

Alkylphenols & Ethoxylates Research Council
Comments for Washington Ecology on APEs
December 19, 2019
ATTACHMENT I
TABLES IA and IB
Laundry Worker Exposure and Margin of Exposure

While the exposure estimates developed in an EPA Engineering Report are useful to demonstrate low exposures to NPE in laundry detergent, they are extremely conservative and can be further refined using other available data and models.¹ The Alkylphenols & Ethoxylates Research Council (APERC) conducted exposure screening assessments to calculate potential exposure of industrial laundry workers to NPE. They are based on multiple, conservative assumptions regarding exposure and therefore represent an upper bound estimate of laundry worker occupational exposure - not actual exposure.

Table IA.			
Calculated Upper-Bound Laundry Worker Inhalation Exposure to NPE9 from Respirable Dust in Granular Laundry Detergent			
	Value	Units	
			Basis
Exposure scenario	Double pouring granular detergent. No personal protection equipment		Hendricks (1970)
Dust exposure factor	0.27	µg	Hendricks (1970) measured 0.27 µg exposure per 0.2 kg handled

¹ US EPA. (2007, July 18). Draft: Engineering report of nonylphenol (NP) and nonylphenol ethoxylates (NPEs) in response to section 21 petition

**Table IA.
Calculated Upper-Bound Laundry Worker Inhalation Exposure to NPE9 from Respirable Dust in Granular Laundry Detergent**

	Value	Units	Basis
Exposure scenario	Double pouring granular detergent. No personal protection equipment		Hendricks (1970)
NPE percentage in detergent	28%	%	EPA (2007) assumes powdered detergents used in smaller laundries formulated similar to consumer detergents
Respirable dust fraction in granular laundry detergent	0.2%	%	Hendricks (1970)
Detergent handled daily	154	kg	EPA (2007) Assumes one worker handles all detergent for site in 8 hour shift
Inhalation dose	0.116	µg/day	Calculated
Convert units	1.2E-04	mg/day	Calculated. Inhalation Dose/1000
Body weight	71.8	kg	EPA (1999) Table 7-2. Mean body weight (males and females age 18<75)
Estimated daily dose	1.6E-06	mg/kg-bw/day	Calculated

**Table IA.
Calculated Upper-Bound Laundry Worker Inhalation Exposure to NPE9 from Respirable Dust in Granular
Laundry Detergent**

	Value	Units	Basis
Exposure scenario	Double pouring granular detergent. No personal protection equipment		Hendricks (1970)
No Observed Effect Level (NOEL) for NPE9	50	mg/kg/day	EPA (2006, July 31)
Margin of Exposure (MOE)	30,835,567	none	Calculated MOE = NOEL ÷ Est. Daily Dose (inhalation)

**Table IB.
Calculated Upper-Bound Laundry Worker Dermal Exposure to NPE9
from Laundry Detergents (Liquid and Granular)**

	A*	B*	C	D	Units	Basis
Exposure scenario	Single layer clothing, no gloves	Single layer clothing, no gloves	Single layer clothing, using gloves	Single layer clothing, using gloves		EPA PHED (1998)
	Granular, open loading and washing	Liquid, open loading and washing	Liquids, open loading and washing	Liquids, closed loading and washing		EPA PHED (1998).
Dermal unit exposure value	0.0084	2.9	0.023	0.0086	mg NPE / lb detergent handled	Derived from EPA PHED (1998) active ingredient exposure based on lbs handled
NPE fraction of detergent	28%	100%	100%	100%	fraction	EPA (2007) 28% for powder and 100% for liquid.
Detergent handled daily by one worker in 8 hour shift	154	154	154	154	kg	
NPE handled daily	95.1	339.6	339.6	339.6	lb	Calculated
External dermal dose	0.80	984.75	7.81	2.92	mg/day	Calculated
Relative dermal absorption	1%	1%	1%	1%	%	Monteiro-Riviere et al., 2000

Table IB.						
Calculated Upper-Bound Laundry Worker Dermal Exposure to NPE9 from Laundry Detergents (Liquid and Granular)						
	A*	B*	C	D	Units	Basis
Exposure scenario	Single layer clothing, no gloves	Single layer clothing, no gloves	Single layer clothing, using gloves	Single layer clothing, using gloves		EPA PHED (1998)
	Granular, open loading and washing	Liquid, open loading and washing	Liquids, open loading and washing	Liquids, closed loading and washing		EPA PHED (1998).
Dermal dose	0.008	9.848	0.078	0.029	mg/day	Calculated
Mean body weight	71.8	71.8	71.8	71.8	kg	EPA (1999) Table 7-2. Mean body weight (males and females age 18<75)
Absorbed dose	1.11E-04	1.37E-01	1.09E-03	4.07E-04	mg/kg/day	Calculated
NOEL for NPE9	50	50	50	50	mg/kg/day	EPA (2006, July 31)
MOE	449,498	365	45,966	122,932	none	Calculated

* Note EPA PHED (1998) did not have an exposure estimate value for a scenario for loading powders or liquids with single layer clothing and no gloves with closed loading and mixing or washing. Scenarios A and B are provided as a worst case alternatives.

Discussion

While the exposure estimates developed in an EPA Engineering Report are useful to demonstrate low exposures to NPE in laundry detergent, they are extremely conservative and can be further refined using other available data and models.²

1. Refinements to respiratory exposure to NPE and MOE for powdered laundry detergent

EPA relies on the OSHA Particulate Not Otherwise Regulated (PNOR) Permissible Exposure Limit (PEL) for nuisance dust (15 mg/m³) to calculate inhalation exposure to NPE. Another approach is to consider data regarding the actual characteristics of dust in granular laundry detergent.

