Supplementary Material: Ethylbenzene Exposure in North America – An Update

SUPPLEMENTARY TABLES

Supplementary Table 1. Summary statistics for ethylbenzene in North American residential indoor air, 1991-2014 (µg/m^3)

Date	Location	n	Sampling time	% Detect	Percentile							Max	Source	Notes
					5th	10th	25th	50th	75th	90th	95th			
1991		24						2.1				25.0	[1]	
1992		61						3.7				26.0	[2]	
1993	Brownsville, TX	9						1.0					[3]	Spring
1993	Brownsville, TX	6						1.4				174.0	[3]	Summer
1994	Southeast Chicago, IL	48						3.2		13.0			[4]	
1996	Greater Toronto Area	44											[5]	
1997	New York state	406					0.4	1.0	2.8	7.4	13.0	340.0	[6]	Fuel oil-heated homes
1998	Denver, CO	375					2.0	3.1	2.6	10.0	17.0	170.0	[7]	
1999	Minneapolis-St. Paul, MN (3 urban communities)	292	48 hours	99		0.5		1.4		8.9			[8]	
1999	New York, NY	32	48 hours	97	0.5	0.8	1.4	1.6	2.2	2.7	3.6	5.1	[9]	Summer
1999	New York, NY	35	48 hours	100	0.8	1.0	1.1	1.6	2.0	3.4	14.1	34.3	[9]	Winter
1999	Los Angeles, CA	191	48 hours	85.6	0.4			1.4			8.0		[10]	
1999	Elizabeth, NJ	195	48 hours	72	0.4			1.3			6.1		[10]	
1999	Houston, TX	234	48 hours	100	0.6			1.7			7.4		[10]	
1999	Fort McKay, AB	30	4 days	80				1.8			5.9		[11]	
1999	St Albert, AB	30	24 hours	100				1.8			10.0		[11]	
1999	Sherwood Park, AB	31	24 hours	100				1.4			6.4		[11]	
2000	Fort McKay, AB	29	4 days	97				2.8			7.6		[11]	
2000	Minneapolis-St. Paul, MN	93	48 hours	100		0.6		1.0		2.8			[12]	Winter (includes smokers)
2000	Minneapolis-St. Paul, MN	88	48 hours	100		0.5		1.0		3.8			[12]	Spring (includes smokers)
2000	Los Angeles, CA	29	48 hours		0.9	1.0	1.4	1.8	2.7	3.7	5.8	15.1	[13]	Fall
2000	Los Angeles, CA	35	48 hours		1.4	1.7	1.9	2.8	3.5	4.9	5.7	6.1	[13]	Winter
2000	Grande Prairie, AB	132	7 days	75				0.8			7.0		[11]	
2000-2001	South Baltimore, MD	31	3 days			1.1	1.3	2.2	4.3	5.7		19.4	[14]	Industry-impacted community

Date	Location	n	Sampling time	% Detect	Percentile							Max	Source	Notes
					5th	10th	25th	50th	75th	90th	95th			
2000-2001	Central Baltimore, MD	20	3 days			0.8	0.8	1.2	1.8	4.3		10.7	[14]	Control urban community
2001	Syracuse, NY	254	24 hours	30				2.6		14.2	21.9	576.6	[15]	High prevalence of smokers
2001	Fort Saskatchewan, AB	138	7 days	75				1.2			6.0		[11]	
2004	Boston, MA	83	48 hours	98				0.8			9.7		[16]	
2004	Massachusetts	100	24 hours	26					2.0	6.5		30.0	[7]	
2004	New Jersey	100	24 hours	56				2.2	2.8	9.6	12.0	39.0	[17]	Suburban and rural
2004	Wabamun Lake, AB	193	7 days	86				0.9			5.0		[11]	
2005	Southeastern MI	15	4 days	100	0.2		0.8	2.1	3.7		5.2		[18]	
2004-2005	Missoula, MT	35	12 hours					2.0			20.6		[19]	Rural
2004-2005	Ann Arbor, Ypsilanti, & Dearborn, MI	158	3-4 days	100			0.6	1.1	2.0	4.6	5.9	40.6	[20]	
2005	Quebec City, QC	96	7 days	96				2.5					[21]	
2005	Windsor, ON	217	24 hours	100	0.9		1.8	2.9	7.1	23.9	39.7	912.8	[22]	Summer
2005	Windsor, ON	232	24 hours	100	0.5		0.7	1.1	2.5	5.6	11.3	609.9	[22]	Winter
2005	Fort Chipewyan, AB	30	7 days	97				1.2			13.0		[11]	
2005	Fort McMurray, AB	29	7 days	98				1.3			9.2		[11]	
2005-2006	Missoula, MT	51	12 hours					1.1			19.2		[19]	Rural
2006	Windsor, ON	211	24 hours	99.5			1.6	2.5	7.0	26.4	54.3	308.4	[22]	Summer
2006	Windsor, ON	224	24 hours	100			0.7	1.2	2.0	5.0	10.2	1198.5	[22]	Winter
2006	Fort McKay, AB	35	7 days	100				1.8			8.3		[11]	
2006	Detroit, MI	41	7 days	100			0.8	1.3	2.1	9.0		20.8	[23]	Includes smokers
2007	Regina, Saskatchewan	88	5 days	100	0.4		1.0	2.2	4.5	8.3	18.3	216.5	[24]	Summer (nonsmokers)
2007	Regina, Saskatchewan	13	5 days	100	0.5		1.4	1.5	2.3	8.5	11.7	11.7	[24]	Summer (smokers)
2007	Regina, Saskatchewan	70	5 days	100	0.2		0.6	0.9	2.1	2.8	5.1	41.9	[24]	Winter (nonsmokers)
2007	Regina, Saskatchewan	19	5 days	100	0.3		0.5	1.0	1.7	3.8	6.1	6.1	[24]	Winter (smokers)
2007	Regina, Saskatchewan	91	24 hours	100	0.4		0.8	1.7	4.1	7.2	15.6	66.6	[24]	Summer (nonsmokers)
2007	Regina, Saskatchewan	84	24 hours	100	0.1		0.6	1.1	2.0	4.0	5.8	14.3	[24]	Winter (nonsmokers)
2007-2008	Anchorage, AK	509	7 days				0.3	0.8	1.7			13.7	[25]	Attached garages

Date	Location	n	Sampling time	% Detect	Percentile							Max	Source	Notes
					5th	10th	25th	50th	75th	90th	95th			
2008-2009	Houston, TX	139	24 hours		0.2		0.7	1.1	1.8		4.9		[26]	
2009-2010	Detroit, MI	325	7 days	100	0.5	0.6	0.7	1.1	1.9	3.7	4.7	22.5	[27]	Includes smokers
2009-2011	18 collection sites in 5 regions in Canada	3857	7 days	99.95	0.3	0.4	0.6	1.2	2.6	7.0	13.6		[28]	Includes smokers
2012-2013	18 collection sites in 5 regions in Canada	3524	7 days	99.77	0.3	0.3	0.5	1.0	2.7	6.2	9.5		[29]	Includes smokers
2013-2014	Boston, MA	10	7 days	60				1.0			2.0	2.2	[30]	Low-income housing (pre-occupancy)
2013-2014	Boston, MA	26	7 days	27							1.6	2.2	[30]	Low-income housing (post-occupancy)
2017	Memphis Metropolitan Area	30	7 days	100				0.58				21.1	[31]	

Supplementary Table 2. Summary statistics for studies of ethylbenzene in personal air, 1999-2009 (μg/m³)

Date	Location	n	Mean	Percentile							Source
				5	10	25	50	75	90	95	
Adults											
1999	Minneapolis-St. Paul, MN	288	5.6	na	0.9	na	2.2	na	11.8	na	[8]
1999	NHANES VOC Subsample	639	8.4	na	na	1.3	2.6	5.2	14.2	25.2	[32]
1999-01	Los Angeles CA, Elizabeth NJ, Houston TX	545	2.8	0.4	0.6	1.0	1.7	2.7	5.2	7.5	[10]
2000-1	South Baltimore, MD	31	3.6	na	1.2	1.5	2.5	4.5	6.9	na	[14]
2000-1	Central Baltimore, MD	20	3.3	na	0.8	1.1	1.8	2.8	6.8	na	[14]
2004-5	Boston, MA	55	2.2	na	na	na	1.3	na	na	5.6	[16]
2004-6	Waterfront South (Camden, NJ)	200	1.4	0.3	na	na	0.9	na	na	3.2	[33,34]
2004-6	Copewood-Davis (Camden, NJ)	165	1.6	0.2	na	na	1.0	na	na	5.4	[33,34]
2005-6	Windsor, ON	207	10.6	1.0	na	1.6	2.4	5.6	18.9	27.3	[22]
2005-6	Windsor, ON	225	8.3	0.6	na	0.9	1.4	2.7	5.5	9.8	[22]
2005-7	Detroit, MI	1,007	3.9	na	na	1.4	2.3	3.7	na	na	[35]
2005-7	United Kingdom	191	2.5	na	na	0.7	1.2	2.1	na	na	[36]
2005-7	United Kingdom	209	4.4	na	na	0.9	1.5	2.8	na	na	[36]
2005-7	United Kingdom	100	2.1	na	na	0.7	1.4	3.1	na	na	[36]
2008-9	Houston, TX	140	2.7	0.2	na	0.7	1.2	2.3	na	11.4	[26]
Children											
1999	New York, NY	35	2.0	na	na	1.1	1.4	1.8	na	na	[9]
1999	New York, NY	31	2.9	na	na	1.5	2.4	3.7	na	na	[9]
2000	Minneapolis-St. Paul, MN	8	na	na	0.6	na	1.0	na	2.4	na	[37]
2000	Minneapolis-St. Paul, MN	10	na	na	0.5	na	0.9	na	2.0	na	[37]
1999-01	Los Angeles CA, Elizabeth NJ, Houston TX	209	3.3	0.4	0.7	1.2	2.0	3.1	5.1	10.3	[10]
2000	Los Angeles, CA	33	3.1	na	na	na	2.9	na	na	na	[13]
2000	Los Angeles, CA	38	5.1	na	na	na	3.4	na	na	na	[13]

na = not available

Supplementary Table 3. Estimated ethylbenzene doses for adults using consumer products

Product type	Product	Estimated dose (mg/kg BW-day)				Estimated airborne concentration (µg/m^3) *
		Ingestion	Dermal	Inhalation	Total	
Arts and crafts	finish-NOC	6.53E-08	3.91E-02	9.07E-02	1.30E-01	3.97E+02
	paint	5.29E-08	3.17E-02	7.35E-02	1.05E-01	3.22E+02
	finish-spray	2.56E-08	1.64E-02	3.96E-02	5.60E-02	1.73E+02
	wood adhesive-spray	1.61E-10	3.52E-03	8.50E-03	1.20E-02	3.72E+01
Home maintenance	stripper-NOC	0.00E+00	3.92E+00	9.08E+00	1.30E+01	3.97E+04
	paint-NOC	0.00E+00	2.44E+00	5.66E+00	8.10E+00	2.48E+04
	finish-NOC	0.00E+00	1.34E+00	3.10E+00	4.44E+00	1.36E+04
	finish-spray	0.00E+00	1.04E+00	2.51E+00	3.55E+00	1.10E+04
	primer-spray	0.00E+00	9.23E-01	2.23E+00	3.15E+00	9.76E+03
	paint-interior	0.00E+00	7.69E-01	1.78E+00	2.55E+00	7.79E+03
	paint cleaner-NOC	0.00E+00	3.93E-01	1.00E+00	1.39E+00	4.38E+03
	adhesive remover-NOC	0.00E+00	3.30E-01	8.43E-01	1.17E+00	3.69E+03
	primer-NOC	0.00E+00	3.59E-01	8.33E-01	1.19E+00	3.64E+03
	stain-NOC	0.00E+00	3.09E-01	7.16E-01	1.03E+00	3.13E+03
	paint-spray	0.00E+00	2.43E-01	5.86E-01	8.29E-01	2.56E+03
	surface sealer-NOC	0.00E+00	1.82E-01	4.22E-01	6.04E-01	1.85E+03
	paint thinner	0.00E+00	1.10E-01	2.81E-01	3.91E-01	1.23E+03
	corrosion protection-spray	0.00E+00	7.51E-02	1.81E-01	2.56E-01	7.92E+02
	corrosion protection-NOC	0.00E+00	4.61E-02	1.07E-01	1.53E-01	4.68E+02
	caulk or sealant	0.00E+00	3.18E-02	7.37E-02	1.06E-01	3.22E+02
	primer-interior	0.00E+00	1.58E-02	3.67E-02	5.25E-02	1.61E+02
	lubricant-NOC	0.00E+00	1.09E-02	2.79E-02	3.88E-02	1.22E+02
	wood adhesive-NOC	0.00E+00	4.75E-03	1.14E-02	1.62E-02	4.99E+01
	putty or filler	0.00E+00	4.52E-03	1.05E-02	1.50E-02	4.59E+01
Lawn and yard	grill or camping fuel	0.00E+00	2.05E-05	1.88E-02	1.88E-02	8.23E+01

Source: [38]

* Calculated assuming default adult body weight of 70 kg and inhalation rate of 16 m^3/day

Supplementary Table 4. Summary of modeled adult inhalation and dermal ethylbenzene exposure from use of consumer products

Product type	Ethylbenzene content	Mean air concentration on day of event (µg/m^3)	Dermal exposure (mg/kg-bw per event)
Spray paint	0.01 – 5%	6 – 3,000	0.002 – 1.1
Liquid paint	0.1 – 1%	1,300 – 13,000	0.051 – 0.51
Paint remover	4%	2,800	0.28
Lacquer/stain/varnish	0.1 – 2%	500 – 9,400	0.051 – 1.0
Sealant	0.1 – 5%	100 – 5,200	0.021 – 1.1

Source: [39]

Supplementary Table 5. Statistical summary of ethylbenzene concentrations in foodstuffs sampled in the 2014 Canadian Total Diet Study (µg/kg)

Food category	n	% Detected	Minimum detected	Maximum	Mean	SD	10%ile	25%ile	50%ile	75%ile	90%ile	95%ile
Baby food	9	100%	0.09	2.80	0.67	0.85	0.15	0.22	0.27	0.64	1.34	2.07
Beverage	14	64%		0.24	0.04	0.06	0.01	0.01	0.03	0.04	0.07	0.14
Cereal	21	100%	0.28	9.80	3.12	2.99	0.35	1.10	2.00	4.90	8.40	8.60
Dairy	14	57%		8.00	1.42	2.11	0.04	0.09	0.56	2.30	2.91	4.75
Fast food	9	100%	0.39	2.50	1.53	0.58	1.04	1.40	1.50	1.80	2.10	2.30
Fat/Oil	3	67%		4.50	2.60	1.47	1.21	1.66	2.40	3.45	4.08	4.29
Fish	4	100%	2	6.10	3.25	1.91	2.12	2.30	2.45	3.40	5.02	5.56
Fruit	17	94%		3.00	0.51	0.78	0.13	0.16	0.19	0.28	1.48	2.12
Meat	11	100%	1.4	3.30	2.36	0.56	1.60	2.10	2.40	2.70	2.90	3.10
Miscellaneous*	18	94%		10	1.56	72.99	0.02	0.04	0.27	1.9	4.18	5.68
Poultry	3	100%	1.7	5.30	3.07	1.95	1.80	1.95	2.20	3.75	4.68	4.99
Soup	4	100%	0.12	0.44	0.25	0.15	0.13	0.14	0.21	0.32	0.39	0.42
Vegetable	26	100%	0.02	4.90	0.60	1.14	0.05	0.10	0.26	0.50	0.76	3.05

