)/9	—	—
Open Ended Lines	Gas	0.0%/(0.0, 30.8)/10	—	0.0%/(0.0, 19.5)/17
	Light Liquid	1.5%/(0.5, 3.2)/412	1.8%/(0.2, 6.4)/111	—
	Heavy Liquid	0.0%/(0.0, 60.2)/4	—	—
Agitator Seals	Light Liquid	—	0.0%/(0.0, 97.5)/1	—
Relief Valves	Light Liquid	0.0%/(0.0, 70.8)/3	—	—
Valves	Gas	0.0%/(0.0, 12.3)/28	—	0.0%/(0.0, 16.8)/20
	Light Liquid	0.1%/(0.0, 0.3)/1620	1.1%/(0.3, 2.8)/373	—
	Heavy Liquid	0.0%/(0.0, 26.5)/12	—	—
Pumps	Light Liquid	8.3%/(2.8, 18.4)/60	10.0%/(0.2, 44.5)/10	—
Other <sup>1</sup>	Gas	33.3%/(0.0, 90.6)/3	—	—
	Light Liquid	9.5%/(1.2, 30.4)/21	0.0%/(0.0, 84.2)/2	—

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

<sup>1</sup>Includes expansion joint, rupture disk, and sight glass seal.

**Table 8. Fugitive Emission Profile With Confidence Intervals - Cumene**

Source	Service	Weighted Average	Unit #5	Unit #6	
Flanges	Gas	5.2%/(3.2, 8.1)/367	1.0%/(0.0, 5.5)/100	6.7%/(4.1, 10.5)/267	
	Light Liquid	1.6%/(0.7, 3.0)/568	0.3%/(0.0, 1.8)/317	3.2%/(1.4, 6.2)/251	
	Heavy Liquid	0.0%/(0.0, 2.8)/130	0.0%/(0.0, 6.2)/58	0.0%/(0.0, 5.0)/72	
Process Drains	Gas	0.0%/(0.0, 45.9)/6	—	0.0%/(0.0, 45.9)/6	
	Light Liquid	3.2%/(0.1, 16.7)/31	3.2%/(0.1, 16.7)/31	—	
Open Ended Lines	Gas	0.0%/(0.0, 45.9)/6	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 60.2)/4	
	Light Liquid	13.3%/(1.7, 40.5)/15	0.0%/(0.0, 45.9)/6	22.2%/(2.8, 60.0)/9	
	Heavy Liquid	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1	
Relief Valves	Gas	100%/(2.5, 100)/1	100%/(2.5, 100)/1	—	
	Valves	Gas	14.1%/(11.1, 17.8)/448	4.6%/(1.5, 10.7)/108	17.1%/(13.5, 21.9)/340
	Light Liquid	10.5%/(8.5, 12.8)/799	11.0%/(7.9, 15.1)/328	10.2%/(7.7, 13.4)/471	
Pumps	Heavy Liquid	0.0%/(0.0, 1.8)/198	0.0%/(0.0, 5.7)/63	0.0%/(0.0, 2.7)/135	
	Light Liquid	16.0%/(4.5, 36.1)/25	30.0%/(6.7, 65.2)/10	6.7%/(0.2, 32.0)/15	
	Heavy Liquid	0.0%/(0.0, 70.8)/3	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 84.2)/2	

