

XIII. TABLES

TABLE XIII-1

END-USES OF STYRENE

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Polystyrene	Insulation board, loose-fill packaging, disposable dinnerware, food containers, toys, games, hobby kits, housings for room air conditioners and small handheld appliances, television cabinets, shower doors, drain pipes, tubing, light diffusers, audio and video tape cassettes, combs, brushes, eyeglasses, picnic coolers, molded shutters, furniture parts, watering cans, soap dishes, room dividers
Acrylonitrile-Butadiene-Styrene (ABS)	Piping (drain, waste, and vent), conduit, pipefittings, automotive components (instrument panels, consoles, front radiator grilles, headlight housings, etc.), refrigerator doorliners and food compartments, telephones, luggage and cases, toys, hobby kits, shower stalls and bathroom fixtures for mobile homes, margarine tubs, radio chassis
Styrene-Acrylonitrile (SAN)	Drinking tumblers, blender jars and covers, dishes, instrument panel lenses, battery cases
Styrene-Butadiene Latexes	Tufted carpet and upholstery backcoatings, binder for paper coatings, binder for felt base of vinyl floor tile, cement additive, component of latex paints
Other Copolymers	Ion-exchange resins (divinylbenzene-modified polystyrene), paints, paper coatings, and floor polishes (styrene-acrylic copolymer emulsions), footwear and adhesives (styrene block copolymers)
Styrene-Butadiene Rubber (SBR)	Passenger car tires, industrial hoses, conveyer belts, appliance parts, wire and cable insulation, footwear, coated fabrics, car bumpers and weatherstrips, additive in cements and adhesives
Unsaturated Polyester Resins (Reinforced plastics/composites)	Boats, open storage tanks, tub and shower units truck camper tops, recreational vehicles, wall panels

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Adapted from references [23,25,344,345].

TABLE XIII-2

Occupational Styrene Exposures by Worksite or Process  
(Excluding the Reinforced Plastics/Composites Industry)

Worksite or Process	Reference	Year	Samples	Styrene, ppm		Comments
				Range	Average	
Styrene Monomer Production	[56]	'52	6	ND	*	NAM
	[84]	'74	29	0.8-7.8	2.5	
	[75]	'78	60	ND-6.8	0.5	LDL:1 ppb
	[31]	'80	*	<10	*	NAM
SAN Copolymer Production	[93]	'71	*	< 1.2	<1.2	NAM
ABS-SAN Resin Production	[333]	'77	11	ND-3.1	0.7	LDL:10 ppb
Copolymer Production (maleic anhydride)	[84]	'74	6	0.9-2.1	1.5	
Styrene-Butadiene Latex Production	[84]	'74	11	1.0-3.9	2.5	
	[31]	'80	*	4-22	*	NAM
Acrylic Ester-Styrene Copolymer Production	[346]	'82	50	ND-20	0.6	LDL:10 ppb
alpha-Methyl Styrene Production	[347]	'80	14	ND-0.1	0.03	LDL:2 ppb
Polystyrene Production	[56]	'52	2	ND-188*	NAM	
	[94]	'63	*	0.05-2.2	<2.2	NAM
	[93]	'71	*	< 5	<5	NAM
	[84]	'74	13	1.2-18	7.2	
	[32]	'74	*	< 5	<5	
	[333]	'77	11	ND-1.7	0.2	LDL:100 ppb
	[75,77]	'78	70	0.1-47	1.8	
	[31]	'80	*	<10	*	NAM
SBR Production	[348]	'44	*	< 500*	NAM	
	[349]	'68	*	14-31*	NAM	
	[350]	'77	50	0.05-10	0.07	
	[333]	'77	119	ND-3.8	1.3	LDL:20 ppb
	[351]	'78	21	ND-2.3	0.4	LDL:20 ppb
	[352,353]	'81	57	ND-4.4	0.9	LDL:50 ppb
	[352,353]	'81	35	0.04-12	2.0	
	[354]	'82	159	0-65	1.7	CT & PDD
SBR Vulcanization/Curing	[355]	'69	*	0.5-9.4*	NAM	
	[356]	'77	18	0.06-0.18	0.10	