Source: [40]

Summary statistics computed using EPA's ProUCL 5.1 [41]

* Excludes result for chewing gum

Supplementary Table 6. Sample-weighted geometric mean and selected upper limit values of whole blood ethylbenzene concentrations for U.S. and Canadian general populations (μg/L)

Years	Sample size	Det. freq.	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)
NHANES cycle[a]							
2001-02	879	--	0.034 (0.029-0.039)	0.030 (0.030-0.040)	0.050 (0.050-0.070)	0.090 (0.070-0.120)	0.140 (0.090-0.180)
2003-04	1,299	--	0.035 (0.033-0.037)	0.032 (0.030-0.036)	0.053 (0.048-0.057)	0.083 (0.077-0.088)	0.110 (0.098-0.120)
2005-06	3,119	--	0.038 (0.036-0.041)	0.035 (0.033-0.037)	0.059 (0.052-0.067)	0.100 (0.093-0.114)	0.140 (0.122-0.160)
2007-08	2,750	--	*	< LOD	0.038 (0.031-0.047)	0.083 (0.071-0.098)	0.122 (0.099-0.143)
2009-10	3,209	--	*	< LOD	0.047 (0.038-0.059)	0.114 (0.090-0.145)	0.175 (0.133-0.250)
2011-12	2,657	--	*	< LOD	0.029 (0.025-0.034)	0.074 (0.059-0.090)	0.115 (0.102-0.125)
2013-14	3,077	--	*	< LOD	0.029 (<LOD-0.034)	0.074 (0.065-0.083)	0.118 (0.098-0.143)
2015-16	3,059	--	*	< LOD	0.028 (0.024-0.031)	0.077 (0.066-0.087)	0.114 (0.104-0.125)
2017-18	2,866	--	*	< LOD	0.026 (<LOD-0.036)	0.072 (0.057-0.088)	0.118 (0.093-0.143)
CHMS cycle[b]							
2012-13	2,441	82%	0.026 (0.020-0.033)	0.025 (0.017-0.033)	--	0.084 (0.070-0.098)	0.120 (0.095-0.150)
2014-15	2,505	90%	0.026 (0.022-0.031)	0.024 (0.018-0.029)	--	0.078 (0.061-0.094)	0.110 (0.089-0.130)
2016-17	2,576	78%	0.023 (0.019-0.028)	0.021 (0.016-0.026)	--	0.083 (0.056-0.110)	0.120 (0.080-0.170)

a [42,43]

b [44]

* = Not calculated: proportion of results below limit of detection was too high to provide a valid result (>40%).

-- = Not provided

CHMS = Canadian Health Measures Study; CI = confidence interval; GM = geometric mean; < LOD = below limit of detection; NHANES = National Health and Nutrition Examination Survey

Supplementary Table 7. Sample-weighted geometric mean and selected upper limit values of whole blood ethylbenzene concentrations for U.S. and Canadian adults by sex (µg/L)

Gender	Sample size	Det. freq.	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)
Female							
NHANES cycle[a]							
2001-2	460	--	0.033 (0.028-0.038)	0.030 (0.030-0.040)	0.050 (0.040-0.060)	0.080 (0.060-0.120)	0.130 (0.070-0.180)
2003-4	674	--	0.032 (0.030-0.034)	0.030 (0.027-0.033)	0.048 (0.041-0.053)	0.081 (0.071-0.089)	0.100 (0.091-0.120)
2005-6	1,645	--	0.035 (0.032-0.038)	0.032 (0.029-0.035)	0.052 (0.047-0.061)	0.093 (0.081-0.103)	0.120 (0.106-0.150)
2007-8	1,394	--	*	< LOD	0.032 (0.027-0.043)	0.074 (0.058-0.092)	0.116 (0.089-0.134)
2009-10	1,627	--	*	< LOD	0.040 (0.031-0.054)	0.099 (0.076-0.122)	0.153 (0.114-0.236)
2011-12	1,326	--	*	< LOD	0.025 (<LOD-0.030)	0.064 (0.051-0.085)	0.107 (0.085-0.125)
2013-14	1,591	--	*	< LOD	<LOD	0.068 (0.062-0.077)	0.107 (0.092-0.124)
2015-16	1,546	--	*	< LOD	<LOD	0.067 (0.052-0.081)	0.109 (0.088-0.119)
2017-18	1,473	--	*	< LOD	<LOD	0.065 (0.050-0.081)	0.109 (0.082-0.133)
CHMS cycle[b]							
2012-13	1,229	80%	0.025 (0.018–0.033)	0.025 (0.016–0.033)	--	0.080 (0.057–0.10)	0.11 (0.076–0.14)
2014-15	1,266	90%	0.024 (0.020–0.029)	0.022 (0.018–0.026)	--	0.065 (0.046–0.084)	0.093 (0.068–0.12)
2016-17	1,295	78%	0.021 (0.016–0.028)	0.019 (0.014–0.025)	--	0.064 (0.033–0.095)	0.11 (0.059–0.15)
Male							
NHANES cycle[a]							
2001-2	419	--	0.035 (0.029-0.041)	0.030 (<LOD-0.040)	0.060 (0.040-0.070)	0.100 (0.070-0.150)	0.150 (0.090-0.220)
2003-4	625	--	0.037 (0.034-0.041)	0.036 (0.031-0.040)	0.057 (0.051-0.065)	0.086 (0.078-0.099)	0.110 (0.094-0.130)
2005-6	1,474	--	0.042 (0.039-0.044)	0.038 (0.036-0.041)	0.067 (0.057-0.074)	0.114 (0.099-0.131)	0.160 (0.136-0.180)
2007-8	1,356	--	*	< LOD	0.044 (0.037-0.056)	0.090 (0.077-0.105)	0.128 (0.102-0.154)
2009-10	1,582	--	*	< LOD	0.055 (0.045-0.070)	0.127 (0.099-0.168)	0.189 (0.156-0.342)
2011-12	1,331	--	*	< LOD	0.034 (0.029-0.039)	0.080 (0.067-0.095)	0.117 (0.106-0.145)
2013-14	1,486	--	*	< LOD	0.031 (0.027-0.036)	0.079 (0.063-0.101)	0.135 (0.106-0.159)
2015-16	1,513	--	*	< LOD	0.032 (0.028-0.038)	0.086 (0.073-0.097)	0.126 (0.111-0.153)
2017-18	1,393	--	*	< LOD	0.032 (0.024-0.041)	0.082 (0.065-0.095)	0.128 (0.093-0.159)
CHMS cycle[b]							
2012-13	1,212	84%	0.028 (0.022–0.034)	0.026 (0.018–0.034)	--	0.088 (0.063–0.11)	0.140 (0.096–0.180)
2014-15	1,239	90%	0.028 (0.023–0.035)	0.027 (0.019–0.034)	--	0.088 (0.067–0.11)	0.120 (0.086–0.150)
2016-17	1,281	78%	0.027 (0.022–0.033)	0.026 (0.020–0.032)	--	0.100 (0.077–0.12)	0.130 (0.100–0.160)

a [42,43,45]

b [44]

* = Not calculated: proportion of results below limit of detection was too high to provide a valid result (>40%).

-- = Not provided

CHMS = Canadian Health Measures Study; CI = confidence interval; GM = geometric mean; < LOD = below limit of detection; NHANES = National Health and Nutrition Examination Survey

Supplementary Table 8. Sample-weighted geometric mean and selected upper limit values of whole blood ethylbenzene concentrations in general U.S. and Canadian populations by age group (µg/L)

Age group	Sample size	Det. freq.	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)
NHANES cycle[a]							
12-19 years							
2005-6	909	--	0.032 0.030-0.034)	0.031 (0.029-0.033)	0.046 (0.042-0.049)	0.070 (0.058-0.085)	0.096 (0.075-0.120)
2007-8	448	--	*	< LOD	0.026 (<LOD-0.035)	0.051 (0.036-0.059)	0.068 (0.057-0.090)
2009-10	550	--	*	< LOD	0.028 (<LOD-0.032)	0.055 (0.041-0.071)	0.082 (0.065-0.117)
2011-12	502	--	*	<LOD	<LOD	0.040 (0.036-0.044)	0.046 (0.044-0.070)
2013-14	576	--	*	<LOD	<LOD	0.032 (0.025-0.041)	0.060 (0.034-0.095)
2015-16	541	--	*	<LOD	<LOD	0.029 (0.025-0.036)	0.048 (0.036-0.057)
2017-18	474	--	*	<LOD	<LOD	0.025 (<LOD-0.036)	0.036 (0.025-0.071)
20-59 years							
2005-6	1,539	--	0.040 (0.037-0.043)	0.037 (0.034-0.039)	0.062 (0.054-0.073)	0.110 (0.098-0.126)	0.150 (0.130-0.180)
2007-8	1,473	--	*	< LOD	0.045 (0.036-0.056)	0.094 (0.077-0.114)	0.131 (0.112-0.160)
2009-10	1,767	--	*	< LOD	0.058 (0.044-0.075)	0.129 (0.104-0.166)	0.189 (0.149-0.518)
60+ years							
2005-6	671	--	0.037 (0.033-0.040)	0.033 (0.030-0.036)	0.056 (0.046-0.068)	0.098 (0.090-0.110)	0.130 (0.110-0.160)
2007-8	829	--	*	< LOD	0.032 (0.026-0.038)	0.062 (0.050-0.083)	0.100 (0.074-0.123)
2009-10	892	--	*	< LOD	0.041 (0.032-0.050)	0.086 (0.067-0.116)	0.139 (0.108-0.186)
20+ years							
2011-12	2,155	--	*	< LOD	0.030 (0.026-0.036)	0.080 (0.067-0.095)	0.117 (0.104-0.140)
2013-14	2,501	--	*	< LOD	0.032 (0.026-0.038)	0.079 (0.069-0.092)	0.124 (0.106-0.150)
2015-16	2,518	--	*	< LOD	0.029 (0.026-0.035)	0.083 (0.070-0.094)	0.120 (0.112-0.135)
2017-18	2,392	--	*	< LOD	0.030 (<LOD-0.041)	0.079 (0.066-0.093)	0.127 (0.099-0.145)
CHMS cycle[b]							
12–19 years							
2012-3	731	79%	0.020 (0.016–0.027)	0.021 (0.015–0.027)	--	0.064 (0.044–0.084)	0.081 (0.056–0.110)
2014-5	709	86%	0.022 (0.017–0.027)	0.022 (0.016–0.027)	--	0.053 (0.044–0.061)	0.065 (0.052–0.077)
2016-7	835	70%	0.018 (0.014–0.025)	0.019 (0.014–0.024)	--	0.047 (0.032–0.062)	0.065 (0.032–0.097)
20–39 years							
2012-3	532	81%	0.026 (0.019–0.035)	0.026 (0.012–0.041)	--	0.077 (0.040–0.110)	0.120 (0.058–0.170)
2014-5	596	89%	0.024 (0.019–0.032)	0.023 (0.016–0.029)	--	0.062 (0.034–0.089)	
2016-7	591	77%	0.024 (0.018–0.032)	0.023 (0.015–0.031)	--	0.079 (0.054–0.100)	0.110 (0.081–0.140)
40–59 years							
2012-3	591	85%	0.029 (0.024–0.037)	0.027 (0.020–0.034)	--	0.100 (0.082–0.120)	0.140 (0.100–0.180)
2014-5	622	92%	0.029 (0.023–0.036)	0.025 (0.017–0.033)	--	0.098 (0.070–0.130)	0.120 (0.100–0.140)
2016-7	569	82%	0.026 (0.020–0.033)	0.024 (0.018–0.030)	--	0.097 (0.062–0.130)	0.130 (0.095–0.170)
60–79 years							
2012-3	587	82%	0.025 (0.019–0.032)	0.024 (0.016–0.032)	--	0.079 (0.064–0.094)	0.120 (0.062–0.170)

Age group	Sample size	Det. freq.	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)
2014-5	578	90%	0.027 (0.024–0.030)	0.026 (0.022–0.029)	--	0.087 (0.074–0.100)	0.120 (0.084–0.150)
2016-7	581	78%	0.023 (0.019–0.028)	0.021 (0.016–0.026)	--	0.083 (0.056–0.110)	0.120 (0.080–0.170)

a [42,43,45]

b [44]

* = Not calculated: proportion of results below limit of detection was too high to provide a valid result (>40%).

-- = Not provided

CHMS = Canadian Health Measures Study; CI = confidence interval; GM = geometric mean; < LOD = below limit of detection; NHANES = National Health and Nutrition Examination Survey

Supplementary Table 9. Sample-weighted geometric mean and selected upper limit values of whole blood ethylbenzene concentrations in the general U.S. population by racial/ethnic group (µg/L)

Demographic category/ NHANES cycle	Sample size	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)
Mexican Americans						
2001-02	220	*	0.030 (<LOD-0.040)	0.040 (0.040-0.060)	0.070 (0.050-0.110)	0.120 (0.070-0.210)
2003-04	253	0.031 (0.027-0.036)	0.029 (<LOD-0.035)	0.044 (0.035-0.048)	0.064 (0.051-0.074)	0.091 (0.066-0.170)
2005-06	752	0.032 (0.028-0.036)	0.030 (0.026-0.036)	0.047 (0.039-0.057)	0.072 (0.051-0.093)	0.086 (0.073-0.120)
2007-08	557	*	<LOD	0.029 (0.025-0.036)	0.050 (0.040-0.068)	0.072 (0.059-0.100)
2009-10	626	*	<LOD	0.035 (0.027-0.052)	0.070 (0.056-0.096)	0.114 (0.078-0.247)
2011-12	276	*	<LOD	0.024 (<LOD-0.030)	0.050 (0.031-0.068)	0.078 (0.041-0.415)
2013-14	491	*	<LOD	<LOD	0.040 (0.032-0.051)	0.064 (0.047-0.092)
2015-16	556	*	<LOD	<LOD	0.051 (0.036-0.058)	0.085 (0.057-0.096)
2017-18	419	*	<LOD	<LOD	0.035 (<LOD-0.055)	0.061 (0.032-0.093)
Non-Hispanic Blacks						
2001-02	159	0.032 (0.027-0.038)	0.030 (<LOD-0.040)	0.050 (0.030-0.070)	0.080 (0.060-0.130)	0.130 (0.070-0.240)
2003-04	281	0.032 (0.027-0.038)	0.030 (<LOD-0.037)	0.050 (0.037-0.066)	0.079 (0.065-0.100)	0.110 (0.084-0.130)
2005-06	809	0.037 (0.035-0.040)	0.034 (0.030-0.038)	0.057 (0.052-0.064)	0.095 (0.085-0.100)	0.120 (0.104-0.140)
2007-08	559	*	<LOD	0.048 (0.037-0.053)	0.086 (0.066-0.105)	0.117 (0.089-0.170)
2009-10	688	*	<LOD	0.029 (0.025-0.035)	0.063 (0.054-0.076)	0.097 (0.076-0.113)
2011-12	583	*	<LOD	0.047 (0.030-0.083)	0.137 (0.075-0.215)	0.215 (0.097-10.52)
2013-14	590	*	<LOD	0.044 (0.032-0.055)	0.088 (0.074-0.095)	0.125 (0.102-0.143)
2015-16	632	*	<LOD	0.038 (0.030-0.054)	0.094 (0.069-0.120)	0.130 (0.109-0.155)
2017-18	637	*	<LOD	0.046 (0.037-0.052)	0.094 (0.079-0.105)	0.127 (0.115-0.139)
Non-Hispanic Whites						
2001-02	432	0.035 (0.029-0.043)	0.030 (<LOD-0.040)	0.060 (0.050-0.070)	0.090 (0.070-0.140)	0.150 (0.090-0.190)
2003-04	669	0.036 (0.034-0.038)	0.034 (0.030-0.038)	0.055 (0.050-0.061)	0.087 (0.081-0.092)	0.110 (0.098-0.130)
2005-06	1,326	0.039 (0.037-0.042)	0.036 (0.033-0.038)	0.061 (0.053-0.072)	0.110 (0.095-0.120)	0.150 (0.125-0.180)
2007-08	1,190	*	<LOD	0.040 (0.031-0.053)	0.090 (0.075-0.112)	0.128 (0.105-0.154)
2009-10	937	*	<LOD	0.031 (0.027-0.038)	0.085 (0.071-0.097)	0.118 (0.108-0.140)
2011-12	1,465	*	<LOD	0.054 (0.042-0.065)	0.121 (0.099-0.151)	0.180 (0.145-0.281)
2013-14	1,241	*	<LOD	0.032 (0.025-0.040)	0.083 (0.066-0.106)	0.140 (0.107-0.169)
2015-16	991	*	<LOD	0.029 (0.024-0.034)	0.084 (0.070-0.095)	0.117 (0.108-0.144)
2017-18	977	*	<LOD	0.025 (<LOD-0.041)	0.072 (0.052-0.093)	0.129 (0.087-0.151)
Asians						
2011-12	400	*	<LOD	<LOD	0.030 (0.026-0.037)	0.042 (0.034-0.055)
2013-14	351	*	<LOD	<LOD	0.036 (0.025-0.052)	0.054 (0.036-0.076)
2015-16	349	*	<LOD	<LOD	0.029 (<LOD-0.042)	0.047 (0.032-0.070)
2017-18	405	*	<LOD	<LOD	0.031 (<LOD-0.066)	0.053 (0.030-0.113)

Demographic category/ NHANES cycle	Sample size	GM (95% CI)	50th %ile (95% CI)	75th %ile (95% CI)	90th %ile (95% CI)	95th %ile (95% CI)

Source: [42,45]

* = Not calculated: proportion of results below limit of detection was too high to provide a valid result (>40%)).