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

**Table 9. Fugitive Emission Profile With Confidence Intervals - Ethylene**

Source	Service	Weighted Average	Unit #2	Unit #4	Unit #11
Flanges	Gas	6.2%/(4.5, 8.5)/627	3.5%/(1.1, 8.1)/142	6.7%/(4.6, 9.5)/448	10.8%/(3.0, 25.4)/37
	Light Liquid	6.1%/(4.0, 8.9)/407	2.0%/(0.1, 10.5)/51	6.9%/(4.5, 10.3)/335	4.8%/(0.1, 23.8)/21
	Heavy Liquid	0.0%/(0.0, 4.1)/89	0.0%/(0.0, 4.9)/73	0.0%/(0.0, 21.8)/15	0.0%/(0.0, 97.5)/1
Process Drains	Gas	12.5%/(0.3, 52.6)/8	50.0%/(1.3, 98.7)/2	—	0.0%/(0.0, 45.9)/6
	Light Liquid	1.0%/(0.3, 2.5)/407	0.0%/(0.0, 3.8)/94	0.0%/(0.0, 1.2)/300	30.8%/(9.1, 61.4)/13
	Heavy Liquid	7.1%/(0.2, 33.9)/14	7.1%/(0.2, 33.9)/14	—	—
Open Ended Lines	Gas	12.1%/(8.7, 16.4)/305	22.0%/(11.5, 36.0)/50	18.3%/(10.1, 29.3)/71	7.1%/(3.8, 11.8)/184
	Light Liquid	19.2%/(11.8, 21.1)/214	31.6%/(17.5, 48.6)/38	16.7%/(7.9, 29.3)/54	16.4%/(10.3, 24.2)/122
	Heavy Liquid	0.0%/(0.0, 4.0)/91	0.0%/(0.0, 4.1)/88	0.0%/(0.0, 70.8)/3	—
Relief Valves	Gas	3.9%/(0.5, 13.5)/51	—	—	3.9%/(0.5, 13.5)/51
	Light Liquid	9.1%/(0.2, 41.3)/11	—	—	9.1%/(0.2, 41.3)/11
Valves	Gas	14.8%/(13.9, 15.8)/6294	14.8%/(13.2, 16.5)/2153	20.1%/(18.1, 22.1)/1970	10.2%/(8.9, 11.6)/2171
	Light Liquid	23.2%/(21.8, 24.7)/4176	25.9%/(23.1, 29.0)/1191	24.2%/(22.1, 26.5)/1990	17.9%/(15.6, 20.4)/995
	Heavy Liquid	1.1%/(0.6, 1.8)/1237	1.0%/(0.5, 1.7)/1144	3.7%/(0.5, 12.8)/54	0.0%/(0.0, 9.0)/39
Pumps	Light Liquid	25.6%/(16.4, 36.8)/78	37.5%/(15.2, 64.6)/16	28.6%/(14.6, 46.3)/35	14.8%/(14.2, 33.7)/27
	Heavy Liquid	0.0%/(0.0, 21.8)/15	0.0%/(0.0, 21.8)/15	—	—
Compressors	Gas	5.9%/(0.2, 28.7)/17	14.3%/(0.4, 57.9)/7	0.0%/(0.0, 70.8)/3	0.0%/(0.0, 41.0)/7

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

**Table 10. Fugitive Emission Profile With Confidence Intervals - Methyl Ethyl Ketone**

Source	Service	Weighted Average	Unit #31	Unit #32
Flanges	Gas	0.0%/(0.0, 15.4)/22	0.0%/(0.0, 45.9)/6	0.0%/(0.0, 20.6)/16
	Light Liquid	0.0%/(0.0, 4.7)/76	0.0%/(0.0, 10.0)/35	0.0%/(0.0, 8.6)/41
Process Drains	Gas	16.7%/(0.4, 64.1)/6	16.7%/(0.4, 64.1)/6	—
	Light Liquid	21.7%/(7.5, 43.7)/23	21.4%/(4.7, 50.8)/14	22.2%/(2.8, 60.0)/9
Open Ended Lines	Gas	8.1%/(1.7, 21.9)/37	8.3%/(0.2, 38.5)/12	8.0%/(1.0, 26.0)/25
	Light Liquid	10.2%/(6.3, 15.5)/186	8.6%/(3.8, 16.2)/93	11.8%/(6.1, 20.2)/93
Agitator Seals	Gas	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 97.5)/1	—
Relief Valves	Gas	0.0%/(0.0, 70.8)/3	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 84.2)/2
Valves	Gas	9.2%/(5.7, 14.1)/207	18.5%/(10.7, 28.7)/81	3.2%/(0.9, 7.9)/126
	Light Liquid	5.1%/(3.6, 7.1)/671	5.3%/(3.2, 8.5)/321	4.9%/(2.9, 7.8)/350
Pumps	Light Liquid	3.2%/(0.1, 16.7)/31	0.0%/(0.0, 21.8)/15	6.2%/(0.2, 30.2)/16
Compressors	Gas	100%/(2.5, 100)/1	—	100%/(2.5, 100)/1

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/ number screened.

