The Soap and Detergent Association
Washington, D.C.

Calculation of Component Chemical Air Emission Factors for:

- **Hand Dishwashing Detergents**
- **Liquid Laundry Detergent**
- **Liquid Fabric Softener**

Executive Summary

August 2007

Prepared by

Thomas R. Card
Environmental Management Consulting
41125 278th Way SE, Enumclaw, WA 98022 USA
360-802-5540 trcard@earthlink.net

Introduction

This document summarizes two companion documents. The first document provides estimates of selected consumer product component air emission factors at point-of-use. The second document provides estimates for air emissions for these products when they leave the household down the drain to a central wastewater treatment facility.

The documents provide an estimate of emissions of seven compounds found in consumer products. These products contain these compounds of interest: isopropyl alcohol, ethanol, methanol, ethylene glycol monobutyl ether, propylene glycol, dipropylene glycol methyl ether, and monoethanolamine. The emission estimates presented were prepared in a systematic and scientific manner using EPA and CARB methodologies. All methodologies provide conservative estimates (overestimation) and should be considered worst case system emissions. The results presented in this report are intended for use in developing regional air emission inventories to establish regulatory priorities.

Summary

Tables 1 through 3 present the emission factor data for liquid hand dishwashing detergent, liquid laundry detergent, and liquid, rinse-added fabric softener, respectively. These tables present the component chemical compounds in the products ranked by emissions potential (highest percentage emitters to lowest percentage emitters).

Point-of-use emissions were calculated using the methodologies described in EPA 600/R-00/096. The methodology consists of a computer fate model based on specific household activities. Estimates were both for a typical use and high emitting scenarios. For the high emitting scenarios, the temperatures were quite high (55 ^{o}C). EPA methodology for estimating high temperature Henry's Law Coefficients was found to be significantly underestimating. Therefore, a more sophisticated estimation method was used for the compounds that had data available.

Wastewater collection system emissions were estimated using a conservative equilibrium approach based on a prototype collection system developed by CARB. The CARB report developed a more refined approach for collection system emissions than was used in this report and produced the SUDS (Sewer Uniform reach with Drop Solutions) computer collection system fate model. Unfortunately, the computational techniques used in SUDS only allowed for the successful calculation of emission factors for highly volatile compounds. The program was numerically unstable and could not calculate emissions for the low volatility compounds that are the subject of this report. Therefore, the more conservative and computationally simple equilibrium approach was used. Based on the CARB report, and calculations on chloroform using the equilibrium model, the equilibrium model appears to overestimate emissions by a factor of three. Therefore, we can consider the use of the equilibrium model to represent a 'worst case' emissions scenario.

Wastewater treatment plan emissions were estimated based on a methodology developed by CH2M HILL in 1994 using data and equations from EPA-453/R-94-080A. This methodology was repeated as originally reported, but with the exception that CARB Henry's Law data was used for the current effort.

In conclusion, the quality of these factors is summarized below:

Point of Use Emission Factors

These factors have been calibrated against laboratory data and represent very high data quality and subsequent very high accuracy.

Wastewater Collection System Emission Factors

Due to the complex nature of collection systems these factors have been very conservatively estimated by assuming that the gas phase is always in equilibrium with the liquid phase. This approach was found to over estimate chloroform emissions by a factor of 3.

Wastewater Treatment System Emission Factors

These factors were estimated using a conventional fate modeling approach. This approach normally overestimates emissions by about factor of 1.5 (50% higher than actual emissions).

Total System Emission Factors

The component emission factors are not additive because they are based on the amount that enters the process. To calculate the total system emissions, the downstream emission factor (i.e., during wastewater collection and treatment) must be adjusted for the upstream losses (i.e., during consumer use). Therefore, to calculate total system emissions the following formula is used:

$$TEF = PEF + (1\text{-}PEF)*WEF$$

Where *TEF* is the total emission factor, *PEF* if the point of use emission factor (percent of total compound used by consumers that is emitted to the atmosphere during consumer use), and *WEF* is the wastewater treatment emission factor (percent of total compound used by consumers that is discharged to the drain which is emitted to the atmosphere).

Thus, the total system emission factors are the fraction emitted to the atmosphere as a percentage of the total mass used by the consumer.

Table 1. - Summary of Calculated Emission Factors for Liquid Hand Dishwashing Detergent Component Compounds.

Liquid Hand Dishwashing Detergent Component Compound	Point of Use Emissions		Wastewater Collection and Treatment Emissions	Total System Emisions (percent of total compound used by consumers that is emitted to atmosphere)	
	Typical Use Condition	High Release Condition		Typical Use Condition	High Release Condition
Ethanol	3.92%	6.05%	1.21%	5.09%	7.19%
Methanol	1.89%	2.62%	1.23%	3.10%	3.82%
Propylene glycol	0.419%	0.721%	0.097%	0.516%	0.817%
Monoethanolamine	0.0194%	0.0328%	0.0047%	0.0241%	0.0375%

Table 2. - Summary of Calculated Emission Factors for Liquid Laundry Detergent Component Compounds.

Liquid Laundry Detergent Component Compound	Point of Use Emissions		Wastewater Collection and Treatment Emissions	Total System Emissions (percent of total compound used by consumers that is emitted to atmosphere)	
	Typical Use Condition	High Release Condition		Typical Use Condition	High Release Condition
Isopropanol	0.24%	1.74%	2.27%	2.51%	3.97%
Ethanol	0.19%	1.19%	1.21%	1.41%	2.39%
Methanol	0.14%	0.72%	1.23%	1.369%	1.943%
Ethylene glycol monobutyl ether	0.041%	0.286%	0.15%	0.190%	0.435%
Propylene glycol	0.013%	0.126%	0.097%	0.110%	0.223%
Dipropylene glycol methyl ether	0.0021%	0.0112%	0.0089%	0.0110%	0.0201%
Monoethanolamine	0.0011%	0.0090%	0.0047%	0.0059%	0.0137%

Table 3. - Summary of Calculated Emission Factors for Washing Machine Rinse-added, Liquid Fabric Softener Component Compounds.

Fabric Softener Component Compound	Point of Use Emissions		Wastewater Collection and Treatment Emissions	Total System Emissions (percent of total compound used by consumers that is emitted to atmosphere)	
	Typical Use Condition	High Release Condition		Typical Use Condition	High Release Condition
Isopropanol	0.09%	0.21%	2.27%	2.36%	2.47%
Ethanol	0.08%	0.17%	1.21%	1.29%	1.38%