Appendix H

Health Risk Assessment Methodology for Emissions from Cruise Ship Onboard Incineration

Appendix H

Health Risk Assessment Methodology for Emissions from Cruise Ship Onboard Incineration

A. Introduction

This appendix presents the methodology used to estimate the potential multipathway cancer and noncancer health impacts from exposure to cruise ship onboard incineration emissions, as discussed in Chapter V. The assumptions used to determine these potential health risks are based on a modeling scenario for incineration from cruise ships traveling in and out of both the Port of Los Angeles and the Port of Long Beach (combined). These ports were selected because they have the highest amount of port traffic (from cruise ships) in the State. The next largest port (Port of San Diego) has approximately 50 percent the traffic of the Ports of Los Angeles and Long Beach. Emissions, source release parameters, and modeling inputs are discussed in the sections which follow.

B. Emission Estimates and Source Layout

Emissions data from land-based municipal waste incinerators were used to estimate emissions for cruise ship onboard incinerators because staff was not able to locate any emissions testing for actual cruise ship incinerators. However, as discussed in Chapter V, land-based municipal waste incinerators typically incinerate general household waste and have some similar waste streams to cruise ships, including food waste, packaging, paper and cardboard items, general light plastic waste, rags, etc. Table H-1 shows the emission rates applied to cruise ship onboard incineration for this assessment.

Table H-1. Pollutant Emissions Rates

Pollutant	Controlled (lb/hr)	Uncontrolled (lb/hr)
Hydrochloric Acid (HCl)	3.65	365
Arsenic	3.92E-04	3.92E-02
Beryllium	6.99E-06	6.99E-04
Chromium	3.88E-05	3.88E-03
Lead	7.79E-04	7.79E-02
Cadmium	2.55E-05	2.55E-03
Manganese	5.23E-04	5.23E-02
Nickel	2.22E-04	2.22E-02
Mercury	1.50E-02	1.50E+00
Naphthalene	4.36E-05	4.36E-03
Total Polycyclic Aromatic Hydrocarbons (treated as Benzo(A)pyrene for HRA)	4.02E-07	4.02E-05

Data from the Cruise Ship Onboard Incinerator Survey (Survey) indicated that onboard incinerators are both controlled and uncontrolled, depending on the individual cruise ship, whereas the available data for land-based incinerators were all controlled. In order to account for this, we increased the controlled emission rates from land-based incinerators by 99 percent in order to provide an estimate for uncontrolled cruise ship emission rates. This adjustment is based on a 99 percent control efficiency of the air pollution control equipment typically used in conjunction with incineration (see Chapter IV).

ARB staff estimated that about ten percent of the port calls (visits) in 2004 were by cruise ships with a control efficiency similar to the municipal waste incinerators. Another 30 percent had some type of control device but most likely were not controlled to the efficiency of the municipal waste incinerators. Therefore, for this analysis we assumed ten percent of the port calls were made by ships with a 99 percent control efficiency and the rest were uncontrolled.

For this health risk assessment (HRA), staff evaluated the potential health impacts at the Port of Los Angeles and the Port of Long Beach (Ports). We adjusted emissions by using the annual number of port calls at the Ports since they are in close proximity to each other and the combination of both ports could cumulatively impact the potential health impacts for workers at the Ports or residents living near the Ports. Staff chose these Ports for the HRA since they are the most highly visited by the cruise ships in California. Due to a significantly lower number of port calls at other ports throughout California, it is not expected that the potential health impacts at other ports would be higher than what is seen at the Ports of Los Angeles and Long Beach. As shown in Table H-2, calls to the Ports accounted for 55 percent of total port calls statewide in 2004.

Table H-2. Cruise Ship Port Calls to California Ports[1]

Port Name	Number of Port Calls	Percent of Port Calls[2]
Los Angeles & Long Beach	361	55
San Diego	179	27
San Francisco	76	12
All Others (Avalon/Catalina, Monterey, Oakland, Port Hueneme, Humboldt, Santa Barbara)	36	6
Total	652	-

1. Source: CSLC, 2004. Port calls to Los Angeles and Long Beach are reported as a total and are not separated out.
2. Values have been rounded.