**Table 11. Fugitive Emission Profile With Confidence Intervals - Formaldehyde**

Source	Service	Unit #22
Flanges	Gas	0.0%/(0.0, 84.2)/2
	Light Liquid	12.5%/(0.3, 52.6)/8
Open Ended Lines	Gas	0.0%/(0.0, 23.2)/14
	Light Liquid	0.0%/(0.0, 9.7)/36
Valves	Gas	2.4%/(0.1, 12.9)/41
	Light Liquid	0.0%/(0.0, 3.0)/121
Pumps	Light Liquid	0.0%/(0.0, 36.9)/8

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

**Table 12. Fugitive Emission Profile With Confidence Intervals - Methyl Methacrylate**

Source	Service	Unit #34
Flanges	Gas	0.0%/(0.0, 9.2)/38
	Light Liquid	0.0%/(0.0, 1.5)/247
Process Drains	Light Liquid	0.0%/(0.0, 16.1)/21
	Gas	0.0%/(0.0, 5.7)/63
Open Ended Lines	Light Liquid	0.3%/(0.0, 1.7)/335
	Gas	33.3%/(0.0, 90.6)/3
Agitator Seals	Light Liquid	0.0%/(0.0, 70.8)/3
	Gas	0.0%/(0.0, 60.2)/4
Relief Valves	Light Liquid	8.3%/(0.2, 38.5)/12
	Gas	0.0%/(0.0, 1.9)/190
Valves	Light Liquid	0.1%/(0.0, 0.5)/1058
	Gas	4.4%/(0.5, 15.1)/45

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

**Table 13. Fugitive Emission Profile With Confidence Intervals - Vinyl Acetate**

Source	Service	Weighted Average	Unit #1	Unit #3
Flanges	Gas	2.8%/(0.6, 8.0)/107	2.6%/(0.1, 13.8)/38	2.9%/(0.4, 10.1)/2
	Light Liquid	0.0%/(0.0, 2.1)/173	0.0%/(0.0, 6.4)/56	0.0%/(0.0, 3.2)/117
	Heavy Liquid	0.0%/(0.0, 36.9)/8	0.0%/(0.0, 70.8)/3	0.0%/(0.0, 52.2)/5
Process Drains	Gas	0.0%/(0.0, 5.7)/63	—	0.0%/(0.0, 5.7)/63
	Light Liquid	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1
	Heavy Liquid	0.0%/(0.0, 70.8)/3	—	0.0%/(0.0, 70.8)/3
Open Ended Lines	Gas	5.5%/(2.4, 10.6)/145	2.7%/(0.1, 14.2)/37	6.5%/(2.6, 13.0)/108
	Light Liquid	2.5%/(1.1, 5.0)/318	0.0%/(0.0, 7.7)/46	2.9%/(1.3, 5.8)/272
	Heavy Liquid	9.1%/(1.1, 29.2)/22	0.0%/(0.0, 36.9)/8	14.3%/(1.8, 42.8)/14
Agitator Seals	Gas	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1
	Light Liquid	0.0%/(0.0, 70.8)/3	0.0%/(0.0, 70.8)/3	—
	Heavy Liquid	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 97.5)/1	—
Relief Valves	Gas	0.0%/(0.0, 97.5)/1	—	0.0%/(0.0, 97.5)/1
	Light Liquid	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2	—
Valves	Gas	3.7%/(2.6, 5.1)/949	3.6%/(1.9, 6.4)/329	3.7%/(2.4, 5.5)/620
	Light Liquid	0.4%/(0.2, 0.7)/2136	0.1%/(0.0, 0.8)/736	0.5%/(0.2, 1.0)/1400
	Heavy Liquid	0.0%/(0.0, 2.9)/124	0.0%/(0.0, 5.4)/67	0.0%/(0.0, 6.3)/57
Pumps	Light Liquid	4.5%/(1.2, 11.1)/89	6.8%/(1.4, 18.7)/44	2.2%/(0.1, 11.8)/45
	Heavy Liquid	0.0%/(0.0, 52.2)/5	0.0%/(0.0, 52.2)/5	—
Compressors	Gas	0.0%/(0.0, 36.9)/8	0.0%/(0.0, 60.2)/4	0.0%/(0.0, 60.2)/4
Other <sup>1</sup>	Gas	16.7%/(0.4, 64.1)/6	16.7%/(0.4, 64.1)/6	—
	Light Liquid	0.0%/(0.0, 45.9)/6	0.0%/(0.0, 45.9)/6	—

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

<sup>1</sup>Includes filter and vacuum breaker.