TABLE XIII-2 (CONTINUED)

Occupational Styrene Exposures by Worksite or Process  
(Excluding the Reinforced Plastics/Composites Industry)

Worksite or Process	Reference	Year	Samples	Styrene, ppm		Comments
				Range	Average	
<b>MISC. APPLICATIONS/USES</b>						
<b>Styrene-Polyester Resins</b>						
Surface coatings	[357]	'60	*	200-700	*	NAM
Filter parts (molding)	[102]	'66	*	40-100	*	NAM
Furniture parts (molding)	[358]	'74	5	2-13	8	
Electrical parts (molding)	[159]	'74	2	50-200	125	
Putty (splicing)	[359]	'76	5	2-16	7	15-min. Peaks
Imitation ice cubes (molding)	[360]	'79	5	0.5-3.1	1.1	
Marble bath tubs & vanity tops	[361]	'81	2	15-19	17	
	[361]	'81	9	1.6-60	23	15-min. Peaks
	[361]	'81	1	82	82	5-min. Peaks
Styrene-Acrylic Pump Parts	[362]	'80	32	4-220	40	
Plastic Concrete Pouring (confined space)	[363]	'67	*	25-1000	*	DT & CGM
<b>ABS Fabrication</b>						
Injection Molding (dashboards)	[364]	'76	7	ND	<LD	LDL:20 ppb
Extrusion and Injection Molding	[365]	'78	4	ND	<LD	LDL:4 ppb
Injection Molding (visors)	[366]	'80	10	0.3-0.9	0.5	
Paper Coating	[367]	'75	9	0.7-3.1	1.6	
	[368]	'80	2	ND	<LD	LDL:1 ppm
Glues and Fillers	[369]	'77	5	ND-38	11	LDL:10 ppb
SBR Extrusion (hose)	[370]	'73	24	ND	<LD	LDL:5 ppb
Recording Tape	[371]	'81	13	<1	<1	
Polystyrene Injection Molding	[372]	'81	19	ND	<LD	LDL:2 ppb

Note: Unless specified as "Peaks," exposure levels are time-weighted averages

ND - none detected

\* - not given

NAM - no analysis method given

LDL - lower detection limit in parts per billion (ppb) of styrene

DT & CGM - peak samples measured with detector tubes and a combustible gas meter

CT & PDD - charcoal tubes and passive diffusion dosimeters

Gas chromatography analysis techniques were used unless noted by NAM or DT-CGM.

TABLE XIII-3

Occupational Styrene Exposures in the  
Reinforced Plastics/Composites Industry

Items Fabricated	Reference	Year	Samples	Styrene, ppm		Comments
				Range	Average	
Boats	[373]	'55	*	200-700	*	NAM
	[110]	'63	*	11-736	<209	NAM
	[35]	'72	15	17-292	*	
			*	1500	*	5-10 min. Peak
	[113]	'77	25	1-144	49	
			2	87-102	95	
			41	ND-111	44	LDL:0.1 ppm
	[112]	'77	*	< 1-217	3-44	1 hr.
			*	< 1-402	5-312	1 hr.
			*	< 1-324	3-171	1 hr.
			*	2-384	20-144	1 hr.
	[75]	'78	11	50-300	148	DT
	[374]	'81	23	6-90	39	
			21	4-179	52	
			57	1-399	142	
			19	13-382	71	
			100	2-509	143	
			94	26-745	203	
			19	11-371	133	
			37	10-161	86	
			77	30-466	179	
			70	43-214	86	
			18	64-187	126	
			97	1-226	63	
	[343]	'82	53	7-85	37	GM
			67	10-183	60	GM
			38	18-179	70	GM
		69	30-158	86	GM	
		62	17-154	58	GM	
		116	2-121	28	GM	
		59	15-160	74	GM	
Small parts	[110]	'63	*	3-75	<44	NAM
Big parts			*	4-329	<106	NAM

TABLE XIII-3 (CONTINUED)

