HEALTH RISK EVALUATION OF PCBs FROM JOINT COMPOUND MEASURED ON SURFACES AND IN AIR

L.J. Yost,[1] S. Shock,[1] M. Garry,[1] Y.N. Garson,[2] A.K. Sugino,[3] W.J. Shields[1]

1. Exponent, 15375 SE 30th Place, Suite 250, Bellevue, WA, USA 98007
2. The Boeing Company, P.O. Box 3707, MC 1W-12, Seattle, WA, USA 98124
3. The Boeing Company, P.O. Box 3707, MC 0K-FP, Seattle, WA, USA 98124

Introduction

A human health risk assessment was conducted to evaluate potential exposure to polychlorinated biphenyls (PCBs) from a joint compound used in expansion joints between concrete panels within a 50,900-m^2 outdoor work area. Early in 2000, the joint compound was discovered to contain PCBs at percent-level concentrations. The joint compound is currently being removed under an agreement with the U.S. Environmental Protection Agency (EPA). In a review of the literature, no prior studies were identified relating to migration and human contact with PCBs in joint compound in an outdoor setting. The risk assessment and supporting site characterization were conducted in accordance with EPA guidance[1–8] and approved by EPA. The risk assessment evaluates exposure over the period from the time of the study (2002) until the completion of joint compound removal, which is expected by 2006. The location under consideration included certain portions of the South Complex Flightline (Flightline) at The Boeing Company's (Boeing) Commercial Airplane Group's Everett Plant in Everett, Washington.

The Flightline area is used to finish and test airplanes in production. The area is completely paved, fenced, and guarded, is kept free of any debris, and has no significant plantings or other surface features that would accumulate dust or sediments. Site use is occupational and thus, only worker exposures were evaluated. There are seven work sheds on the area that are used to store tools and other work gear. The Flightline workers spend a majority of their time inside the airplanes with some time spent in the sheds to access their tools and some time on the Flightline when working on the airplane exteriors.

Materials and Methods

Site Characterization: In 2001, sampling was conducted to assess potential worker exposure to PCBs from joint compound. Possible points of contact include surfaces within Flightline work sheds and outdoor surfaces. The sampling locations and the type of sampling required (i.e., surface wipes and air samples) were determined following a thorough review of existing data,[9] an assessment of potential worker exposure routes, and through conversations with Boeing staff. No specific guidance was identified for conducting wipe samples as part of the data collection during risk assessment. Aspects of the EPA sampling methods for site cleanup (40 CFR 761.125 and 40 CFR 761.300–316) were applied where most applicable, including the use of a 100 cm^2 sampling grid and the use of randomly located samples. Sampling methods also took into consideration the location and nature of the source material (i.e., recessed within expansion joints) and the size of the work area. Wipe samples were collected from concrete and/or joint compound surfaces throughout the Flightline area, including within seven work sheds. In addition to wipe sampling, one outdoor and three indoor (work shed) air samples were collected and are evaluated in the risk assessment. A high-volume sampler was used to collect air samples by EPA Method TO-4A. Wipe and air samples were extracted either

by EPA Method 3500B/3540C or Method 3500B/3550B. The extracts were analyzed for PCB Aroclors® by Method 8082 (40 CFR 761.272).

Risk Assessment Methodology: Risk estimates for workers were calculated using EPA methodology to evaluate the following pathways: 1) incidental ingestion of PCBs transferred to hands from surfaces, 2) dermal contact with PCBs on surfaces, and 3) inhalation of PCBs in air from the work area (Table 1). Toxicity values applied are those identified by EPA (Table 2). It was assumed that workers might be exposed to PCBs in air or might contact PCBs on surfaces by touching these surfaces with their hands and subsequently inadvertently ingesting PCBs from their hands or absorbing PCBs through the skin (Table 1). Although data are lacking to estimate hand-to-mouth activity in adults, the estimate of four events per day is consistent with the fact that workers are restricted from eating or smoking on Flightline areas. It was also assumed that 6 percent of the hand surface (i.e., the finger tips) containing PCBs would contribute to PCB exposure through hand-to-mouth contact (i.e., 6 percent of 520 cm^2, or 31 cm^2).[10]

