1-B. Asbestos Exposure Assessment and Control in Occupational Settings

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Asbestos has been used widely in various industries because of its useful physical and chemical properties such as high flexibility, durability of abrasion and heat resistance. The published literature contains numerous data sets on airborne asbestos concentrations in various occupational settings. In 2007, Williams et al reviewed the published and selected unpublished literature on historical asbestos exposure among skilled craftsmen in various non-shipyard and shipyard settings. In this document, 24 published studies, including recent ones not covered by Williams et al, on asbestos exposure concentration are reviewed and exposure levels commonly encountered in variable situations and conditions in occupational settings are presented according to the industries and worker tasks in the format of tables. In spite of limited detailed information associated with the data sets, data mining through this document and Williams's work shall provide information about asbestos exposure levels of various situations and conditions in occupational settings.

Table 1. Measured airborne asbestos exposure levels of workers in asbestos-containing product manufacturing industries.

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Asbestos mill, India	Asbestos mill in Rajaschan, India	PCM[1)]	Personal/Area	30			2.00-5.09	Ansari et al. 2007
	Asbestos mill in Deogarh, India			25			4.07-15.60	
Thermal insulating board manufacturing, India	Feeding of materials	PCM	Personal	4	0.1087	0.0631	0.0341-0.1681	Bhagia et al. 2010
	Weighing/Slurry making			6	0.0571	0.0255	0.0571-0.0812	
	Pressing			6	0.0656	0.0378	0.0383-0.1220	
	Machine grinding			6	0.0817	0.0437	0.0289-0.1384	
	Hand finishing			6	0.0451	0.0257	0.0189-0.0783	
Cement sheet and pipe manufacturing, Iran	Storage(raw materials and productions)	PCM	Personal	7	0.056	0.01	0.04-0.07	Marioryad et al. 2011
	Feeding of raw materials (milling and mixing)			8	0.131	0.027	0.09-0.17	
	Sheet molding(hacheck, perdorit)			11	0.085	0.025	0.04-0.12	
	Pipe molding			12	0.125	0.021	0.1-0.17	
	Sheet finishing			12	0.168	0.069	0.08-0.3	
	Pipe finishing			13	0.223	0.065	0.14-0.34	
	Recycling (residual mill)			7	0.453	0.06	0.39-0.55	
	Laboratory (physics lab, chemistry lab)			8	0.041	0.014	0.02-0.06	
	Administration (health care clinic, office)			12	0.043	0.015	0.02-0.06	
	Others (kitchen, dining, laundry)			8	0.040	0.011	0.03-0.06	
Slate manufacturing, Korea	Mixing	PCM	Personal	6	0.05(GM)	2.37(GSD)		Oh et al.1993
	Cutting			2	0.04(GM)	1.23(GSD)		
	Pressing			2	0.12(GM)	11.68(GSD)		
Textile manufacturing, Korea, (1987)	Fiberizing and Mixing	PCM	Personal	4	4.5(GM)	3.07(GSD)		Park and Paik. 1988
	Carding			8	3.9(GM)	3.56(GSD)		
	Spinning			11	5.6(GM)	2.16(GSD)		
	Twisting			10	4.8(GM)	2.29(GSD)		
	Winding			7	3.0(GM)	2.37(GSD)		
	Weaving			4	5.3(GM)	1.83(GSD)		
Textile manufacturing, Korea, (1992)	Mixing	PCM	Personal	1	6.10(GM)			Oh et al.1993
	Carding			8	0.91(GM)			
	Spinning			12	0.85(GM)			
	Twisting			14	0.94(GM)			
	Weaving			5	1.33(GM)			

[1)] : Phase contrast microscopy (PCM)-based method

Table 1. (continued)