Occupational Styrene Exposures in the  
Reinforced Plastics/Composites Industry

Items Fabricated	Reference	Year	Samples	Styrene, ppm		Comments
				Range	Average	
Large parts	[109]	'67	10	6-94	*	POL
Truck parts	[375]	'72	60	0.2-70	9	
Storage Tanks	[376]	'73	71	10-210	*	
Bathroom fixtures	[377]	'73	18	7-188	49	
Tubs and Showers	[104]	'74	32	45-550	183	
Large Containers	[378]	'75	21	7-162	63	
Pipe connectors	[379]	'76	23	2-54	13	
	[380]	'76	24	ND-34	8	LDL:0.2 ppm
	[381]	'76	20	0.2-136	27	
Various items	[382]	'78	*	4-291	56	MED
Moldings, sheets	[75]	'78	9	50-70	*	Peaks, DT
Moldings, mats		'78	9	50-300	129	Peaks, DT
Molds	[383]	'78	1	12	12	
Aircraft parts	[36]	'79	43	6-293	36	
			18	39-1080	368	15-min. Peaks
Instrument cases	[384]	'79	12	9-48	22	
			20	4-200	44	
			9	10-700	*	Peaks, PI
Scrubber component	[385]	'79	24	ND	<LDL	LDL:0.2 ppm
Pump parts	[362]	'80	32	4-200	40	

TABLE XIII-3 (CONTINUED)

Occupational Styrene Exposures in the  
Reinforced Plastics/Composites Industry

Items Fabricated	Reference	Year	Samples	Styrene, ppm		Comments
				Range	Average	
Storage tanks, pumps	[386]	'80	9	15-47	30	
Large pipes	[387]	'81	38	1-29	8	
Storage tanks, hoods, ducts	[388]	'81	12	4-35	13	
Model trucks	[389]	'81	3	ND-3	2	LDL:0.2 ppm

Note: Unless specified as "Peaks," exposure levels are time-weighted averages

\* - not given

ND - none detected

NAM - analytical method not given, otherwise gas chromatographic methods were used

LDL - lower detection limit

DT - detector tubes

POL - polarography used

PI - photoionizer used

GM - geometric mean instead of average

MED - median value instead of average

TABLE XIII-4

Other Substances Found at Worksites Processing, Handling, or Using  
Styrene or Styrene-Containing Materials

Worksite or Process	Substances Found in Measurable Quantities in Air Samples
Styrene Monomer Production	Benzene, ethylbenzene [31,33,56,84]; toluene [33,84]; ethane, ethylene[33]
Polystyrene Production	Ethylbenzene [32]; benzene, toluene, tricalcium phosphate dust, cadmium sulfide dust, pentane [84]; phenylether, diphenylether [32]
SBR Production	Butadiene [333,349,350,351,353,354]; toluene [350,353,354]; 4-vinyl-1-cyclohexene [350,353]; benzene [350,354]; cyclooctadiene [350]; benzene [333]; 4-isopropyl-1-methyl-cyclohexane, methanes, ethylbenzene, dust [353]
SBR Vulcanization/Curing	Toluene, 4-vinyl-1-cyclohexene, ethylbenzene, 1,5-cyclooctadiene, 1,5,9-cyclo-dodecatrienes [356]; butadiene, oil aerosols, formaldehyde, methanol, sulfur dioxide, acrolein, aromatic amines, acrylonitrile, carbon monoxide [355]
Styrene-maleic Anhydride Resin Production	Toluene [84]
Styrene-butadiene Latex Production	Toluene, benzene [84]; ammonia, formaldehyde [31,84]; butadiene, acrylic acid, hydroxyethyl acrylate, sodium pentachlorophenate, silica [31]
SAN Production	Acrylonitrile [93]
ABS Production	Acrylonitrile [333]
Acrylic Ester-Styrene Copolymer Production	Alpha-methyl styrene, methyl methacrylate, ethyl acrylate, n-butyl acrylate, 2-ethylhexyl acrylate [346]

TABLE XIII-4 (CONTINUED)

Other Substances Found at Worksites Processing, Handling, or Using  
Styrene or Styrene-Containing Materials