-- = Not provided

CI = confidence interval; GM = geometric mean; < LOD = below limit of detection; NHANES = National Health and Nutrition Examination Survey

Supplementary Table 10. Sample-weighted geometric mean and selected upper limit values of the creatinine-normalized molar sum of MA + PGA in urine in the U.S. general population, 2005 – 2016 (µmol/g creatinine)

Demographic group/ NHANES cycle	Sample size	Geometric mean	50th %ile	75th %ile	90th %ile	95th %ile
Total population						
2005-06	3,334	1.58	1.79	2.78	4.32	5.91
2011-12	2,466	2.27	2.25	3.18	4.70	6.30
2013-14	2,575	2.14	2.13	3.13	4.82	6.46
2015-16	3,013	2.37	2.34	3.28	4.52	5.73
Females						
2005-06	1,749	1.65	1.86	2.89	4.46	5.99
2011-12	1,215	2.41	2.41	3.29	4.83	6.52
2013-14	1,293	2.27	2.26	3.41	5.25	7.00
2015-16	1,516	2.49	2.46	3.41	4.78	6.12
Males						
2005-06	1,585	1.51	1.72	2.72	4.17	5.93
2011-12	1,251	2.15	2.11	3.03	4.60	6.13
2013-14	1,282	2.01	2.03	2.84	4.47	6.17
2015-16	1,497	2.25	2.24	3.10	4.27	5.25
Age 3-5 years						
15-16	459	3.27	3.44	4.55	5.86	6.78
Age 6-11 years						
11-12	394	2.41	2.49	3.29	4.34	4.97
13-14	389	2.37	2.50	3.33	4.43	5.29
15-16	373	2.62	2.68	3.49	4.33	5.22
Age 12-19 years						
2005-06	1,027	1.26	1.50	2.26	3.15	3.92
2011-12	384	1.82	1.89	2.55	3.15	4.08
2013-14	443	1.73	1.82	2.35	3.29	4.15
2015-16	395	1.85	1.85	2.38	3.07	3.53
Age 20+ years						
2005-06	2,305	1.64	1.85	2.90	4.49	6.13
2011-12	1,688	2.33	2.28	3.29	4.95	6.73
2013-14	1,743	2.19	2.17	3.22	5.23	6.85
2015-16	1,786	2.40	2.36	3.34	4.64	6.00
Asians						
2011-12	341	2.14	2.13	2.96	3.87	4.97
2013-14	281	1.95	2.05	2.95	4.21	4.85
2015-16	329	2.23	2.21	2.99	4.00	5.01
All Hispanics						
2011-12	566	2.05	2.03	2.78	3.82	4.81
2013-14	695	2.00	2.00	2.87	4.33	5.62
2015-16	969	2.22	2.21	3.07	4.18	5.14
Mexican Americans						
2005-06	816	1.48	1.70	2.61	3.66	5.20
2011-12	313	2.01	2.00	2.74	3.69	4.95
2013-14	449	1.99	1.97	2.76	4.09	5.40
2015-16	578	2.16	2.17	3.01	4.07	4.94
Non-Hispanic Blacks						
2005-06	896	1.33	1.63	2.43	3.75	4.96
2011-12	662	1.93	1.92	2.62	3.69	5.06

Demographic group/ NHANES cycle	Sample size	Geometric mean	50th %ile	75th %ile	90th %ile	95th %ile
2013-14	568	1.91	1.84	2.86	4.81	6.02
2015-16	656	2.19	2.13	3.07	4.39	5.48
Non-Hispanic Whites						
2005-06	1,365	1.63	1.83	2.89	4.55	6.22
2011-12	810	2.42	2.39	3.39	5.00	6.90
2013-14	935	2.25	2.22	3.25	5.19	6.82
2015-16	911	2.47	2.44	3.43	4.74	6.00

Source: [43]

MA = mandelic acid; PGA = phenylglyoxylic acid

Supplementary Table 11. Comparison of sample-weighted creatinine-normalized ethylbenzene metabolite concentrations in urine of smokers vs. non-smokers, NHANES survey years 2005 to 2012

Demographic group	No. Non-smokers	No. Smokers	Median (25th, 75th %ile) MA (µg/L)		Median (25th, 75th %ile) PGA (µg/L)		Molar sum MA + PGA Median (25th, 75th %ile) (µmol/g creatinine)	
			Non-smoker	Smoker	Non-smoker	Smoker	Non-smoker	Smoker
Total								
2005 – 2006	2,261	569	120 (88.1, 161)	239 (160, 389)	120 (42.4, 190)	216 (98.3, 331)	1.59 (1.09, 2.21)	3.00 (2.04, 4.66)
2011 – 2012	1,562	298	122 (88.9, 164)	255 (158, 370)	193 (140, 254)	306 (188, 451)	2.11 (1.61, 2.72)	3.69 (2.62, 5.61)
All	3,823	867	121 (88.4, 161)	246 (159, 382)	164 (101, 231)	258 (156, 416)	1.89 (1.34, 2.49)	3.40 (2.25, 5.11)
Age (years)								
6–11	276	0	129 (94.6, 176)	na	227 (178, 305)	na	2.41 (1.87, 3.10)	na
12–19	1,002	133	102 (77.3, 137)	165 (119, 266)	155 (93.2, 208)	240 (136, 338)	1.69 (1.15, 2.20)	2.78 (1.67, 3.73)
20–39	968	306	117 (88.1, 160)	212 (137, 323)	146 (102, 215)	230 (141, 371)	1.76 (1.30, 2.38)	2.99 (2.04, 4.24)
40–59	756	279	129 (97.1, 168)	272 (179, 472)	165 (91.0, 231)	286 (170, 436)	1.94 (1.40, 2.52)	3.69 (2.48, 5.64)
≥60	821	149	125 (86.8, 169)	274 (199, 399)	176 (99.2, 246)	292 (174, 500)	2.00 (1.38, 2.58)	3.82 (2.71, 5.64)
Race/ethnicity								
Mexican-American	828	97	121 (93.5, 159)	168 (111, 276)	157 (98.4, 222)	181 (87.9, 268)	1.84 (1.34, 2.41)	2.13 (1.50, 3.32)
Non-Hispanic Black	956	275	102 (74.0, 137)	196 (136, 287)	133 (90.2, 186)	205 (146, 307)	1.56 (1.14, 2.11)	2.73 (1.99, 3.89)
Non-Hispanic White	1,448	403	124 (89.9, 167)	260 (174, 411)	173 (102, 239)	280 (167, 434)	1.95 (1.38, 2.56)	3.60 (2.49, 5.48)
Other Hispanic or Multi-Race	591	92	123 (94.3, 162)	239 (156, 362)	163 (109, 231)	291 (166, 409)	1.85 (1.44, 2.51)	3.64 (1.93, 4.83)
Sex								
Female	2,065	354	128 (93.7, 171)	268 (179, 448)	176 (104, 247)	290 (173, 439)	2.00 (1.42, 2.65)	3.76 (2.72, 5.57)
Male	1,758	513	113 (84.4, 151)	222 (141, 354)	152 (92.3, 213)	218 (140, 377)	1.77 (1.25, 2.31)	3.00 (2.03, 4.59)

Source: [46]

na = not applicable

MA = mandelic acid; NHANES = National Health and Nutrition Examination Survey; PGA = phenylglyoxylic acid

Supplementary Table 12. Calculated age-specific central tendency and upper bound ethylbenzene intakes via inhalation (µg/kg BW-day)

Age group	Mean inhalation rate (m^3/day)[a]	Body weight (kg)[a]	Central tendency[b]		Upper bound[c]	
			Non-smoking	Smoking	Non-smoking	Smoking
< 1 month	3.6	4.8	1.28		8.48	
1<3 months	3.5	5.9	1.01		6.70	
3<6 months	4.1	7.4	0.94		6.26	
6<12 months	5.4	9.2	1.00		6.63	
1-year weighted average			1.01		6.7	
1<2 years	8	11.4	1.19		7.93	
2<3 years	8.9	13.8	1.10		7.29	
3<6 years	10.1	18.6	0.92		6.14	
6<11 years	12	31.8	0.64		4.26	
11<16 years	15.2	56.8	0.45		3.02	
16<21	16.3	71.6	0.39	1.04	2.57	5.14
21<31 years	15.7	80	0.33	0.90	2.22	4.44
31<41 years	16	80	0.34	0.92	2.26	4.52
41<51 years	16	80	0.34	0.92	2.26	4.52
51<61 years	15.7	80	0.33	0.90	2.22	4.44
61<71 years	14.2	80	0.30	0.81	2.01	4.01
71<81 years	12.9	80	0.27	0.74	1.82	3.64
Occupational[d]	10	80	37.2		372	

[a] [47]

[b] Central tendency representative inhalation concentrations are 1.7 µg/m^3 for the general population and 434 µg/m^3 for production workers. Smoking adjustment factor = 2.7 (see text).

[c] Upper bound representative concentrations are 11.3 µg/m^3 for the general population and 4,343 µg/m^3 for production workers. Smoking adjustment factor = 2.0 (see text).

[d] Adjusted for occupational exposure frequency (250 days/year)

Supplementary Table 13. Age-specific central tendency and upper bound ethylbenzene intakes for infants up to one year old from mother's milk or infant formula (µg/kg BW-day)

Age group	General population				Worker	
	Milk		Formula			
	Central tendency	Upper bound	Central tendency	Upper bound	Central tendency	Upper bound
Birth to <1 month	0.017	0.055	0.063	0.134	0.330	4.62
1 to > 3 months	0.015	0.048	0.059	0.115	0.308	3.99
3 to <6 months	0.012	0.038	0.046	0.091	0.242	3.15
6 to <12 months	0.009	0.033	0.035	0.079	0.183	2.73
1-year weighted average	**0.012**	**0.038**	**0.044**	**0.093**	**0.231**	**3.20**

Age-specific milk/formula intake rates from [47]

Central tendency and upper bound ethylbenzene concentrations in milk = 0.11 and 0.25 µg/L, respectively for the general population, and 2.2 and 21 µg/L, respectively for occupationally exposed mothers.

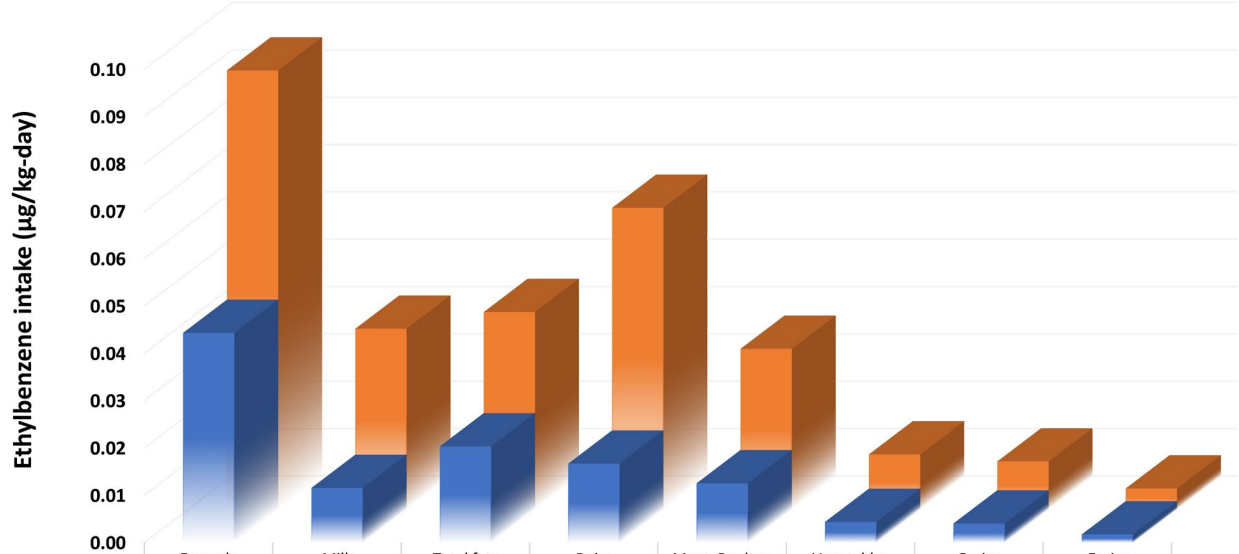
Ethylbenzene concentrations in formula (average of milk- and soy-based formulae) = 0.42 µg/L [40]

Supplementary Table 14. Modeled predictions of general population exposure to ethylbenzene (µg/kg BW-day)

Demographic	Median	95th Percentile
Age 6-11	0.1750	9.25
Age 12-19	0.0746	6.01
Age 20-65	0.0919	8.02
Age 65+	0.0689	6.84
BMI < 30	0.0791	5.29
BMI > 30	0.0717	9.29
Females	0.0629	5.13
Males	0.1020	7.48
Repro. age females	0.0771	7.93
Total	0.0135	722