**Table 14. Fugitive Emission Profile With Confidence Intervals - Vinyl Chloride Monomer**

Source	Service	Weighted Average	Unit #21	Unit #29
Flanges	Gas	4.0%/(0.1, 20.4)/25	0.0%/(0.0, 84.2)/2	4.3%/(0.1, 22.0)/23
	Light Liquid	0.6%/(0.0, 3.4)/163	0.0%/(0.0, 7.9)/45	0.8%/(0.0, 4.6)/118
Open Ended Lines	Gas	0.0%/(0.0, 3.6)/100	0.0%/(0.0, 60.2)/4	0.0%/(0.0, 3.8)/96
	Light Liquid	3.4%/(2.0, 5.5)/473	4.8%/(0.6, 16.2)/42	3.2%/(1.8, 5.5)/431
Relief Valves	Gas	0.0%/(0.0, 41.0)/7	0.0%/(0.0, 45.9)/6	0.0%/(0.0, 97.5)/1
	Light Liquid	0.0%/(0.0, 30.8)/10	0.0%/(0.0, 30.8)/10	—
Valves	Gas	1.0%/(0.3, 2.5)/402	0.0%/(0.0, 4.6)/79	1.2%/(0.3, 3.2)/323
	Light Liquid	1.1%/(0.7, 1.6)/2250	0.0%/(0.0, 0.6)/670	1.5%/(1.0, 2.3)/1580
Pumps	Light Liquid	5.3%/(1.1, 14.6)/57	0.0%/(0.0, 30.8)/10	6.4%/(1.3, 17.5)/47

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

**Table 15. Fugitive Emission Profile With Confidence Intervals - Ethylene Dichloride**

Source	Service	Weighted Average	Unit #20	Unit #28
Flanges	Gas	12.5%/(1.6, 38.4)/16	0.0%/(0.0, 30.8)/10	33.3%/(4.3, 77.7)/6
	Light Liquid	0.0%/(0.0, 7.6)/47	0.0%/(0.0, 8.8)/40	0.0%/(0.0, 41.0)/7
Process Drains	Light Liquid	40.0%/(5.3, 85.3)/5	50.0%/(1.3, 98.7)/2	33.3%/(0.0, 90.6)/3
Open Ended Lines	Gas	3.6%/(0.4, 12.5)/55	0.0%/(0.0, 11.6)/30	8.0%/(1.0, 26.0)/25
	Light Liquid	5.3%/(3.2, 8.4)/340	2.3%/(0.8, 5.5)/213	10.2%/(5.6, 16.9)/127
Agitator Seals	Gas	0.0%/(0.0, 84.2)/2	0.0%/(0.0, 84.2)/2	—
	Light Liquid	0.0%/(0.0, 97.5)/1	0.0%/(0.0, 97.5)/1	—
Relief Valves	Gas	0.0%/(0.0, 26.5)/12	0.0%/(0.0, 41.0)/7	0.0%/(0.0, 52.2)/5
	Light Liquid	0.0%/(0.0, 33.6)/9	0.0%/(0.0, 41.0)/7	0.0%/(0.0, 84.20)/2
Valves	Gas	7.3%/(5.0, 10.3)/412	2.2%/(0.8, 4.8)/276	17.6%/(11.7, 25.2)/136
	Light Liquid	1.0%/(0.5, 1.7)/1210	0.5%/(0.1, 1.3)/798	1.9%/(0.8, 3.8)/412
Pumps	Light Liquid	10.8%/(4.4, 20.9)/65	9.1%/(2.5, 21.7)/44	14.3%/(3.1, 36.3)/21

Each cell contains: Percent  $\geq$  10,000 ppmv/95% confidence interval/number screened.

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The complete report, entitled "Frequency of Leak Occurrence for Fittings in Synthetic Organic Chemical Plant Process Units," (Order No. PB 81-141 566;

Cost: \$14.00, subject to change) will be available only from:

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