Worksite or Process	Substances Found in Measurable Quantities in Air Samples
Miscellaneous Plastic Operations/Uses	
SBR extrusion (weatherstrips)	N-butyl acetate, asbestos, acetone, isopropyl acetate, petroleum naphtha, methyl ethyl ketone, carbon monoxide [390]
Styrene-polyester Usage	
molding (furniture parts)	Methylene chloride, petroleum naphtha [358]
molding (ice cubes)	Methyl ethyl ketone peroxide [360]
molding (marble bath tubs)	Acetone, toluene, methyl ethyl ketone, dust [361]
coating (paper)	Petroleum naphtha, toluene, xylene [367]
Styrene-acrylics Molding	Xylene, 1,1,1-trichloroethane [362]
ABS Usage	
injection molding (visors)	Butadiene, methyl ethyl ketone [366]
extrusion & injection molding	Carbon monoxide, hydrogen cyanide, butadiene, benzene, acrolein, dust, acetaldehyde, formaldehyde, aliphatic amines [365]
molding (aircraft parts)	Methylene chloride, methyl ethyl ketone, methanol, dust [36]
injection molding	Butyl-p-cresol, dust, carbon monoxide, formaldehyde [364]
Paper Coating	Formaldehyde [368]
Recording Tape	Methyl-iso-butyl ketone, toluene, 1,1,1-trichloroethane [371]
Combustion Products of Polystyrene (experiment)	Benzaldehyde, styrene oxide, acetophenone, 1-phenylethanol, phenol, formaldehyde, carbon monoxide, allylbenzene, benzene, toluene, ethylbenzene, isopropylbenzene, alpha-methyl styrene, acrylaldehyde [391]



TABLE XIII-4 (CONTINUED)

Other Substances Found at Worksites Processing, Handling, or Using  
Styrene or Styrene-Containing Materials

Worksite or Process	Substances Found in Measurable Quantities in Air Samples
Reinforced Plastics/Composites	Acetone [36,113,375,376,377,378,383,384,388]; methylene chloride [113,375,376,383,386,388]; dust [361,375,383,386,387]; fibrous glass [377,378,386,388]; toluene [113,375,376,389]; methyl ethyl ketone [113,375,383,386]; methyl-iso-butyl ketone [375,389]; silica [379,380]; MDI [104,376]; xylene [113,375]; amines [104]; naphtha, mold release agents [113]; methyl acetate [113]; isopropyl alcohol, n-butyl acetate, cellosolve acetate [375]; TDI [377]; benzene, ethylbenzene [380]; benzoyl peroxide [387]; bisphenol A, diglycidyl ether of bisphenol A [389]; aliphatic hydrocarbons, perchloroethylene [383]; trichloroethylene [36]; methyl ethyl ketone peroxide [384]; styrene oxide [233,269].

TABLE XIII-5

Identification of Major Industries Producing, Using,  
or Handling Styrene

Industry (Use or Product)	SIC Major Group Code*
Construction (painting, concrete finishing)	15,16,17
Textiles (coated fabrics)	22
Wood Products and Furniture (RP/C - mobile home components)	24,25
Paper Products (paper coatings)	26
Chemicals and Allied Products (monomer, resins, paints, adhesives, etc.)	28
Rubber and Plastic Products (tires, molded and extruded items, RP/C - tanks, bathtubs, shower stalls, etc.)	30
Stone, Clay, Glass, and Concrete Products (pressed glass, pipe connectors, marble items)	32
Fabricated Metal Parts (painting)	34
Machinery (painting, molded parts, RP/C - TV cabinets, farm equipment, ventilation ducts, etc.)	35,36
Transportation Equipment (RP/C - boats, ships, parts)	37
Measuring Instruments; Medical Goods (surgical instruments, RP/C - instrument cases)	38
Miscellaneous Manufacturing (sporting goods, costume jewelry, buttons, signs, RP/C - swimming pools)	39
Automotive Repair Shops (RP/C)	75

\*Taken from the Standard Industrial Classification Manual 1972 (U.S. GPO Stock No.041-001-00066-6).

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