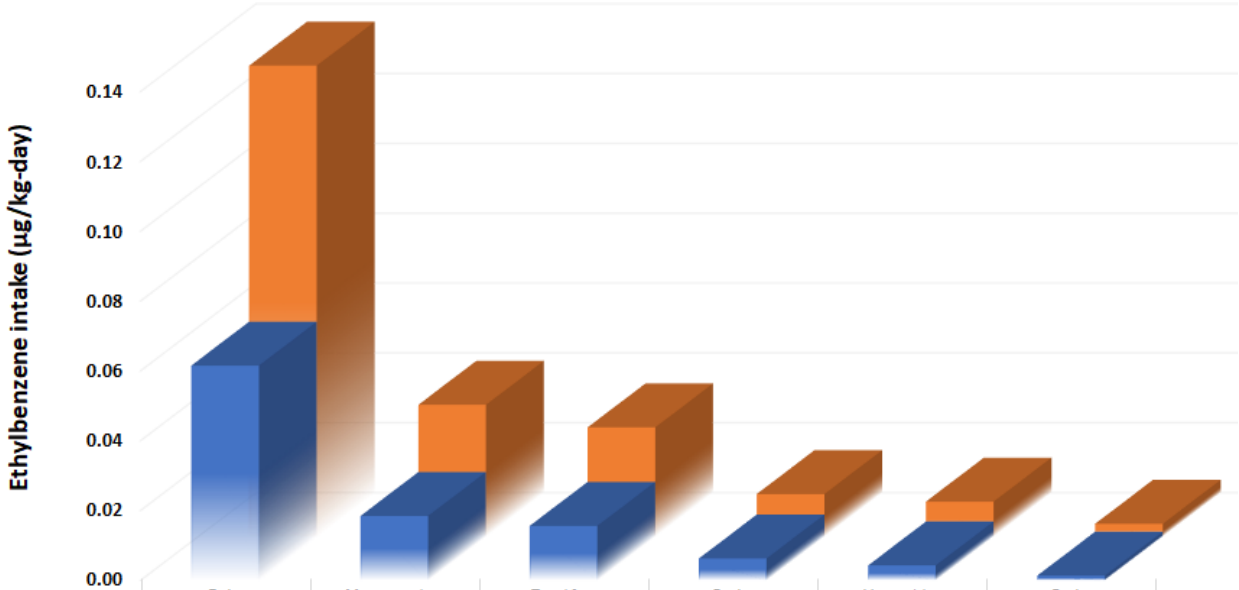
Source: [48]

SUPPLEMENTARY FIGURES



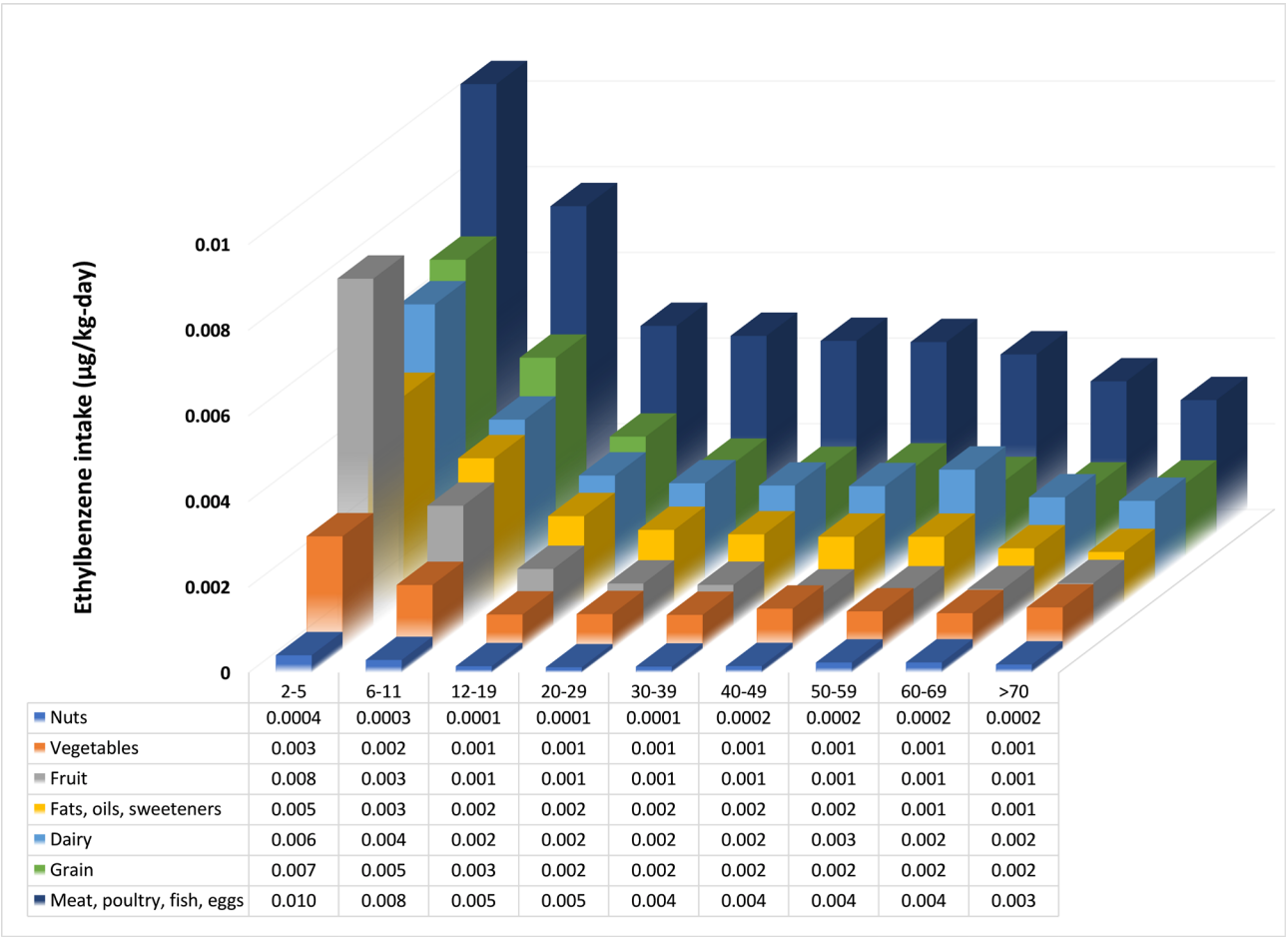
	Formula	Milk	Total fats	Dairy	Meat, Poultry, Fish, Eggs	Vegetables	Grains	Fruits
Central tendency	0.044	0.012	0.020	0.017	0.013	0.004	0.004	0.002
Upper bound	0.093	0.038	0.042	0.064	0.034	0.012	0.010	0.004

Supplementary Figure 1. Central tendency and upper bound estimates of dietary ethylbenzene intake by children aged 0 to 1 year



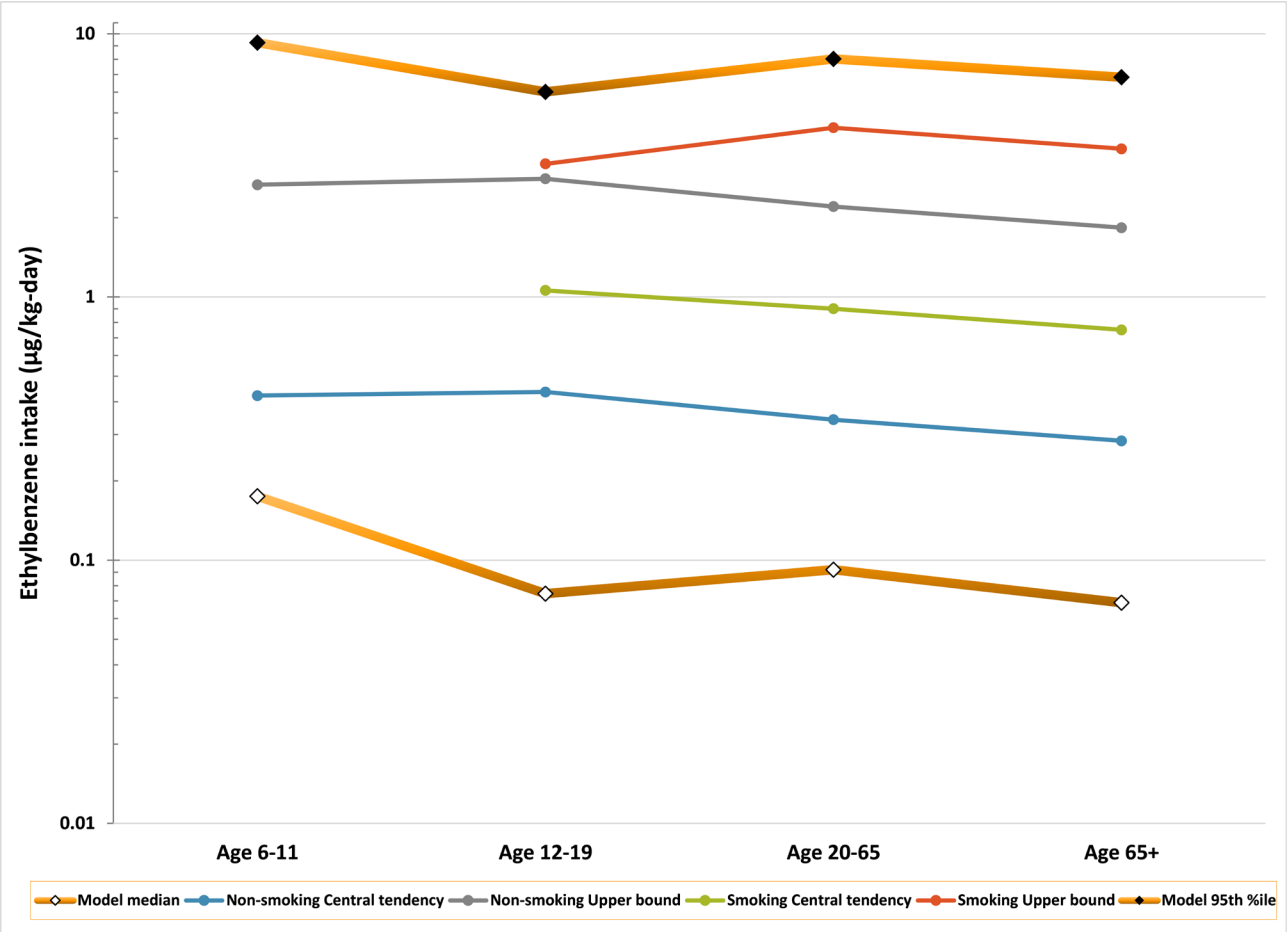
	Dairy	Meat, poultry, fish, eggs	Total fats	Grains	Vegetables	Fruits
Central tendency	0.062	0.018	0.016	0.006	0.004	0.001
Upper bound	0.135	0.038	0.031	0.012	0.010	0.004

Supplementary Figure 2. Central tendency and upper bound estimates of dietary ethylbenzene intake by children aged 1 to 2 years



	2-5	6-11	12-19	20-29	30-39	40-49	50-59	60-69	>70
Nuts	0.0004	0.0003	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002
Vegetables	0.003	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fruit	0.008	0.003	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Fats, oils, sweeteners	0.005	0.003	0.002	0.002	0.002	0.002	0.002	0.001	0.001
Dairy	0.006	0.004	0.002	0.002	0.002	0.002	0.003	0.002	0.002
Grain	0.007	0.005	0.003	0.002	0.002	0.002	0.002	0.002	0.002
Meat, poultry, fish, eggs	0.010	0.008	0.005	0.005	0.004	0.004	0.004	0.004	0.003

Supplementary Figure 3. Central tendency and upper bound estimates of dietary ethylbenzene intake by children and adults aged 2 to >70 years



Supplementary Figure 4. Comparison of calculated central tendency and upper bound ethylbenzene intakes with ExpoCast meta-model median and 95th percentile estimates of geometric mean intakes by general population age group

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Supplementary Material: Ethylbenzene Exposure in North America – An Update

Attachment A

Final Report

A Survey of Personal Occupational Exposures to Ethylbenzene Associated with the Production of Styrene

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Contents

Summary

A survey of historical measurements of occupational ethylbenzene exposure was conducted with a group of styrene manufacturers. A total of 638 short-term (defined as 59 minutes or less) and long-term (defined as 1 to 12 hours) measurements were amassed along with ancillary information on the job description, sampling duration, engineering controls, and analytical methods. The measurements were collected over a twenty-year period from 2000 to 2020 and were assigned to one of the following six job categories: supervisors/administrators, system operators, maintenance mechanics, equipment cleaners, sampling technicians, and laboratory personnel. The available exposure measurements were initially culled, pooled and randomized before being anonymized to conceal their source. The final list of values represents personal exposure measurements that do not take into consideration the protection afforded by the use of a respirator. The individual datasets were characterized by a very high percentage of non-detect values that were assigned a usable value using a conservative approach recognized by the USEPA. The overall non-detect percentage for the entire dataset was 88% with the percentage ranging from 57% to 100% for the individual job categories.

Descriptive statistics, obtained using the ProUCL (v 5.1) platform, showed that the mean personal short-term 15-min time weighted average (TWA) exposure levels were less than 0.5 ppm, with the highest maximum level of 2.1 ppm observed in sampling technicians. Similarly, the mean personal long-term 8-hr TWA ethylbenzene levels were less than 0.3 ppm, with the highest maximum level of 9.9 ppm associated with maintenance mechanics. A goodness-of-fit test with the measurements from each job function showed that the distribution pattern was lognormal for two of the four short-term job categories and two of the six long-term categories. Upper confidence limits (UCL) were determined for the lognormally distributed values using minimum variance unbiased estimators (MVUE) to obtain the best possible estimate. The job categories that failed the goodness-of-fit test were examined using a non-parametric technique (i.e., the Chebyshev Inequality method) that made no assumptions regarding the nature of the distribution.

The 95th percentile UCL for the short-term 15-min TWA measurements did not exceed about 1.0 ppm and was highest for the maintenance mechanics and lowest for the sampling technicians. The 95th percentile UCL for the long-term 8-hr TWA exposure levels did not exceed 0.9 ppm and was highest for maintenance mechanics and lowest for system operators. These values are believed to provide a reasonably accurate picture of the ethylbenzene exposure levels that accompany the production of styrene in North American facilities. To allow for the use of alternative pooling techniques or statistical methods, all of the raw individual measurements have been appended to this report.

Background

A survey has been conducted to acquire and summarize historical occupational exposure measurements of ethylbenzene. Short-term and long-term inhalation exposure levels were obtained at styrene manufacturing operations located in North America. The measurements were comprised of indoor and outdoor personal monitoring of the exposures associated with a variety of job descriptions, including: supervisors/administrators, system operators, maintenance mechanics, equipment cleaners, sampling technicians, and laboratory personnel. The styrene production process takes place in two stages starting with the alkylation of benzene with ethylene to produce the ethylbenzene that is then catalytically dehydrogenated in the vapor phase to yield styrene. Alternatively, the ethylbenzene may undergo hydroperoxidation to produce both styrene and propylene oxide. The final yield of styrene is controlled by manipulating the temperature, pressure, steam-hydrocarbon ratio, and catalyst type [1].

The entire production process takes place under closed conditions with limited opportunities for workplace exposure. Personal protective equipment is used in those operations where an inhalation or dermal exposure can occur. The ethylbenzene exposures associated with these operations were compiled for four styrene producers over a twenty-year period from 2000 to 2020. The final compilation of values was restricted to personal exposure levels and did not include area measurements or instantaneous determinations. The reported short-term and long-term exposure levels were independently evaluated to arrive at 15-min and 8-hr time-weighted averages (TWA).