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Mobile brake lining manufacturing , Iran	Drilling machine	PCM[1)]	Personal	5	0.39	0.06	0.48-0.36	Kakooei et al. 2007
	Reassembling lining from drilling form			5	0.61	0.07	0.65-0.58	
	Both and bottom grinding			5	0.38	0.02	0.43-0.32	
	Cutting			10	0.37	0.08	0.44-0.33	
	Polish machine			10	0.63	0.07	0.68-0.59	
	Bevel			5	0.88	0.06	0.92-0.80	
Automobile brake and clutch manufacturing industry, Iran	Drilling	PCM	Personal	13	0.31(GM)	0.08(GSD)		Kakooei and Marioryad. 2010
	Process baking			6	0.42(GM)	0.08(GSD)		
	Process form			7	0.60(GM)	0.17(GSD)		
	Clutches baking			7	0.43(GM)	0.20(GSD)		
	Bevels			5	0.88(GM)	0.06(GSD)		
	Cutting			10	0.63(GM)	0.07(GSD)		
	Grinding(finishing)			7	0.32(GM)	0.05(GSD)		
Automobile brake lining manufacturing industry, Korea	Weighing/Mixing	PCM	Personal	21	0.15(GM)			Oh et al.1993
	Molding			10	0.14(GM)			
	Drilling			14	0.15(GM)			
	Grinding			28	0.20(GM)			
	Assembling/Packing			19	0.07(GM)			

[1)]: Phase contrast microscopy (PCM) -based method

Table 2. Measured airborne asbestos exposure levels of workers in automobile service industries.

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Automobile brake change	Filing	PCM[1)]	Personal		0.0376			Blake et al. 2003
	Sanding				0.0776			
	Arc grinding1				0.4368			
	Cleaning				0.0146			
	Arc grinding2				0.2005			
	Filing	TEM[2)]	Personal		0.0356			
	Sanding				0.0684			
	Arc grinding1				0.4358			
	Cleaning				0.0048			
	Arc grinding2				0.1734			
Aircraft brake replacement	Brake change	PCM	Personal				<0.011-0.024	Blake et al. 2009
	Brake change using blowout cleaning						<0.001-0.037	
Motor vehicle brake service	Brake replacement(without compressed air)	PCM		16			0.005-0.02	Weir et al. 2001
	Brake replacement(with compressed air)			15			0.05-0.9	
	Arc grinding				0.43			
Motor Brake service	Brake service of 11 vehicles	PCM	Personal	6	0.68			Hickish and Knight. 1970
Heavy equipment brake removal	Brake and bench work(Stockton)	PCM/TEM	Personal	10	0.024	0.016	0.001-0.09	Madl et al. 2009
	Brake and bench work(Big Rock)			1	0.01			
	Clothes handling			2	0.036		0.032-0.039	
Clutch service	Clutch service of 11 vehicles	PCM/TEM	Personal	46	0.047		0.015-0.13	Cohen et al. 2008
Automobile sealants and clutch replacement	Hand scraping of seam sealant	TEM	Personal	7	0.0061			Blake et al. 2008
	Pneumatic chipping of seam sealant			7	0.0059			
	Clutch removal(right shoulder location)			1	Not detected			
	Clutch removal(left shoulder location)			1	Not detected			
	Clutch installation(left shoulder location)			1	0.0027			

[1)] : Phase contrast microscopy-based method
[2)] : Transmission electron microscopy-based method

Table 2. (continued)

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Brake repair of passenger car, Korea	Opening of brake	PCM[1)]	Personal	3	0.06(GM)		0.05-0.08	Shin and Paik. 1989
	Opening and brushing of brake			3	0.07(GM)		0.06-0.18	
	Dry brushing of brake			5	0.27(GM)		0.08-0.62	
	Grinding of brake lining with sand paper			5	0.28(GM)		0.06-0.71	
	Compressed air blowing of dust (no exhaust available)			3	4.26(GM)		0.11-7.28	
	Repair of clutch lining others			5	0.13(GM)		0.04-0.30	
	Others			17	0.05(GM)		0.02-0.11	
Brake repair of truck and bus, Korea	Opening of brake			3	0.03(GM)		0.01-0.06	
	Opening and brushing of brake			7	0.16(GM)		0.01-0.69	
	Dry brushing of brake			7	0.25(GM)		0.10-0.61	
	Grinding of brake lining with sand paper			8	0.46(GM)		0.04-2.51	
	Compressed air blowing of dust (no exhaust available)			2	4.26(GM)		2.58-7.04	
	Opening and assembling of brake			6	0.06(GM)		0.02-0.24	
	Sweeping floor of garage			5	0.03(GM)		<0.01-0.07	
	Others			10	0.06(GM)		0.01-0.17	

[1)] : Phase contrast microscopy-based method

Table 3. Measured airborne asbestos exposure levels of workers gaskets and packaging service industries.