Results and Discussion

Site Characterization: Aroclor® 1254 was detected in only 4 of 93 wipe samples from outdoor areas (detected concentrations ranged from 1.2 to 2.8 $\mu g/100\ cm^2$) and in 5 of 7 shed wipe samples (concentrations ranged from 2.1 to 13 $\mu g/100\ cm^2$). Other Aroclors® were undetected. The wipe sample detection limit was 1 $\mu g/100\ cm^2$. PCB concentrations were primarily below the cleanup criterion of 10 $\mu g/100\ cm^2$ identified in 40 CFR 761.125 (c)(4)(ii), as appropriate for "indoor solid surfaces and high contact outdoor solid surfaces, defined as high contact residential/commercial surfaces."

The four air samples collected all had detectable concentrations of PCBs (i.e., Aroclor® 1254) ranging from 0.014 $\mu g/m^3$ in outdoor air to 0.081 $\mu g/m^3$ in a tool shed. All air concentrations were well below the recommended occupational exposure limit set by the National Institute for Occupational Safety and Health of 1 $\mu g/m^3$ and the Occupational Safety and Health Administration permissible exposure limit of 1,000 $\mu g/m^3$, which must be met in workplace air. The outdoor air concentration measured in one sample from the site was also compared with concentrations typically detected in outdoor air. Although there is uncertainty due to the single sample, the measured site concentration of 0.014 $\mu g/m^3$ is elevated above pristine background concentrations identified in recent reviews, but is consistent with the upper-end background concentrations in urban areas, which have been identified as ranging from 0.001 to 0.014 $\mu g/m^3$.[11] Indoor air PCB concentrations tend to be higher than those in outdoor air.[11] In houses that were distant from a Superfund site and sampled as part of that investigation, indoor air PCB concentrations ranged from 0.0052 to 0.051 $\mu g/m^3$.[11]

Risk Assessment Results: Although there were limited detections at relatively low concentrations, Boeing elected to conduct a risk assessment to ensure full consideration of potential health risks for site workers. Risk estimates were calculated applying conservative assumptions regarding current and future site use. These include the application of the single highest concentration in sheds to represent indoor concentrations and the assumption that exposure will not diminish over the time period while removal is under way. Despite these conservative assumptions, all cancer and noncancer estimates were within the levels typically considered acceptable by EPA (Table 2).

Discussion: Considering the conservative aspects of the assessment, the finding that all cancer and noncancer estimates are within the levels typically considered acceptable by EPA indicates that no

Table 1. Values used for daily intake calculations

Exposure Route	Parameter Definition	Reasonable Maximum Exposure Value
Ingestion		
Parameter Code		
CS	Chemical concentration on surfaces indoors[a]	13 μg/100 cm^2
	Chemical concentration on surfaces outdoors[a]	0.58 μg/100 cm^2
CF	Conversion factor	0.00001 μg/100 cm^2 to mg/cm^2
SA	Surface area of hands exposed (palms)[4,6]	520 cm^2/event
TF	Fraction of surface PCBs transferred to skin[6]	0.25 (unitless)
FH	Fraction of hand contacting mouth[10]	0.06 (unitless)
EV	Daily hand-to-mouth events[10]	4 (unitless)
EF	Exposure frequency[3,4]	250 days/year
ED	Exposure duration (site-specific)	4 years
BW	Body weight[3]	70 kg
AT-C	Averaging time (cancer)[6]	27,375 days
AT-NC	Averaging time (noncancer)[2]	1,460 days
Intake Equation: Chronic Daily Intake (CDI) (mg/kg-day) = $\frac{(CS \times CF \times SA \times TF \times FH \times EV \times EF \times ED)}{(BW \times AT)}$		
Dermal		
Parameter Code		
ABS	Dermal absorption factor for PCBs[1]	0.14 (unitless)
1 – FH	Amount remaining on hand[8]	1 – 0.06 (unitless)
	Remaining definitions same as for ingestion	
Intake Equation: CDI (mg/kg-day) = $\frac{(CS \times CF \times SA \times TF \times ABS \times [1 - FH] \times EV \times EF \times ED)}{(BW \times AT)}$		
Inhalation		
Parameter Code		
C_{air}	Aroclor® 1254 concentration in outdoor air[a]	0.000081 mg/m^3
	Aroclor® 1254 concentration in indoor air (max)[a]	0.000014 mg/m^3
IR_{air}	Inhalation rate for air[b4]	10.4 m^3
FI	Fraction of inhalation occurring at work	1.0 (unitless)
	Remaining definitions same as for ingestion	
Intake Equation: CDI (mg/kg-day) = $\frac{(C_{air} \times IR_{air} \times FI \times EF \times ED)}{(BW \times AT)}$		

[a] Exposure calculated assuming 1 hour indoors and 7 hours outdoors per day.