Methods

Personal exposure data was received from four North American manufacturers of styrene with whom non-disclosure agreements (NDAs) were signed and agreed upon. The monitoring occurred at 10 styrene production facilities over a twenty-year period. In keeping with the NDAs, the measurements were anonymized. The anonymization included the use of a random sampling scheme if any one company submitted a disproportionately large number of measurements. Under these circumstances, a statistically identified random sample was selected that provided a 95% level of confidence that the sample was representative of the entire dataset within a margin of error of ±5% [2]. Prior to selecting this random sample, the entire population of exposure measurements was reviewed, and all area and instantaneous measurements were removed along with those measurements representing time-weighted averages greater than 12 hours in duration. This step resulted in the removal of less than 4% of the measurements from any single data set and improved the reliability of the final statistical analysis. Once this step was complete, the measurements were manually tagged and assigned to one of the following six job categories using the information supplied by the manufacturer:

- Supervisors/Administrators
- System Operators
- Maintenance Mechanics
- Equipment Cleaners
- Sampling Technicians
- Laboratory Personnel

The measurements associated with each job category were then segregated according to the sampling duration. Short-term samples included any measurement collected for 59 minutes or less, whereas the long-term values included sampling periods lasting from 1 to 12 hours. The stratified values from each company were then pooled according to the job description and sample duration then randomized to further mask their source. Measurements below the limit of quantitation (LOQ) were assigned a useable value by a simple substitution method that divided the LOQ by the square root of two (√2) or 1.414. This conservative approach was necessitated by the very high percentages of non-detect values which prevented the use of more robust statistical techniques [3]. The USEPA advocates the use of this adjustment factor when the geometric standard deviation of a dataset is less than 3 [4]. A larger factor of 2 has been recommended for use with datasets having a variance greater than 3. Since the ethylbenzene datasets stratified according to job type contained very high percentages of non-detect values, reliable variance estimates could not be obtained. Consequently, the more conservative recommended approach of dividing the reported value by 1.41 was adopted for assigning useable values to all of the reported exposure levels below the LOQ.

The short-term and long-term measurements were finally normalized to obtain 15-min and 8-hr TWAs.[1] This was accomplished using standard and well established assumptions that have been adopted by many regulatory authorities including the USEPA [5,6]. If the sampling duration was greater or less than 15 min for short-term samples or 480 min for long-term samples, the TWA was calculated by dividing the concentration-duration cross product by an averaging time of either 15 or 480 min.

$$8\text{–}hr\ TWA = (Reported\ Conc\ \times Reported\ Sample\ Duration) \div 480\ min$$

For exposure periods that were less than 480 minutes, this approach assumes that the exposure takes place within the stated sampling time and that exposures are absent during the interval when sampling does not occur. For example, if the stated sampling time was 400 min, the normalization attenuates the measurement by assuming that there is no exposure to ethylbenzene for the remaining 80 minutes. When the actual exposure durations are greater than 480 minutes, the procedure intensifies the measurement by assuming that the exposure level is compressed into a shorter measurement. When 12-hr measurements are normalized to an 8-hr TWA value, the exposure concentration is raised by a maximum of 1.5-fold (720/480 min). Since many of the examined datasets included an appreciable number of samples where the short-term and long-term exposure durations were greater than 15 or 480 min, the described normalization approach yielded conservative estimates of the actual TWA.

The resulting uncensored and time-normalized values were analyzed using the ProUCL software package (v 5.1) developed by the USEPA for summarizing environmental exposure information [7,8]. Statistical outliers were also flagged for each dataset, however, no action was taken when they were identified, since there was no justification for their removal.

A goodness-of-fit test was used to determine if the distribution pattern for the measurements associated with each job category could be described as lognormal. If the test showed that a

[1] This procedure was only applied to exposure measurement that were not already normalized prior to submission. As a result, only a portion of the submitted exposure measurements needed to undergo this adjustment.

dataset was lognormally distributed, a Chebyshev minimum variance unbiased estimate (MVUE) of the upper confidence limits was reported, since it provides the best estimates of the high end exposures values with this type of distribution [8,9]. In those instances where the distributions were not lognormal, a nonparametric method was applied that was not dependent on the distribution type. The nonparametric Chebyshev Inequality method was used to obtain values at the 75th, 90th, and 95th percentiles [10].

To facilitate the use of alternative statistical estimation techniques to obtain either a central tendency or a high-end exposure estimate, the individual analytical measurements used to compile the results in this report are listed in Appendix A Tables A.1 through A.10.

Results

A total of 638 short-term and long-term personal samples were amassed and pooled from the four styrene producing companies participating in the survey. The sample distribution across the ten North American monitoring locations was as follows:

Site 1 – 2 samples	Site 6 – 8 samples
Site 2 – 65 samples	Site 7 – 1 sample
Site 3 – 2 samples	Site 8 – 70 samples
Site 4 – 274 samples	Site 9 – 22 samples
Site 5 – 37 samples	Site 10 – 157 samples

All measurements were accompanied by a detailed description of the sample duration, job description, sampling method, analytical method, limit of quantitation, and relevant administrative/engineering controls. Three types of sampling/analytical methods were commonly, though not exclusively, used to measure ethylbenzene in the workplace. These included the now withdrawn highly generalized OSHA Method 7, which used tubes packed with activated charcoal or passive samplers containing activated carbon together with GC-FID (gas chromatography-flame ionization detection) for separation and analysis [11]. This method was supplanted by OSHA Method 1002 which also used charcoal tubes and passive samplers, but was more specifically tailored for use with ethylbenzene [12,13]. Another often reported method was NIOSH Method 1501 using an activated carbon badge dosimeter or a solid sorbent tube packed with activated charcoal for sampling and GC-FID for analysis [14]. Tables A.1 through A.10 in Appendix A list all of the individual exposure measurements together with the sampling and analytical methods that were utilized.

The goodness-of-fit testing showed that the distribution exposure values for each job category was lognormal for two of the four short-term datasets and two of the six long-term datasets. Similarly, the results in Table 1 show that in nearly every case the job category measurements could not be fit to either a normal or a gamma distribution. These findings are likely the result of the inordinately large percentage of non-detect values found in many of the examined datasets. The results of the fit testing also indicated that a non-parametric method was needed to determine the upper confidence limit values for those job categories that could not otherwise be classified. As seen in the quote below, upper limit values are needed along with a measure of central tendency to satisfy USEPA requirements for using occupational exposure measurements in a TSCA-related risk determination [5].

> "EPA will provide occupational exposure and environmental release data and results representative of *central tendency* conditions and *high-end* conditions. A central tendency is assumed to be representative of occupational exposures and environmental releases in the center of the distribution for a given condition of use. For risk evaluation, EPA may use the 50th percentile (median), mean (arithmetic or geometric), mode, or midpoint values of a distribution as representative of the central tendency scenario. EPA's preference is to provide the 50th percentile of the distribution. However, if the full distribution is not known, EPA may assume that the mean, mode, or midpoint of the distribution represents the central tendency depending on the statistics available for the distribution."

Central tendency estimates for the ethylbenzene exposure measurement categories are shown in Table 2. The mean, median, and mode are provided along a determination of the geometric mean and geometric standard deviation for those distributions shown to be lognormal. Sample sizes ranged from 7 to 280 for the different job categories and exposure durations. The largest number of samples were collected for system operators monitored long-term. The datasets are notable for the relatively small number of samples above the limit of quantitation. The results also show that the maximum level of exposure did not exceed 2.1 ppm for the 15-min TWA exposures and 9.9 ppm for the 8-hr TWA levels. The arithmetic average personal exposure concentration of ethylbenzene did not exceed 0.5 ppm for the short-term job categories or 0.3 ppm for the long-term. These measurements are likely an overestimate of the actual exposures since they do not take into account the protection afforded by the half or full-face air purifying respirators noted to be in use (along with nitrile gloves) during many of the cleaning and maintenance activities.

High end estimates for each job category are shown in Table 3. Using parametric and non-parametric statistical methods, exposure levels were determined at the 75th, 90th, and 95th percentiles of the distribution. The analysis shows that the ethylbenzene exposure levels at the upper 95th percentile are about 1 ppm or less for all of the short-term job categories, whereas the value for the long-term exposure categories are about 0.4 ppm or less for all but one of the job categories. The highest 8-hr TWA ethylbenzene exposure levels were observed in maintenance mechanics where the level at the 95th percentile was nearly 0.9 ppm. This value is in agreement with the short-term measurements, where maintenance mechanics were again shown to be the job type with the highest ethylbenzene exposure levels.

Table 1. Results of a goodness-of-fit test of each exposure dataset with three types of exposure distributions*

Job Category	Sample size	Distribution of exposure values		
		Normal	Lognormal	Gamma
Short-term samples (15-min TWA)				
System Operators	14	no	yes	no
Maintenance Mechanics	16	no	yes	no
Sampling Technicians	62	no	no	no
Laboratory Personnel	19	no	no	no
Long-term samples (8-hr TWA)				
Supervisors/ Administrators	10	no	yes	no
System Operators	280	no	no	no
Maintenance Mechanics	81	no	no	no
Equipment Cleaners	128	no	no	no
Sampling Technicians	7	yes	yes	yes
Laboratory Personnel	21	no	no	no

* tested at a significance level of 5%

Table 2. Descriptive statistics and summary information for the personal ethylbenzene exposure measurements for each job category

Job Category	Sample Size	No. of detects	Min (ppm)	Max (ppm)	Mode (ppm)	Median (ppm)	Mean (ppm)	SD (ppm)	GM (ppm)	GSD
Short-term samples (15-min TWA)										
System Operators	14	0	0.040	0.89	0.21	0.21	0.43	0.35	0.29	2.68
Maintenance Mechanics	16	3	0.050	1.60	ND	0.14	0.41	0.51	0.19	3.58
Sampling Technicians	62	4	0.030	2.12	0.14	0.14	0.26	0.34	ND	ND
Laboratory Personnel	19	0	0.140	0.90	0.14	0.21	0.39	0.29	ND	ND
Long-term samples (8-hr TWA)										
Supervisors/ Administrat	10	2	0.027	1.20	0.064	0.06	0.20	0.36	0.10	2.86
System Operators	280	37	0.003	2.67	0.064	0.07	0.13	0.28	ND	ND
Maintenance Mechanics	81	13	0.002	9.90	0.006	0.06	0.30	1.20	ND	ND
Equipment Cleaners	128	13	0.007	2.00	0.074	0.06	0.12	0.25	ND	ND
Sampling Technicians	7	3	0.010	0.34	ND	0.07	0.13	0.11	0.09	3.10
Laboratory Personnel	21	2	0.006	0.21	0.064	0.14	0.12	0.08	ND	ND

ND – not determined
SD – standard deviation
GM – geometric mean
GSD – geometric standard deviation

Table 3. Upper confidence limit estimates of ethylbenzene exposures assuming a lognormal distribution of values

Job Category	Sample size	Statistical Analysis[1]	75th % UCL	90th % UCL	95th % UCL
Short-term samples (15-min TWA)					
System Operators	14	parametric[2]	0.682	0.847	1.024
Maintenance Mechanics	16	parametric[2]	0.656	0.841	1.039
Sampling Technicians	62	non-parametric[3]	0.334	0.388	0.446
Laboratory Personnel	19	non-parametric[3]	0.506	0.592	0.683
Long-term samples (8-hr TWA)					
Supervisors/ Administrators	10	parametric[2]	0.257	0.328	0.404
System Operators	280	non-parametric[3]	0.157	0.178	0.200
Maintenance Mechanics	81	non-parametric[3]	0.517	0.679	0.853
Equipment Cleaners	128	non-parametric[3]	0.157	0.185	0.215
Sampling Technicians	7	parametric[2]	0.250	0.327	0.411
Laboratory Personnel	21	non-parametric[3]	0.153	0.174	0.196

[1] A parametric statistic is based on assumptions about the distribution from which the sample was taken. Nonparametric statistics are not based on any assumptions regarding the nature of the distribution.
[2] Minimum Variance Unbiased Estimation (MVUE)
[3] Chebyshev Inequality estimate

Discussion

Results from the survey show that the ethylbenzene exposure levels associated with the production of styrene are well below recognized occupational exposure limits. The average ethylbenzene 15-min TWA exposure levels did not exceed 0.5 ppm and the maximum observed concentration was 2.1 ppm for a sampling technician. Likewise, the average 8-hr TWA exposure levels did not exceed 0.3 ppm with the highest measured concentration of about 10 ppm observed with a maintenance mechanic. Long-term ethylbenzene exposures were notably similar for five of the six job categories examined with maintenance mechanics exposed to somewhat higher levels than the the other groups. Regardless, the reported levels are all far below the 8-hr occupational exposure limit (OEL) of 100 ppm and short-term exposure limt (STEL) of 125 ppm

issued by OSHA and NIOSH [15]. The levels are also appreciably less than the ACGIH (American Conference of Governmental Industrial Hygienists) and Canada Labour Code 8-hr OEL of 20 ppm [15,16].

Overall, the submitted ethylbenzene exposure measurements are characterized by a very high percentage of values below the limit of quantitation. Approximately 88% of the 638 short-term and long-term measurements collected over the twenty-year survey period were below the limit of quantitation. Although this high percentage affected the frequency distribution used to characterize the results, the failure to reliably detect ethylbenzene in many of the airborne measurements suggested a high degree of exposure control throughout the styrene production industry. This observation is supported by the fact that the higher level exposure excursions from the current study are generally similar to the values recorded from an earlier survey.

The previous survey examined ethylbenzene exposure levels in seven styrene production facilities over a ten-year period [17]. A total of 1727 8-hr TWA exposure measurements were examined from 1990 to 2000. A rudimentary analysis of the measurements found that 71% were either below the LOQ or less than 0.1 ppm. The highest four measured exposure concentrations ranged between 6 and 9 ppm for employees working as process operators or maintenance mechanics. Two other measurements from these two groups of employees were simply reported as greater than 5 ppm without further qualification. A comparison of the results from this earlier survey with those decribed in this report show relatively good agreement, as shown in Table 4. The percentage of ethylbenzene exposure measurements greater than 0.1 ppm is approximately the same for the system operators and maintenance mechanics examined in the 1990-2000 and 2000-2020 surveys. This is notable since these job categories include some of the largest sample sizes and are a good reflection of the actual conditions on the plant floor. Overall this basic comparison of the results from the two eras indicate that personal ethylbenzene exposures have been maintained at a low and managable level over a prolonged period of time.

In summary, the survey of short-term and long-term peronal exposure levels of ethylbenzene appear to be well below applicable occupational exposure limits. A statistical analysis of the measurements in each job categories allowed for the determination of three measures of central tendency after the censored measurements were assigned a usable value. The application of a goodness-of-fit test to the range of values in each job category showed notable inconsistencies, with the shape often failing to conform with the pattern for a normal, lognormal, or gaussian distribution. This observation was likely the result of the excessive number of censored non-detect values that were reported. This deficiency required the application of non-parametric statistical methods to obtain upper limit values for those job categories that did not display a discernablle distribution pattern. Using this approach, the upper 95th confidence limit for the short-term 15-min exposures was about 1 ppm or less whereas the long-term 8-hr 95th UCL was 0.9 ppm or less for the different job categories. Those wishing to use alternative statistical methods to determine a central tendency and distribution pattern for the individual job categories can take advantage of the itemized listing of EB exposure levels provided in Appendix A.