Emissions were spread across the most heavily traveled southern shipping lane of the Ports, which handles the vast majority of cruise ship traffic. The incineration of materials was assumed to be taking place from the Three Nautical Mile Line, as specified on the National Oceanic and Atmospheric Administration (NOAA) Nautical Charts, to 30 miles out at sea. ARB staff placed the ships at 21 locations between the 3 and 30-mile marks on this shipping lane; assuming the emissions are spread evenly at each emission point. The incineration time in this 27-mile zone was estimated to be approximately 1.5 hours in each direction, traveling inbound and outbound from the Three Nautical Mile Line.

C. Air Dispersion Modeling

The model that was used during this HRA was Hot Spots Analysis and Reporting Program (HARP) (ARB, 2005b). HARP includes an air dispersion model, ISCST3. U.S. EPA recommends the ISCST3 model for refined air dispersion modeling (U.S. EPA, 1995). HARP is a recommended tool for risk analysis in California and can be used for most source types (e.g., point, area, and volume sources) and is currently used by the ARB, districts, and other states.

Cruise ship operators provided ARB staff with information on incinerator design and information such as stack height, diameter, temperature, and flow rates. This data was used in the air dispersion modeling analysis to estimate downwind concentrations. The meteorological data used for this air dispersion modeling scenario is Wilmington 2001. Wilmington meteorological data was used because it is the closest available data to the Ports. Table H-3 summarizes the modeling parameters used for this analysis.

Table H-3. Modeling Parameters

Parameter	Value
Model	ISCST (Version 99155)
Emission Rates	Source Test Data
Operating Hours	3 hours per port call, 379 port calls per year for a total of 1137 hours
Source Type	Series of point sources distributed in shipping channel (21 discrete locations at 3, 5, 7, 9, 11 13, 15, 17, 19, 21, 24, and 30 miles)
Dispersion Setting	Rural
Receptor Height	1.5 meters
Stack Diameter	12 inches
Stack Height	50 meters
Stack Temperature	300 and 600 degrees Fahrenheit
Stack Exit velocity	4200 feet/minute
Time Emissions Emitted	All hours
Meteorological Data	Wilmington 2001

D. Pollutant-Specific Health Values

Dose-response or pollutant-specific health effects values are developed to characterize the relationship between a person's exposure to a pollutant and the incidence or occurrence of an adverse health effect. A cancer potency factor (CPF) is used when estimating potential cancer risks and reference exposure levels (RELs) are used to assess potential non-cancer health impacts.

As presented in Appendix F, exposure to TACs may result in both cancer and non-cancer health effects. The inhalation and oral CPFs and non-cancer acute and chronic RELs that are used for this HRA are listed in Table H-4 (at the end of this appendix). Also included in Table H-4 are the non-cancer acute and chronic toxicological endpoints for the pollutants. Table H-4 reflects the most current OEHHA-adopted health effects values for these compounds.

E. Risk Assessment

ARB staff conducted a multipathway HRA to evaluate cancer and noncancer health impacts remaining after implementation of the proposed airborne toxic control measure (ATCM). Pathways included for evaluation include inhalation, dermal, ingestion of soil, and mother's (breast) milk. These are the minimum pathways that should be evaluated when assessing compounds with multipathway effects. The risk assessment was completed using the Tier 1 multipathway methodology outlined in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments, August 2003* (OEHHA Guidelines) (OEHHA, 2003). In conjunction with the OEHHA Guidelines, staff also followed the ARB's *Recommended Interim Risk Management Policy For Inhalation-Based Residential Cancer Risk* (ARB, 2003).