[b] Calculated for an 8-hour workday, based on hourly rate of 1.3 m^3, which EPA[4] identifies as the mean of slow, moderate, and heavy activities for outdoor workers.

Table 2. Excess cancer risks and hazard estimates for workers

		Cancer Risk Estimates		Noncancer Risk	
Pathway	Concentration of Aroclor® 1254	Carcinogenic Slope Factor (mg/kg-day)$^{-1}$	Excess Cancer Risk	Reference Dose (mg/kg-day)	Hazard Quotient/ Index
Ingestion	2.1 μg/100 cm^2	2	7×10^{-7}	0.00005	0.13
Dermal	2.1 μg/100 cm^2	2	2×10^{-6}	0.00005	0.29
Inhalation	0.000022 mg/m^3	2	2×10^{-7}	0.00005	0.024
		Total Cancer Risk:	**2×10^{-6}**	**Total Hazard Index:**	**0.44**

adverse effects would be expected. Moreover, site concentrations can also be considered in light of the 10 μg/100 cm^2 cleanup criterion for high-contact residential/commercial surfaces (40 CFR 761.725 (c)(4)(ii)), which was met in all but one of the 100 Flightline samples. In addition, air sample results were similar to their respective outdoor and indoor air background concentrations. Thus, any risks related to PCB inhalation exposure from remaining joint compound on the Flightline would not be expected to be substantially different from those in background locations. Uncertainties in the exposure assessment of wipe sample data would be reduced by additional research in hand-to-mouth activity in adults and by additional analyses of the degree of transfer of PCBs from surfaces.

Acknowledgements
We would like to acknowledge Mark Molinari and Karen Mixon at URS, Dan Duncan at EPA Region 10, and technical reviewers from Versar for their assistance on the site characterization and review of the risk assessment. We would also like to acknowledge Monica Perri at Exponent for editorial support.

References

1. U.S. EPA. 1996. PCBs: Cancer dose-response assessment and application to environmental mixtures. EPA/600/P-96/001F. U.S. Environmental Protection Agency, Office of Research and Development, National Center for Environmental Assessment, Washington, DC.
2. U.S. EPA. 1989. Risk assessment guidance for Superfund. Volume 1: Human health evaluation manual (Part A). Interim Final Report. EPA/540/1-89/002. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
3. U.S. EPA. 1991. Risk assessment guidance for Superfund. Volume I: Human health evaluation manual supplemental guidance. Standard default exposure factors. Interim Final. OSWER Directive 9285.6-03. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
4. U.S. EPA. 1997. Exposure factors handbook. EPA/600/P-95/002F. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.
5. U.S. EPA. 1999. Risk assessment guidance for Superfund supplemental guidance: Dermal risk assessment. Interim Guidance (Internal Draft). U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
6. U.S. EPA. 2000. Interim draft PCB risk assessment review guidance document. U.S. Environmental Protection Agency, Office of Pollution Prevention and Toxics. Prepared by Versar, Springfield, VA.
7. U.S. EPA. 2001. Risk assessment guidance for Superfund. Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). EPA/540/R/99/055. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, DC.
8. U.S. EPA. 2002. Comments from EPA on December 2001 HHRA for Boeing Everett Flightline. U.S. Environmental Protection Agency.
9. URS. 2001. Draft remedial investigation report. Revision 1.0, BCAG Everett Plant, Everett, Washington. Prepared for The Boeing Commercial Airplane Group. URS Corporation.
10. Tetra Tech NUS. 2000. Risk assessment of polychlorinated biphenyls (PCBs) at Naval Air Warfare Center, Indianapolis, Indiana. Tetra Tech NUS, Inc., Pittsburgh, PA.
11. ATSDR. 2000. Toxicological profile for polychlorinated biphenyls. U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.