Table 4. A comparison of the exposure measurements in the current report with those from an earlier survey

Job Category	Percentage >0.1 ppm (%)		Percentage >1.0 ppm (%)	
	1990-2000	2000-2020	1990-2000	2000-2020
Supervisors/ Administrators	16.7	40.0	0.0	10
System Operators	28.7	26.1	3.7	1.4
Maintenance Mechanics	31.3	35.8	4.6	3.7
Equipment Cleaners	ND	12.5	ND	1.5
Sampling Technicians	ND	42.9	ND	0.0
Laboratory Personnel	33.9	57.1	7.8	0.0
Shipping	13.8	ND	3.1	ND

ND – not determined

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Appendix A

Individual short-term and long-term personal exposure measurements of ethylbenzene for identified job functions

Table A.1. Short-term sampling and analysis of personal exposures to ethylbenzene in system operators

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
1	System Operators	21	<0.19	0.14	0.14	charcoal tube/badge	OSHA Method 7
2	System Operators	21	<1.26	0.89	0.89	charcoal monitor	NIOSH 1501
3	System Operators	15	<0.30	0.21	0.21	charcoal monitor	NIOSH 1501
4	System Operators	18	<1.20	0.85	0.85	charcoal monitor	NIOSH 1501
5	System Operators	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
6	System Operators	15	<0.30	0.21	0.21	charcoal monitor	NIOSH 1501
7	System Operators	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
8	System Operators	20	<1.23	0.87	0.87	charcoal monitor	NIOSH 1501
9	System Operators	18	<1.20	0.85	0.85	charcoal monitor	NIOSH 1501
10	System Operators	15	<0.30	0.21	0.21	charcoal monitor	NIOSH 1501
11	System Operators	7	<0.06	0.04	0.04	charcoal tube/badge	OSHA Method 7
12	System Operators	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
13	System Operators	15	<1.20	0.85	0.85	charcoal monitor	NIOSH 1501
14	System Operators	13	<0.87	0.62	0.53	charcoal monitor	NIOSH 1501

Total number of samples	14	Minimum	0.04 ppm
Number of left-censored samples	14	Maximum	0.89 ppm
Percentage of non-detects	100%	Arithmetic mean	0.43 ppm
		Standard deviation	0.35 ppm

Table A.2. Short-term sampling and analysis of personal exposures to ethylbenzene in maintenance mechanics

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
1	Maintenance Mechanics	16	<0.15	0.11	0.11	charcoal tube	NIOSH 1501
2	Maintenance Mechanics	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
3	Maintenance Mechanics	35	<0.07	0.05	0.05	charcoal tube	NIOSH 1501
4	Maintenance Mechanics	16	1.48	1.48	1.48	charcoal tube	NIOSH 1501
5	Maintenance Mechanics	55	1.60	1.60	1.60	charcoal badge	NIOSH 1501
6	Maintenance Mechanics	15	<1.63	1.15	1.15	charcoal tube	NIOSH 1501
7	Maintenance Mechanics	8	<0.53	0.38	0.38	charcoal tube/badge	OSHA Method 7
8	Maintenance Mechanics	15	<1.55	1.10	1.10	charcoal tube	NIOSH 1501
9	Maintenance Mechanics	55	<0.40	0.28	0.28	charcoal badge	NIOSH 1501
10	Maintenance Mechanics	31	<0.08	0.06	0.06	charcoal tube	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
11	Maintenance Mechanics	32	<0.07	0.05	0.05	charcoal tube	NIOSH 1501
12	Maintenance Mechanics	21	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
13	Maintenance Mechanics	32	<0.07	0.05	0.05	charcoal tube	NIOSH 1501
14	Maintenance Mechanics	30	<0.08	0.06	0.06	charcoal tube	NIOSH 1501
15	Maintenance Mechanics	15	0.30	0.30	0.30	charcoal tube/badge	OSHA Method 7
16	Maintenance Mechanics	27	<0.09	0.06	0.06	charcoal tube	NIOSH 1501

Total number of samples	16	Minimum	0.05 ppm
Number of left-censored samples	13	Maximum	1.60 ppm
Percentage of non-detects	81%	Arithmetic mean	0.41 ppm
		Standard deviation	0.51 ppm

Table A.3. Short-term sampling and analysis of personal exposures to ethylbenzene in sampling technicians

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
1	Sampling Technicians	2	<0.66	0.47	0.47	charcoal tube/badge	OSHA Method 7
2	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
3	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
4	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
5	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
6	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
7	Sampling Technicians	15	<3.00	2.12	2.12	charcoal tube/badge	OSHA Method 7
8	Sampling Technicians	12	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
9	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
10	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
11	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
12	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
13	Sampling Technicians	10	<0.15	0.11	0.07	charcoal monitor	NIOSH 1501
14	Sampling Technicians	3	<1.43	1.01	1.01	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
15	Sampling Technicians	20	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
16	Sampling Technicians	18	0.71	0.71	0.71	charcoal monitor	NIOSH 1501
17	Sampling Technicians	2	<0.66	0.47	0.47	charcoal tube/badge	OSHA Method 7
18	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
19	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
20	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
21	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
22	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
23	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
24	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
25	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
26	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
27	Sampling Technicians	60	<0.06	0.04	0.04	charcoal tube/badge	OSHA Method 7
28	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
29	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
30	Sampling Technicians	8	<0.21	0.15	0.08	charcoal monitor	NIOSH 1501
31	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
32	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
33	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
34	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
35	Sampling Technicians	9	0.23	0.23	0.14	charcoal monitor	NIOSH 1501
36	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
37	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
38	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
39	Sampling Technicians	10	<0.15	0.11	0.07	charcoal monitor	NIOSH 1501
40	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
41	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
42	Sampling Technicians	2	<0.66	0.47	0.47	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
43	Sampling Technicians	9	<0.16	0.11	0.07	charcoal monitor	NIOSH 1501
44	Sampling Technicians	9	<0.04	0.03	0.03	charcoal badge	NIOSH 1501
45	Sampling Technicians	3	<1.43	1.01	1.01	charcoal tube/badge	OSHA Method 7
46	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
47	Sampling Technicians	8	<0.53	0.38	0.38	charcoal tube/badge	OSHA Method 7
48	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
49	Sampling Technicians	15	1.30	1.30	1.30	charcoal tube/badge	OSHA Method 7
50	Sampling Technicians	13	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
51	Sampling Technicians	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
52	Sampling Technicians	11	<0.15	0.11	0.08	charcoal monitor	NIOSH 1501
53	Sampling Technicians	9	<0.14	0.10	0.06	charcoal monitor	NIOSH 1501
54	Sampling Technicians	15	0.40	0.40	0.40	charcoal tube/badge	OSHA Method 7
55	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
56	Sampling Technicians	17	<0.14	0.10	0.10	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
57	Sampling Technicians	9	<0.14	0.10	0.06	charcoal monitor	NIOSH 1501
58	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
59	Sampling Technicians	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
60	Sampling Technicians	5	<0.26	0.18	0.18	charcoal tube/badge	OSHA Method 7
61	Sampling Technicians	2	<0.66	0.47	0.47	charcoal tube/badge	OSHA Method 7
62	Sampling Technicians	2	<0.66	0.47	0.47	charcoal tube/badge	OSHA Method 7

Total number of samples	62	Minimum	0.03 ppm
Number of left-censored samples	58	Maximum	2.12 ppm
Percentage of non-detects	94%	Arithmetic mean	0.26 ppm
		Standard deviation	0.34 ppm

Table A.4. Short-term sampling and analysis of personal exposures to ethylbenzene in laboratory personnel

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
1	Laboratory Personnel	19	<1.27	0.90	0.90	charcoal monitor	NIOSH 1501
2	Laboratory Personnel	15	<1.00	0.71	0.71	charcoal monitor	NIOSH 1501
3	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
4	Laboratory Personnel	15	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
5	Laboratory Personnel	15	<1.00	0.71	0.71	charcoal monitor	NIOSH 1501
6	Laboratory Personnel	13	<0.26	0.18	0.18	charcoal tube/badge	OSHA Method 7
7	Laboratory Personnel	15	<1.00	0.71	0.71	charcoal monitor	NIOSH 1501
8	Laboratory Personnel	4	<0.90	0.64	0.64	charcoal tube/badge	OSHA Method 7
9	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
10	Laboratory Personnel	12	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
11	Laboratory Personnel	11	<0.40	0.28	0.28	charcoal tube/badge	OSHA Method 7
12	Laboratory Personnel	14	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
13	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
14	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	15-min TWA (ppm)	Sampling Method	Analytical Method
15	Laboratory Personnel	13	<0.30	0.21	0.21	charcoal tube/badge	OSHA Method 7
16	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal tube/badge	OSHA Method 7
17	Laboratory Personnel	15	<0.20	0.14	0.14	charcoal monitor	NIOSH 1501
18	Laboratory Personnel	21	<1.26	0.89	0.89	charcoal monitor	NIOSH 1501
19	Laboratory Personnel	15	<1.00	0.71	0.71	charcoal monitor	NIOSH 1501

Total number of samples	19	Minimum	0.14 ppm
Number of left-censored samples	19	Maximum	0.90 ppm
Percentage of non-detects	100%	Arithmetic mean	0.39 ppm
		Standard deviation	0.29 ppm

Table A.5. Long-term sampling and analysis of personal exposures to ethylbenzene in supervisors/administrators

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	Supervisors/ Administrators	495	<0.278	0.197	0.197	charcoal monitor	NIOSH 1501
2	Supervisors/ Administrators	415	<0.200	0.141	0.141	charcoal badge	NIOSH 1501
3	Supervisors/ Administrators	507	0.137	0.137	0.137	charcoal monitor	NIOSH 1501
4	Supervisors/ Administrators	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
5	Supervisors/ Administrators	492	<0.083	0.059	0.059	Passive	mod. NIOSH 1501; GC/FID BADGE
6	Supervisors/ Administrators	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
7	Supervisors/ Administrators	495	<0.038	0.027	0.027	charcoal monitor	NIOSH 1501
8	Supervisors/ Administrators	615	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
9	Supervisors/ Administrators	525	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
10	Supervisors/ Administrators	480	1.200	1.200	1.200	charcoal badge	NIOSH 1501

Total number of samples	10	Minimum	0.027 ppm
Number of left-censored samples	8	Maximum	1.20 ppm
Percentage of non-detects	80%	Arithmetic mean	0.20 ppm
		Standard deviation	0.36 ppm

Table A.6. Long-term sampling and analysis of personal exposures to ethylbenzene in system operators