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Installation and removal of gasket	Disassembly and assembly of flanges	PCM[1)]	Personal	9		0.001	0.003-0.006	Mangold et al. 2006
	Gasket activity(hand punching)			5	0.06	0.01		
	Gasket activity(hand operated mechanical punch)			5	0.02	0.02		
	Gasket activity(machine punch)			5	0.11	0.04		
	Gasket activity(hand shaping table with knives, scissors, scribes)			5	0.04	0.02		
	Gasket activity(machine shearing)			5	0.09	0.04		
	Gasket activity(nibbler machine)			5	0.14	0.05		
	Gasket activity(flange opened, no scraping gasket installation)			3	0.03	0.02		
	Gasket activity(flange opened, scraping gasket installing)			3	0.03	0.01		
	Ship flange and gasket removal(onboard ship)			20	0.03	0.021	0.01-0.08	
	Ship flange and gasket removal(on land)			10	0.023	0.013	0.01-0.05	
	Gasket formation, removal and flange face(ball peen hammer)			8	0.005			
	Gasket formation, removal and flange face(hand wire brush)			8	0.07			
	Gasket formation, removal and flange face(power wire brush)			8	0.009			
	Gasket formation, removal and flange face(hand wire brush)	TEM[2)]		8	0.024	0.012	0.012-0.042	
	Gasket formation, removal and flange face(power wire brush)				0.028	0.007	0.021-0.042	
	Removal and replacement of valve packing			8	0.008	0.003	0.002-0.012	

[1)] : Phase contrast microscopy-based method
[2)] : Transmission electron microscopy-based method

Table 3. (continued)

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Gasket removal in chemical industry	Gasket removal with a wetting agent and putty knife	PCM[1)]	Personal	11			0.042-0.242	Spence and Rocchi. 1996
		TEM[2)]		4			0.0007-0.0014	
	Gasket removal(with gaskets difficult to remove)	PCM		10			Not detected - 0.025	
		TEM					Not detected - 0.0037	
Gasket service of automobile		PCM/TEM	Personal	3	0.0026	0.0018	0.0008-0.0044	Blake et al. 2006
Gasket service of a medium duty diesel engine		PCM	Personal/Area	29			<0.011-0.032	Liukonen and Weir. 2005

[1)] : Phase contrast microscopy-based method
[2)] : Transmission electron microscopy-based method

Table 4. Measured airborne asbestos exposure levels of workers in construction industries.

Job task		Analysis method	Sample type	No. of sample	Airborne fiber concentration (fibers/cc)			Reference
					Arithmetic mean	Standard deviation	Range	
Asbestos abatement	Abatement of pipe/boiler in a Crawl space	PCM	Personal	42	0.187		0.005-0.957	Lange et al. 1996
	Abatement of ceiling tile removal in a mini-containment			9	0.022		0.005-0.154	
	Abatement of transite			41	0.077		0.005-0.279	
	Abatement of 10-15% asbestos-containing floor tiles	PCM	Personal	11	0.032	0.020	0.009-0.076	Lange. 2002
	Abatement of 3-5% asbestos-containing floor tiles			14	0.015	0.014	0.006-0.055	
	Abatement of sprayed fireproofing material(dry method)	PCM	Personal	79	16.4(GM)	3.16(GSD)		Paik. 1983
	Abatement of sprayed fireproofing material(wet method)			15	0.5(GM)	2.0(GSD)		
	Abatement of floor tile and mastic(chemical stripping)	PCM	Personal	20	0.0087	0.0072	0.004-0.015	Racine. 2010
	Abatement of floor tile and mastic(wet grinding)			28	0.0124	0.0099	0.007-0.024	
Building maintenance	Asbestos-containing material cleanup	PCM	Personal	9	0.074	0.13	0.012-0.36	Mlynarek et al. 1996
	Bulk sample collection			31	0.034	0.037	0.003-0.17	
	Cable pull			37	0.048	0.041	0.11-0.2	
	Ceiling tile replacement			67	0.35	0.53	0.03-3.5	
	Electrical installation			14	0.037	0.026	0.01-0.11	
	Electrical repair			24	0.02	0.014	0.0034-0.052	
	Fluorescent lamp replacement			78	0.025	0.013	0.0054-0.065	
	HEPA vacuum/wet wiping dust/debris			17	0.098	0.069	0.029-0.3	
	Wet wipe cleaning			25	0.031	0.009	0.0018-0.048	

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