As noted in Chapter V, the cruise ship industry estimates a 25 percent increase in the number of vessels that will operate in the waters of the State over the next ten years (CSETF, 2003). Based on this, staff assumed a 25 percent increase in the number of Port calls until 2015. Noncancer chronic and acute health impacts for both residents and off-site workers are also considered. These values are reported as hazard indices. In general, hazard indices less than one are not a concern to public health. Lead, one of the pollutants of concern, was evaluated by comparing the modeled 30-day concentration to the lead levels found in ARB's *Risk Management Guidelines for New, Modified, and Existing Sources of Lead* (ARB, 2001). The results of this risk assessment are presented in Chapter V, Section C.

Table H-4. Pollutant-Specific Health Values Used for Determining Potential Health Impacts[1]

Chemical	Cancer Risk		Non-Cancer Effects					
	Inhalation[❢] Cancer Potency Factor $(mg/kg\text{-}d)^{-1}$	Oral Slope Factor $(mg/kg\text{-}d)^{-1}$	Acute Inhalation ($\mu g/m^3$)	Acute Target Organs	Chronic Inhalation ($\mu g/m^3$)	Chronic Inhalation Target Organs	Chronic Oral (mg/kg/d)	Chronic Oral Target Organs
Arsenic (Inorganic)	1.2E+01	1.5E+00	1.9E-01 AveP	Developmental, Reproductive	3.0E-02	Cardiovascular, Developmental, Nervous	3.0E-04	Cardiovascular, Skin
Beryllium	8.4E+00				7.0E-03	Immune, Respiratory	2.0E-03	Alimentary
Cadmium	1.5E+01				2.0E-02	Kidney, Respiratory	5.0E-04	Kidney
Chromium (Treated as five percent hexavalent chromium for HRA)	5.1E+02				2.0E-01	Respiratory	2.0E-02	Hematologic
Hydrochloric Acid (Hydrogen chloride)			2.1E+03	Eye, Respiratory	9.0E+00	Respiratory		
Lead (inorganic)	4.2E-02	8.5E-03						
Manganese					2.0E-01	Nervous		
Mercury (Inorganic)			1.8E+00	Developmental, Reproductive	9.0E-02	Nervous	3.0E-04	Immune, Kidney
Nickel	9.1E-01		6.0E+00	Immune, Respiratory	5.0E-02	Hematologic, Respiratory	5.0E-02	Alimentary
Polychlorinated Dibenzo-p-Dioxins (PCDD) (Treated as 2,3,7,8-TCDD for HRA)[2]	1.3E+05	1.3E+05			4.0E-05	Alimentary, Developmental; Endocrine; Hematologic, Reproductive, Respiratory	1.0E-08	Alimentary, Developmental; Endocrine; Hematologic, Reproductive, Respiratory
Polychlorinated Dibenzofurans (PCDF) (Treated as 2,3,7,8-Tetrachlorodibenzo-p-Dioxin for HRA)[2]	1.3E+05	1.3E+05			4.0E-05	Alimentary, Developmental; Endocrine; Hematologic, Reproductive, Respiratory	1.0E-08	Alimentary, Developmental; Endocrine; Hematologic, Reproductive, Respiratory
Polycyclic Aromatic Hydrocarbon (PAH) (Treated as Benzo(a)Pyrene for HRA)	3.9E+00	1.2E+01						

Footnotes: see next page.

Footnotes for Table H-4:

1. Health effect values were obtained from:

    a. The OEHHA Air Toxics "Hot Spots" Program Risk Assessment Guidelines, Part I, The Determination of Acute RELs for Airborne Toxicants, March 1999;

    b. The OEHHA Air Toxics "Hot Spots" Program Risk Assessment Guidelines, Part II, Technical Support Document for Describing Available Cancer Potency Factors (Revised), December 2002;

    c. The Air Toxics Hot Spots Program Risk Assessment Guidelines; Part III; Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels, April 2000; and

    d. The Air Toxics Hot Spots Risk Assessment Guidelines; Part IV; Exposure Assessment and Stochastic Analysis Technical Support Document, September 2000.

2. Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans (also referred to as chlorinated dioxins and dibenzofurans): OEHHA has adopted the World Health Organization 1997 (WHO-$_{97}$) Toxicity Equivalency Factor scheme for evaluating the cancer risk due to exposure to samples containing mixtures of polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) and determining cancer risks for a number of specific PCB congeners. See Appendix A of OEHHA's *Technical Support Document For Describing Available Cancer Potency Factors* for more information about the scheme. See Appendix E of OEHHA's *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* for the methodology for calculating 2,3,7,8-equivalents for PCDDs, PCDFs and a number of specific PCB congeners. See section 8.2.3 of OEHHA's *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* for conducting health risks when total (unspeciated) chlorinated dioxins and furans are reported.

AveP. Polychlorinated Dibenzo-*p*-dioxins and Polychlorinated Dibenzofurans (also referred to as chlorinated dioxins and dibenzofurans): OEHHA has adopted the World Health Organization 1997 (WHO-$_{97}$) Toxicity Equivalency Factor scheme for evaluating the cancer risk due to exposure to samples containing mixtures of polychlorinated dibenzo-*p*-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) and determining cancer risks for a number of specific PCB congeners. See Appendix A of OEHHA's *Technical Support Document For Describing Available Cancer Potency Factors* for more information about the scheme. See Appendix E of OEHHA's *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* for the methodology for calculating 2,3,7,8-equivalents for PCDD, PCDFs and a number of specific PCB congeners. See section 8.2.3 of OEHHA's *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* for conducting health risks when total (unspeciated) chlorinated dioxins and furans are reported.

REFERENCES FOR APPENDIX H

ARB, 2001. Risk Management Guidelines for New, Modified, and Existing Sources of Lead. California Air Resources Board. March 2001.

ARB, 2003. Recommended Interim Risk Management Policy For Inhalation-Based Residential Cancer Risk. California Air Resources Board. October 2003.

ARB, 2005b. Hot Spots Analysis and Reporting Program, version 1.2A. California Air Resources Board. September 2003.

CSETF, 2003. Cruise Ship Environmental Task Force. Report to the Legislature, Regulation of Large Passenger Vessels in California. August 2003.

OEHHA, 1999a. The Air Toxics Hot Spots Program Risk Assessment Guidelines; Part I; The Determination of Acute Reference Exposure Levels for Airborne Toxicants, Office of Environmental Health Hazard Assessment. March 1999.

OEHHA, 2000a. The Air Toxics Hot Spots Program Risk Assessment Guidelines; Part III; Technical Support Document for the Determination of Noncancer Chronic Reference Exposure Levels, Office of Environmental Health Hazard Assessment. Office of Environmental Health Hazard Assessment. April 2000. Including memos and chemical summaries from January 2001 and December 2001.

OEHHA, 2000b. The Air Toxics Hot Spots Risk Assessment Guidelines; Part IV; Exposure Assessment and Stochastic Analysis Technical Support Document. Office of Environmental Health Hazard Assessment. September 2000.

OEHHA, 2002. Part II, Technical Support Document for Describing Available Cancer Potency Factors (Revised). Office of Environmental Health Hazard Assessment. December 2002.

OEHHA, 2003. The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments. Office of Environmental Health Hazard Assessment. August 2003.

OEHHA, 2005. Chemicals Known To The State To Cause Cancer Or Reproductive Toxicity, August 19, 2005. Office of Environmental Health Hazard Assessment. Printed on August 24, 2005, from OEHHA website *www.oehha.ca.gov/prop65/prop65_list/Newlist.html*.

SCEC, 2004. Source Test Report – Monterey Pacific Power Corporation. SCEC. February 2004.

U.S. EPA, 1995. ISCST3 Model User's Guide, EPA-454/B-95-003a. United States Environmental Protection Agency (U.S. EPA). Research Triangle Park, North Carolina. September 1995.