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	System Operators	580	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
2	System Operators	531	0.087	0.087	0.087	charcoal monitor	NIOSH 1501
3	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
4	System Operators	494	<0.036	0.025	0.038	charcoal tube/badge	NIOSH 1501
5	System Operators	510	<0.034	0.024	0.036	charcoal tube/badge	NIOSH 1501
6	System Operators	525	<0.090	0.064	0.095	charcoal tube/badge	OSHA Method 7
7	System Operators	657	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
8	System Operators	600	<0.007	0.005	0.005	charcoal tube/badge	OSHA Method 7
9	System Operators	580	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
10	System Operators	600	<0.042	0.030	0.037	charcoal badge	OSHA 1002
11	System Operators	540	0.021	0.021	0.024	charcoal tube	NIOSH 1501
12	System Operators	480	<0.008	0.006	0.006	charcoal tube/badge	OSHA Method 7
13	System Operators	588	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
14	System Operators	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
15	System Operators	640	0.330	0.330	0.495	charcoal tube/badge	OSHA Method 7
16	System Operators	491	<0.090	0.064	0.095	charcoal tube/badge	OSHA Method 7
17	System Operators	436	<0.272	0.193	0.193	charcoal monitor	NIOSH 1501
18	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
19	System Operators	668	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
20	System Operators	660	<0.038	0.027	0.037	charcoal badge	OSHA 1002
21	System Operators	450	<0.281	0.199	0.199	charcoal monitor	NIOSH 1501
22	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
23	System Operators	600	<0.042	0.030	0.037	charcoal badge	OSHA 1002
24	System Operators	520	<0.325	0.230	0.230	charcoal monitor	NIOSH 1501
25	System Operators	460	<0.288	0.203	0.203	charcoal monitor	NIOSH 1501
26	System Operators	418	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
27	System Operators	690	<0.062	0.044	0.066	charcoal tube/badge	OSHA Method 7
28	System Operators	435	<0.272	0.192	0.192	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
29	System Operators	501	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
30	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
31	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
32	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
33	System Operators	555	<0.038	0.027	0.027	charcoal monitor	NIOSH 1501
34	System Operators	695	0.080	0.080	0.120	charcoal tube/badge	OSHA Method 7
35	System Operators	485	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
36	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
37	System Operators	450	0.980	0.980	0.980	charcoal tube/badge	OSHA Method 7
38	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
39	System Operators	541	<0.400	0.283	0.424	charcoal tube/badge	OSHA Method 7
40	System Operators	444	<0.278	0.196	0.196	charcoal monitor	NIOSH 1501
41	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
42	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
43	System Operators	480	<0.008	0.006	0.006	charcoal tube/badge	OSHA Method 7
44	System Operators	465	<0.291	0.206	0.206	charcoal monitor	NIOSH 1501
45	System Operators	510	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
46	System Operators	565	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
47	System Operators	576	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
48	System Operators	492	<0.036	0.025	0.038	charcoal tube/badge	OSHA Method 7
49	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
50	System Operators	527	<0.038	0.027	0.027	charcoal monitor	NIOSH 1501
51	System Operators	480	<0.035	0.025	0.025	charcoal tube/badge	OSHA Method 7
52	System Operators	570	1.500	1.500	2.250	charcoal tube/badge	OSHA Method 7
53	System Operators	600	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
54	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
55	System Operators	493	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
56	System Operators	600	0.006	0.006	0.008	charcoal tube	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
57	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
58	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
59	System Operators	600	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
60	System Operators	492	<0.036	0.025	0.038	charcoal tube/badge	OSHA Method 7
61	System Operators	418	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
62	System Operators	669	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
63	System Operators	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
64	System Operators	578	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
65	System Operators	610	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
66	System Operators	669	0.016	0.016	0.022	charcoal tube	NIOSH 1501
67	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
68	System Operators	698	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
69	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
70	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
71	System Operators	375	<0.200	0.141	0.212	charcoal tube/badge	NIOSH 1501
72	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
73	System Operators	580	<0.073	0.052	0.077	charcoal tube/badge	OSHA Method 7
74	System Operators	675	<0.063	0.045	0.067	charcoal tube/badge	OSHA Method 7
75	System Operators	580	<0.080	0.057	0.085	charcoal tube/badge	NIOSH 1501
76	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
77	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
78	System Operators	660	<0.039	0.028	0.038	charcoal badge	OSHA 1002
79	System Operators	475	<0.297	0.210	0.210	charcoal monitor	NIOSH 1501
80	System Operators	554	<0.004	0.003	0.003	charcoal tube	NIOSH 1501
81	System Operators	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
82	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
83	System Operators	615	<0.041	0.029	0.037	charcoal badge	OSHA 1002
84	System Operators	690	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
85	System Operators	525	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
86	System Operators	462	<0.038	0.027	0.027	charcoal tube/badge	NIOSH 1501
87	System Operators	585	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
88	System Operators	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
89	System Operators	600	<0.042	0.030	0.037	charcoal badge	OSHA 1002
90	System Operators	666	0.018	0.018	0.025	charcoal tube	NIOSH 1501
91	System Operators	630	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
92	System Operators	403	<0.252	0.178	0.178	charcoal monitor	NIOSH 1501
93	System Operators	622	0.005	0.005	0.006	charcoal tube	NIOSH 1501
94	System Operators	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
95	System Operators	520	<0.271	0.192	0.192	charcoal monitor	NIOSH 1501
96	System Operators	450	<0.100	0.071	0.071	charcoal tube/badge	OSHA Method 7
97	System Operators	746	0.045	0.045	0.068	charcoal tube/badge	OSHA Method 7
98	System Operators	455	<0.284	0.201	0.201	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
99	System Operators	703	<0.060	0.042	0.064	charcoal tube/badge	NIOSH 1501
100	System Operators	541	<0.400	0.283	0.424	charcoal tube/badge	OSHA Method 7
101	System Operators	638	0.012	0.012	0.016	charcoal tube	NIOSH 1501
102	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
103	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
104	System Operators	291	<0.049	0.035	0.035	charcoal tube/badge	NIOSH 1501
105	System Operators	427	<0.096	0.068	0.068	charcoal badge	NIOSH 1501
106	System Operators	665	<0.064	0.045	0.068	charcoal tube/badge	OSHA Method 7
107	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
108	System Operators	720	<0.035	0.025	0.037	charcoal badge	OSHA 1002
109	System Operators	465	<0.291	0.206	0.206	charcoal monitor	NIOSH 1501
110	System Operators	610	<0.041	0.029	0.037	charcoal badge	OSHA 1002
111	System Operators	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
112	System Operators	439	<0.038	0.027	0.027	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
113	System Operators	505	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
114	System Operators	490	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
115	System Operators	459	<0.287	0.203	0.203	charcoal monitor	NIOSH 1501
116	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
117	System Operators	550	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
118	System Operators	525	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
119	System Operators	452	<0.282	0.200	0.200	charcoal monitor	NIOSH 1501
120	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
121	System Operators	525	<0.273	0.193	0.193	charcoal monitor	NIOSH 1501
122	System Operators	515	1.609	1.609	1.609	charcoal monitor	NIOSH 1501
123	System Operators	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
124	System Operators	475	1.979	1.979	1.979	charcoal monitor	NIOSH 1501
125	System Operators	637	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
126	System Operators	480	0.077	0.077	0.077	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
127	System Operators	585	<0.290	0.205	0.308	charcoal tube/badge	OSHA Method 7
128	System Operators	420	<0.262	0.186	0.186	charcoal monitor	NIOSH 1501
129	System Operators	573	0.028	0.028	0.033	charcoal tube	NIOSH 1501
130	System Operators	600	<0.290	0.205	0.308	charcoal tube/badge	OSHA Method 7
131	System Operators	567	<0.080	0.057	0.085	charcoal tube/badge	NIOSH 1501
132	System Operators	384	<0.240	0.170	0.170	charcoal monitor	NIOSH 1501
133	System Operators	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
134	System Operators	465	<0.291	0.206	0.206	charcoal monitor	NIOSH 1501
135	System Operators	703	<0.060	0.042	0.064	charcoal tube/badge	NIOSH 1501
136	System Operators	657	<0.065	0.046	0.069	charcoal tube/badge	OSHA Method 7
137	System Operators	465	<0.291	0.206	0.206	charcoal monitor	NIOSH 1501
138	System Operators	510	0.308	0.308	0.308	charcoal monitor	NIOSH 1501
139	System Operators	586	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
140	System Operators	494	<0.030	0.021	0.021	charcoal tube/badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
141	System Operators	635	<0.300	0.212	0.318	charcoal tube/badge	OSHA Method 7
142	System Operators	541	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
143	System Operators	500	<0.271	0.192	0.192	charcoal monitor	NIOSH 1501
144	System Operators	477	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
145	System Operators	662	0.370	0.370	0.555	charcoal tube/badge	OSHA Method 7
146	System Operators	490	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
147	System Operators	428	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
148	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
149	System Operators	442	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
150	System Operators	435	<0.272	0.192	0.192	charcoal monitor	NIOSH 1501
151	System Operators	484	<0.040	0.028	0.029	charcoal monitor	NIOSH 1501
152	System Operators	691	<0.020	0.014	0.021	charcoal tube/badge	OSHA Method 7
153	System Operators	523	<0.327	0.231	0.231	charcoal monitor	NIOSH 1501
154	System Operators	470	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
155	System Operators	443	<0.092	0.065	0.065	charcoal badge	NIOSH 1501
156	System Operators	427	<0.096	0.068	0.068	charcoal badge	NIOSH 1501
157	System Operators	493	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
158	System Operators	483	<0.038	0.027	0.027	charcoal monitor	NIOSH 1501
159	System Operators	562	<0.080	0.057	0.085	charcoal tube/badge	NIOSH 1501
160	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
161	System Operators	490	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
162	System Operators	450	<0.100	0.071	0.071	charcoal tube/badge	OSHA Method 7
163	System Operators	584	0.038	0.038	0.046	charcoal tube	NIOSH 1501
164	System Operators	576	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
165	System Operators	452	<0.282	0.200	0.200	charcoal monitor	NIOSH 1501
166	System Operators	566	<0.080	0.057	0.085	charcoal tube/badge	NIOSH 1501
167	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
168	System Operators	524	<0.900	0.636	0.636	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
169	System Operators	450	<0.100	0.071	0.071	charcoal tube/badge	OSHA Method 7
170	System Operators	419	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
171	System Operators	669	0.009	0.009	0.013	charcoal tube	NIOSH 1501
172	System Operators	600	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
173	System Operators	475	<0.039	0.028	0.027	charcoal monitor	NIOSH 1501
174	System Operators	500	<0.271	0.192	0.192	charcoal monitor	NIOSH 1501
175	System Operators	630	<0.040	0.028	0.037	charcoal badge	OSHA 1002
176	System Operators	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
177	System Operators	695	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
178	System Operators	530	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
179	System Operators	444	<0.092	0.065	0.065	charcoal badge	NIOSH 1501
180	System Operators	475	0.614	0.614	0.614	charcoal monitor	NIOSH 1501
181	System Operators	512	<0.034	0.024	0.036	charcoal tube/badge	NIOSH 1501
182	System Operators	480	<0.008	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
183	System Operators	520	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
184	System Operators	502	<0.035	0.025	0.037	charcoal tube/badge	NIOSH 1501
185	System Operators	670	<0.063	0.045	0.067	charcoal tube/badge	OSHA Method 7
186	System Operators	480	0.900	0.900	0.900	charcoal monitor	NIOSH 1501
187	System Operators	678	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
188	System Operators	568	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
189	System Operators	626	<0.070	0.049	0.074	charcoal tube/badge	NIOSH 1501
190	System Operators	669	0.005	0.005	0.007	charcoal tube	NIOSH 1501
191	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
192	System Operators	435	0.091	0.091	0.091	charcoal monitor	NIOSH 1501
193	System Operators	683	<0.003	0.002	0.003	charcoal tube	NIOSH 1501
194	System Operators	500	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
195	System Operators	496	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
196	System Operators	590	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
197	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
198	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
199	System Operators	667	<0.030	0.021	0.032	charcoal tube/badge	OSHA Method 7
200	System Operators	500	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
201	System Operators	695	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
202	System Operators	710	0.140	0.140	0.210	charcoal tube/badge	OSHA Method 7
203	System Operators	592	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
204	System Operators	465	0.017	0.017	0.017	charcoal tube/badge	OSHA Method 7
205	System Operators	577	<0.004	0.003	0.003	charcoal tube	NIOSH 1501
206	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
207	System Operators	455	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
208	System Operators	605	<0.070	0.049	0.074	charcoal tube/badge	NIOSH 1501
209	System Operators	670	<0.063	0.045	0.067	charcoal tube/badge	OSHA Method 7
210	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
211	System Operators	583	<0.290	0.205	0.308	charcoal tube/badge	OSHA Method 7
212	System Operators	600	<0.007	0.005	0.005	charcoal tube/badge	OSHA Method 7
213	System Operators	540	<0.047	0.033	0.037	charcoal badge	OSHA 1002
214	System Operators	720	<0.035	0.025	0.037	charcoal badge	OSHA 1002
215	System Operators	561	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
216	System Operators	615	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
217	System Operators	520	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
218	System Operators	709	1.780	1.780	2.670	charcoal tube/badge	OSHA Method 7
219	System Operators	677	<0.020	0.014	0.021	charcoal tube/badge	OSHA Method 7
220	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
221	System Operators	665	<0.064	0.045	0.068	charcoal tube/badge	OSHA Method 7
222	System Operators	500	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
223	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
224	System Operators	683	0.024	0.024	0.034	charcoal tube	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
225	System Operators	447	<0.279	0.198	0.198	charcoal monitor	NIOSH 1501
226	System Operators	588	<0.290	0.205	0.308	charcoal tube/badge	OSHA Method 7
227	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
228	System Operators	505	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
229	System Operators	454	<0.284	0.201	0.201	charcoal monitor	NIOSH 1501
230	System Operators	476	<0.039	0.028	0.027	charcoal monitor	NIOSH 1501
231	System Operators	669	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
232	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
233	System Operators	496	<0.083	0.059	0.059	charcoal badge	NIOSH 1501
234	System Operators	411	<0.200	0.141	0.212	charcoal tube/badge	NIOSH 1501
235	System Operators	515	<0.279	0.197	0.197	charcoal monitor	NIOSH 1501
236	System Operators	480	<0.036	0.025	0.025	charcoal tube/badge	OSHA Method 7
237	System Operators	637	0.059	0.059	0.078	charcoal tube	NIOSH 1501
238	System Operators	450	<0.281	0.199	0.199	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
239	System Operators	600	<0.042	0.030	0.037	charcoal badge	OSHA 1002
240	System Operators	465	<0.271	0.192	0.192	charcoal monitor	NIOSH 1501
241	System Operators	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
242	System Operators	610	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
243	System Operators	600	<0.080	0.057	0.057	charcoal tube/badge	OSHA Method 7
244	System Operators	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
245	System Operators	435	<0.272	0.192	0.192	charcoal monitor	NIOSH 1501
246	System Operators	610	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
247	System Operators	655	<0.065	0.046	0.069	charcoal tube/badge	OSHA Method 7
248	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
249	System Operators	465	<0.291	0.206	0.206	charcoal monitor	NIOSH 1501
250	System Operators	628	<0.068	0.048	0.072	charcoal tube/badge	OSHA Method 7
251	System Operators	688	0.050	0.050	0.072	charcoal tube	NIOSH 1501
252	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
253	System Operators	525	<0.273	0.193	0.193	charcoal monitor	NIOSH 1501
254	System Operators	487	<0.084	0.059	0.059	charcoal badge	NIOSH 1501
255	System Operators	570	0.010	0.010	0.012	charcoal tube	NIOSH 1501
256	System Operators	480	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
257	System Operators	420	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
258	System Operators	630	<0.040	0.028	0.037	charcoal badge	OSHA 1002
259	System Operators	514	0.009	0.009	0.010	charcoal tube	NIOSH 1501
260	System Operators	480	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
261	System Operators	459	<0.287	0.203	0.203	charcoal monitor	NIOSH 1501
262	System Operators	450	<0.100	0.071	0.071	charcoal tube/badge	OSHA Method 7
263	System Operators	480	0.812	0.812	0.812	charcoal tube/badge	OSHA Method 7
264	System Operators	521	<0.004	0.003	0.003	charcoal tube	NIOSH 1501
265	System Operators	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
266	System Operators	480	0.155	0.155	0.155	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
267	System Operators	600	<0.007	0.005	0.005	charcoal tube/badge	OSHA Method 7
268	System Operators	776	0.030	0.030	0.045	charcoal tube/badge	OSHA Method 7
269	System Operators	525	<0.400	0.283	0.424	charcoal tube/badge	OSHA Method 7
270	System Operators	450	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
271	System Operators	490	<0.039	0.028	0.027	charcoal monitor	NIOSH 1501
272	System Operators	496	<0.090	0.064	0.064	charcoal tube/badge	OSHA Method 7
273	System Operators	520	<0.090	0.064	0.095	charcoal tube/badge	OSHA Method 7
274	System Operators	454	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
275	System Operators	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
276	System Operators	600	0.014	0.014	0.014	charcoal tube/badge	OSHA Method 7
277	System Operators	530	<0.033	0.023	0.035	charcoal tube/badge	NIOSH 1501
278	System Operators	435	<0.272	0.192	0.192	charcoal monitor	NIOSH 1501
279	System Operators	570	<0.080	0.057	0.071	charcoal tube/badge	OSHA Method 7
280	System Operators	735	0.033	0.033	0.050	charcoal tube/badge	OSHA Method 7

Total number of samples	280	Minimum	0.003 ppm
Number of left-censored samples	243	Maximum	2.67 ppm
Percentage of non-detects	87%	Arithmetic mean	0.13 ppm
		Standard deviation	0.28 ppm

Table A.7. Long-term sampling and analysis of personal exposures to ethylbenzene in maintenance mechanics

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	Maintenance Mechanics	515	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
2	Maintenance Mechanics	435	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
3	Maintenance Mechanics	552	<0.032	0.023	0.034	charcoal tube/badge	NIOSH 1501
4	Maintenance Mechanics	600	<0.007	0.005	0.005	charcoal tube/badge	OSHA Method 7
5	Maintenance Mechanics	463	<0.289	0.204	0.205	charcoal monitor	NIOSH 1501
6	Maintenance Mechanics	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
7	Maintenance Mechanics	685	<0.490	0.490	0.490	charcoal badge	NIOSH 1501
8	Maintenance Mechanics	540	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
9	Maintenance Mechanics	480	<0.270	0.191	0.191	charcoal monitor	NIOSH 1501
10	Maintenance Mechanics	510	0.100	0.100	0.100	charcoal badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
11	Maintenance Mechanics	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
12	Maintenance Mechanics	650	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
13	Maintenance Mechanics	460	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
14	Maintenance Mechanics	510	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
15	Maintenance Mechanics	452	<0.282	0.200	0.200	charcoal monitor	NIOSH 1501
16	Maintenance Mechanics	485	<0.036	0.025	0.038	charcoal tube/badge	OSHA Method 7
17	Maintenance Mechanics	455	<0.284	0.201	0.201	charcoal monitor	NIOSH 1501
18	Maintenance Mechanics	540	<0.040	0.029	0.029	charcoal monitor	NIOSH 1501
19	Maintenance Mechanics	442	<0.276	0.195	0.195	charcoal monitor	NIOSH 1501
20	Maintenance Mechanics	503	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
21	Maintenance Mechanics	489	<0.084	0.059	0.059	charcoal badge	NIOSH 1501
22	Maintenance Mechanics	150	0.730	0.730	0.730	charcoal badge	NIOSH 1501
23	Maintenance Mechanics	512	<0.041	0.029	0.029	charcoal monitor	NIOSH 1501
24	Maintenance Mechanics	630	9.900	9.900	9.900	charcoal badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
25	Maintenance Mechanics	480	<0.270	0.191	0.191	charcoal monitor	NIOSH 1501
26	Maintenance Mechanics	480	<0.300	0.212	0.212	charcoal monitor	NIOSH 1501
27	Maintenance Mechanics	450	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
28	Maintenance Mechanics	480	<0.300	0.212	0.212	charcoal monitor	NIOSH 1501
29	Maintenance Mechanics	455	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
30	Maintenance Mechanics	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
31	Maintenance Mechanics	140	<0.008	0.006	0.002	charcoal tube	NIOSH 1501
32	Maintenance Mechanics	500	2.900	2.900	2.900	charcoal badge	NIOSH 1501
33	Maintenance Mechanics	450	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
34	Maintenance Mechanics	440	<0.275	0.194	0.194	charcoal monitor	NIOSH 1501
35	Maintenance Mechanics	460	<0.288	0.203	0.203	charcoal monitor	NIOSH 1501
36	Maintenance Mechanics	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
37	Maintenance Mechanics	460	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
38	Maintenance Mechanics	460	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
39	Maintenance Mechanics	645	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
40	Maintenance Mechanics	485	<0.303	0.214	0.214	charcoal monitor	NIOSH 1501
41	Maintenance Mechanics	630	0.230	0.230	0.230	charcoal badge	NIOSH 1501
42	Maintenance Mechanics	445	<0.278	0.197	0.197	charcoal monitor	NIOSH 1501
43	Maintenance Mechanics	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
44	Maintenance Mechanics	492	<0.297	0.210	0.210	charcoal monitor	NIOSH 1501
45	Maintenance Mechanics	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
46	Maintenance Mechanics	600	<0.007	0.005	0.005	charcoal tube/badge	OSHA Method 7
47	Maintenance Mechanics	535	<0.223	0.158	0.158	charcoal monitor	NIOSH 1501
48	Maintenance Mechanics	150	0.560	0.560	0.560	charcoal badge	NIOSH 1501
49	Maintenance Mechanics	540	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
50	Maintenance Mechanics	545	<0.041	0.029	0.029	charcoal monitor	NIOSH 1501
51	Maintenance Mechanics	655	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
52	Maintenance Mechanics	540	<0.080	0.057	0.057	charcoal badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
53	Maintenance Mechanics	690	0.540	0.540	0.540	charcoal badge	NIOSH 1501
54	Maintenance Mechanics	140	<0.008	0.006	0.002	charcoal tube	NIOSH 1501
55	Maintenance Mechanics	500	0.320	0.320	0.320	charcoal badge	NIOSH 1501
56	Maintenance Mechanics	410	1.800	1.800	1.800	charcoal badge	NIOSH 1501
57	Maintenance Mechanics	630	0.870	0.870	0.870	charcoal badge	NIOSH 1501
58	Maintenance Mechanics	519	<0.324	0.229	0.229	charcoal monitor	NIOSH 1501
59	Maintenance Mechanics	491	<0.083	0.059	0.059	charcoal badge	NIOSH 1501
60	Maintenance Mechanics	510	<0.034	0.024	0.036	charcoal tube/badge	OSHA Method 7
61	Maintenance Mechanics	460	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
62	Maintenance Mechanics	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
63	Maintenance Mechanics	615	0.300	0.300	0.300	charcoal badge	NIOSH 1501
64	Maintenance Mechanics	449	<0.091	0.064	0.064	charcoal badge	NIOSH 1501
65	Maintenance Mechanics	520	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
66	Maintenance Mechanics	481	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
67	Maintenance Mechanics	540	<0.040	0.029	0.029	charcoal monitor	NIOSH 1501
68	Maintenance Mechanics	630	0.150	0.150	0.150	charcoal badge	NIOSH 1501
69	Maintenance Mechanics	450	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
70	Maintenance Mechanics	428	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
71	Maintenance Mechanics	500	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
72	Maintenance Mechanics	460	<0.040	0.028	0.028	charcoal monitor	NIOSH 1501
73	Maintenance Mechanics	550	<0.083	0.059	0.088	charcoal tube/badge	OSHA Method 7
74	Maintenance Mechanics	510	<0.080	0.057	0.057	charcoal badge	NIOSH 1501
75	Maintenance Mechanics	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7
76	Maintenance Mechanics	512	<0.041	0.029	0.029	charcoal monitor	NIOSH 1501
77	Maintenance Mechanics	585	<0.030	0.021	0.032	charcoal tube/badge	OSHA Method 7
78	Maintenance Mechanics	535	<0.223	0.158	0.158	charcoal monitor	NIOSH 1501
79	Maintenance Mechanics	545	<0.041	0.029	0.029	charcoal monitor	NIOSH 1501
80	Maintenance Mechanics	484	<0.302	0.214	0.214	charcoal monitor	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
81	Maintenance Mechanics	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Total number of samples	81	Minimum	0.002 ppm
Number of left-censored samples	68	Maximum	9.90 ppm
Percentage of non-detects	84%	Arithmetic mean	0.30 ppm
		Standard deviation	1.20 ppm

Table A.8. Long-term sampling and analysis of personal exposures to ethylbenzene in equipment cleaners

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	Equipment Cleaners	450	<0.039	0.028	0.041	charcoal tube/badge	OSHA Method 7
2	Equipment Cleaners	720	<0.100	0.071	0.106	charcoal tube	OSHA Method 7
3	Equipment Cleaners	723	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
4	Equipment Cleaners	600	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
5	Equipment Cleaners	720	<0.100	0.071	0.106	charcoal tube	OSHA Method 7
6	Equipment Cleaners	705	<0.060	0.042	0.062	charcoal tube	OSHA Method 7
7	Equipment Cleaners	720	<0.024	0.017	0.025	charcoal tube/badge	OSHA Method 7
8	Equipment Cleaners	586	<0.039	0.028	0.041	charcoal tube/badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
9	Equipment Cleaners	545	<0.032	0.023	0.034	charcoal tube/badge	OSHA Method 7
10	Equipment Cleaners	720	1.200	1.200	1.200	charcoal badge	NIOSH 1501
11	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
12	Equipment Cleaners	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
13	Equipment Cleaners	480	<0.700	0.495	0.742	charcoal tube/badge	OSHA Method 7
14	Equipment Cleaners	550	<0.040	0.028	0.028	charcoal tube/badge	NIOSH 1501
15	Equipment Cleaners	630	0.860	0.860	0.860	charcoal badge	NIOSH 1501
16	Equipment Cleaners	660	<0.060	0.042	0.058	charcoal tube	OSHA Method 7
17	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube	OSHA Method 7
18	Equipment Cleaners	540	<0.033	0.023	0.035	charcoal tube/badge	OSHA Method 7
19	Equipment Cleaners	627	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
20	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
21	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube	OSHA Method 7
22	Equipment Cleaners	630	<0.028	0.020	0.030	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
23	Equipment Cleaners	702	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
24	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
25	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
26	Equipment Cleaners	627	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
27	Equipment Cleaners	546	<0.032	0.023	0.034	charcoal tube/badge	NIOSH 1501
28	Equipment Cleaners	606	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
29	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
30	Equipment Cleaners	609	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
31	Equipment Cleaners	680	<0.060	0.042	0.060	charcoal tube	OSHA Method 7
32	Equipment Cleaners	427	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
33	Equipment Cleaners	615	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
34	Equipment Cleaners	687	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
35	Equipment Cleaners	475	<0.090	0.064	0.095	charcoal tube/badge	OSHA Method 7
36	Equipment Cleaners	690	<0.060	0.042	0.061	charcoal tube	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
37	Equipment Cleaners	685	0.160	0.160	0.160	charcoal badge	NIOSH 1501
38	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
39	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
40	Equipment Cleaners	582	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
41	Equipment Cleaners	645	0.850	0.850	0.850	charcoal badge	NIOSH 1501
42	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
43	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
44	Equipment Cleaners	720	<0.100	0.071	0.106	charcoal tube	OSHA Method 7
45	Equipment Cleaners	615	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
46	Equipment Cleaners	540	<0.033	0.023	0.035	charcoal tube/badge	OSHA Method 7
47	Equipment Cleaners	680	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
48	Equipment Cleaners	545	<0.032	0.023	0.034	charcoal tube/badge	OSHA Method 7
49	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
50	Equipment Cleaners	587	<0.030	0.021	0.032	charcoal tube/badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
51	Equipment Cleaners	587	<0.030	0.021	0.032	charcoal tube/badge	NIOSH 1501
52	Equipment Cleaners	587	<0.030	0.021	0.032	charcoal tube/badge	OSHA Method 7
53	Equipment Cleaners	710	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
54	Equipment Cleaners	404	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
55	Equipment Cleaners	539	<0.033	0.023	0.035	charcoal tube/badge	NIOSH 1501
56	Equipment Cleaners	675	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
57	Equipment Cleaners	664	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
58	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
59	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
60	Equipment Cleaners	660	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
61	Equipment Cleaners	425	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
62	Equipment Cleaners	655	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
63	Equipment Cleaners	588	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
64	Equipment Cleaners	555	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
65	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
66	Equipment Cleaners	585	<0.080	0.057	0.085	charcoal tube/badge	OSHA Method 7
67	Equipment Cleaners	620	0.380	0.380	0.380	charcoal badge	NIOSH 1501
68	Equipment Cleaners	540	<0.033	0.023	0.035	charcoal tube/badge	OSHA Method 7
69	Equipment Cleaners	720	2.000	2.000	2.000	charcoal badge	NIOSH 1501
70	Equipment Cleaners	645	0.210	0.210	0.210	charcoal badge	NIOSH 1501
71	Equipment Cleaners	686	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
72	Equipment Cleaners	615	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
73	Equipment Cleaners	422	<0.010	0.007	0.007	charcoal tube/badge	OSHA Method 7
74	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
75	Equipment Cleaners	690	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
76	Equipment Cleaners	410	0.100	0.100	0.100	charcoal badge	NIOSH 1501
77	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube	OSHA Method 7
78	Equipment Cleaners	645	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
79	Equipment Cleaners	708	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
80	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
81	Equipment Cleaners	524	<0.034	0.024	0.036	charcoal tube/badge	NIOSH 1501
82	Equipment Cleaners	680	0.070	0.070	0.105	charcoal tube/badge	OSHA Method 7
83	Equipment Cleaners	660	<0.060	0.042	0.058	charcoal tube	OSHA Method 7
84	Equipment Cleaners	615	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
85	Equipment Cleaners	665	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
86	Equipment Cleaners	385	<0.100	0.071	0.071	charcoal badge	NIOSH 1501
87	Equipment Cleaners	520	<0.090	0.064	0.095	charcoal tube/badge	OSHA Method 7
88	Equipment Cleaners	581	<0.030	0.021	0.032	charcoal tube/badge	NIOSH 1501
89	Equipment Cleaners	720	<0.024	0.017	0.025	charcoal tube/badge	OSHA Method 7
90	Equipment Cleaners	615	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
91	Equipment Cleaners	697	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
92	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
93	Equipment Cleaners	610	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
94	Equipment Cleaners	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
95	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
96	Equipment Cleaners	600	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
97	Equipment Cleaners	720	<0.024	0.017	0.025	charcoal tube/badge	OSHA Method 7
98	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
99	Equipment Cleaners	690	<0.060	0.042	0.061	charcoal tube	OSHA Method 7
100	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
101	Equipment Cleaners	660	<0.060	0.042	0.058	charcoal tube	OSHA Method 7
102	Equipment Cleaners	510	<0.090	0.064	0.064	charcoal tube/badge	NIOSH 1501
103	Equipment Cleaners	645	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
104	Equipment Cleaners	690	0.590	0.590	0.590	charcoal badge	NIOSH 1501
105	Equipment Cleaners	541	<0.033	0.023	0.035	charcoal tube/badge	NIOSH 1501
106	Equipment Cleaners	670	0.580	0.580	0.870	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
107	Equipment Cleaners	600	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
108	Equipment Cleaners	615	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
109	Equipment Cleaners	690	<0.060	0.042	0.061	charcoal tube	OSHA Method 7
110	Equipment Cleaners	650	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
111	Equipment Cleaners	615	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
112	Equipment Cleaners	630	0.400	0.400	0.400	charcoal badge	NIOSH 1501
113	Equipment Cleaners	360	<0.100	0.071	0.053	charcoal tube	OSHA Method 7
114	Equipment Cleaners	586	<0.030	0.021	0.032	charcoal tube/badge	NIOSH 1501
115	Equipment Cleaners	655	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
116	Equipment Cleaners	686	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
117	Equipment Cleaners	650	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
118	Equipment Cleaners	720	<0.024	0.017	0.025	charcoal tube/badge	OSHA Method 7
119	Equipment Cleaners	703	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
120	Equipment Cleaners	600	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
121	Equipment Cleaners	685	<0.070	0.049	0.074	charcoal tube/badge	OSHA Method 7
122	Equipment Cleaners	540	<0.033	0.023	0.035	charcoal tube/badge	OSHA Method 7
123	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube	OSHA Method 7
124	Equipment Cleaners	620	0.520	0.520	0.520	charcoal badge	NIOSH 1501
125	Equipment Cleaners	600	<0.029	0.021	0.031	charcoal tube/badge	OSHA Method 7
126	Equipment Cleaners	660	<0.070	0.049	0.049	charcoal badge	NIOSH 1501
127	Equipment Cleaners	722	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7
128	Equipment Cleaners	720	<0.060	0.042	0.064	charcoal tube/badge	OSHA Method 7

Total number of samples	128	Minimum	0.007 ppm
Number of left-censored samples	115	Maximum	2.00 ppm
Percentage of non-detects	90%	Arithmetic mean	0.12 ppm
		Standard deviation	0.25 ppm

Table A.9. Long-term sampling and analysis of personal exposures to ethylbenzene in sampling technicians

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	Sampling Technicians	465	0.01	0.010	0.010	charcoal badge	NIOSH 1501
2	Sampling Technicians	500	0.20	0.200	0.208	charcoal badge	NIOSH 1501
3	Sampling Technicians	426	<0.10	0.071	0.071	charcoal tube/badge	OSHA Method 7
4	Sampling Technicians	701	<0.07	0.049	0.074	charcoal tube/badge	OSHA Method 7
5	Sampling Technicians	705	<0.06	0.042	0.064	charcoal tube/badge	OSHA Method 7
6	Sampling Technicians	420	<0.20	0.141	0.141	charcoal tube/badge	OSHA Method 7
7	Sampling Technicians	450	0.34	0.340	0.340	charcoal badge	NIOSH 1501

Total number of samples	7	Minimum	0.010 ppm
Number of left-censored samples	4	Maximum	0.34 ppm
Percentage of non-detects	57%	Arithmetic mean	0.13 ppm
		Standard deviation	0.11 ppm

Table A.10. Long-term sampling and analysis of personal exposures to ethylbenzene in laboratory personnel

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
1	Laboratory Personnel	444	<0.092	0.065	0.065	charcoal badge	NIOSH 1501
2	Laboratory Personnel	413	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
3	Laboratory Personnel	428	<0.268	0.189	0.189	charcoal monitor	NIOSH 1501
4	Laboratory Personnel	470	<0.294	0.208	0.208	charcoal monitor	NIOSH 1501
5	Laboratory Personnel	480	<0.270	0.191	0.191	charcoal monitor	NIOSH 1501
6	Laboratory Personnel	480	<0.050	0.035	0.035	charcoal badge	UCC Method 38C-22T1-BCGb
7	Laboratory Personnel	413	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
8	Laboratory Personnel	414	<0.200	0.141	0.141	charcoal tube/badge	OSHA Method 7
9	Laboratory Personnel	480	<0.040	0.028	0.028	charcoal badge	NIOSH 1501
10	Laboratory Personnel	480	<0.270	0.191	0.191	charcoal monitor	NIOSH 1501
11	Laboratory Personnel	480	0.023	0.023	0.023	charcoal tube/badge	OSHA Method 7
12	Laboratory Personnel	443	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
13	Laboratory Personnel	444	<0.278	0.196	0.196	charcoal monitor	NIOSH 1501
14	Laboratory Personnel	480	<0.009	0.006	0.006	charcoal tube/badge	OSHA Method 7

Sample Number	Job Category	Sample Duration (min)	Reported Sample Conc. (ppm)	Uncensored Sample Conc. (ppm)	8-hr TWA (ppm)	Sampling Method	Analytical Method
15	Laboratory Personnel	274	0.057	0.057	0.057	charcoal monitor	NIOSH 1501
16	Laboratory Personnel	420	<0.262	0.186	0.186	charcoal monitor	NIOSH 1501
17	Laboratory Personnel	480	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
18	Laboratory Personnel	505	<0.090	0.064	0.064	charcoal badge	NIOSH 1501
19	Laboratory Personnel	360	<0.30	0.212	0.212	charcoal monitor	NIOSH 1501
20	Laboratory Personnel	480	<0.30	0.212	0.212	charcoal monitor	NIOSH 1501
21	Laboratory Personnel	350	<0.292	0.206	0.206	charcoal monitor	NIOSH 1501

Total number of samples	21	Minimum	0.006 ppm
Number of left-censored samples	19	Maximum	0.21 ppm
Percentage of non-detects	90%	Arithmetic mean	0.12 ppm
		Standard deviation	0.08 ppm