Assumptions regarding the inhalation exposure of NPE from granular detergents can be refined based on data presented in a paper by Hendricks, 1970, which examined dust levels and characteristics in powdered laundry detergents.³ While the focus of this paper was on enzyme exposure, it provides the following useful data regarding the characteristics of dust in laundry detergent. First, on average 0.27 µg detergent dust exposure per cup of product was found for double-pour machine loading with powdered detergent. “Double-pour” indicates pouring from a large container to a measuring container and then pouring from that measuring container into the washing machine; this is similar to the worst-case work practice assumptions in EPA’s Engineering Report. Also, Hendrix reported a maximum of only 0.2% of the dust from granular detergent was found to be less than 5 µ for consumer powdered laundry detergents. The author notes that particles larger than 5 µ are generally considered to be too large to be respirable.

Based on these data provided in the Hendrick, 1970 paper and other assumptions provided in the EPA Engineering Report (i.e., an average laundry site handles 154 kg detergent per day), APERC calculated an inhalation dose of 0.00012 mg NPE /day from granular detergent as shown in Table 8a. APERC assumed one worker handles all 154 kg of laundry detergent during the course of a single 8 hour work shift; the worker double pours the powdered laundry detergent, and no personal protection equipment is worn. Dividing the estimated daily inhalation dose of 0.00012 mg/day by a mean body weight of 71.8 kg results in an average daily dose of 0.0000016 mg/kg-bw/day. When the lowest NOEL for NPE9 (50 mg/kg-bw/day) is divided by this calculated exposure an MOE of 30,835,567 is calculated.

² US EPA. (2007, July 18). Draft: Engineering report of nonylphenol (NP) and nonylphenol ethoxylates (NPEs) in response to section 21 petition

³ Hendricks, M.H. (1970). Measurement of enzyme laundry product dust levels and characteristics in consumer use. Journal of the American Oil Chemists' Society, 47, 207-211.

2. Refinements to dermal exposures to NPE and MOE for powdered and liquid laundry detergent

For dermal exposure calculations EPA assumed that both hands of the worker (840 cm²) were completely exposed to a quantity of detergent (as defined by the EPA Generic Scenario document) without being wiped off and that there was 100% relative dermal absorption.^{4,5} APERC used an alternate approach to refine the dermal exposure calculations that relied on surrogate dermal unit exposure values from the 1998 EPA Pesticide Handler Exposure Database (PHED)⁶ to estimate exposures for manual loading of solid and liquid detergents. EPA commonly uses PHED data, which is based on actual monitoring in occupational settings, for screening level exposure analyses in the absence of monitoring data for other occupational settings as described below.

PHED provides generic pesticide worker (i.e., mixer/loader and applicator) exposure estimates. The dermal and inhalation exposure estimates generated by PHED are based on actual field monitoring data, which are reported generically (i.e., chemical specific names not reported) in PHED. It has been the Agency's policy to use a surrogate or generic exposure data for pesticide applicators in certain circumstances because it is believed that the physical parameters or application technique, not the chemical properties of the pesticide, attribute to exposure levels. [Note: Vapor pressures for the chemicals in PHED are in the range of E-5 to E-7 mm Hg.] Chemical specific properties are accounted for by correcting the exposure data for study specific field and laboratory recovery values as specified by the PHED grading criteria. PHED handler exposure data are generally provided on a normalized basis for use in exposure assessments. The most common method for normalizing exposure is by pounds of active ingredient (ai) handled per replicate (i.e., exposure in mg per replicate is divided by the amount of ai handled in that particular replicate). These unit exposures are expressed as mg/lb ai handled. This normalization method presumes that dermal and inhalation exposures are linear based on the amount of active ingredient handled.⁷

⁴ US EPA. (2006, October 24)

⁵ US EPA. (2007, July 18).

⁶ US EPA. (1998).

⁷ US Environmental Protection Agency (US EPA). (2008, January 9). Occupational and residential exposure chapter for diiodomethyl p-tolyl sulfone.

Commonalities between the process used for loading pesticide into a mixing tank and that used for loading laundry detergent into a washing machine further supports the usefulness of this approach to estimating laundry worker exposure to NPE in detergents. The potential dermal exposure of a laundry worker to NPE from laundry detergent was calculated using data from PHED and the following assumptions during various scenarios of loading detergent:

- Unit exposure factor for **open** mixing and loading of **granular** products, with a single layer of clothing without gloves is 0.0084 mg /lb handled.⁸
- Unit exposure value of 2.9 mg /lb handled for all **liquids, open** mixing and loading based on a single layer of clothing without gloves and 0.023 2.9 mg/lb handled using gloves.⁹
- Unit exposure value of 0.0086 mg /lb handled for all **liquids, closed** mixing and loading based on a single layer of clothing using gloves (Note the EPA PHED did not have a value for a closed system loading not wearing gloves).¹⁰
- An average of 154 kg (340 lb) of solid powder detergent was used per site per day.¹¹
- An average of 154 kg (340 lb) of liquid detergent is used per site per day.
- The NPE represents 28% of the granular detergent and 100% of the liquid detergent formulations.¹²
- One worker manually does all the detergent loading for the site (154 kg) during an 8-hour shift and cleans his/her skin at the end of the shift.
- The relative dermal absorption of NPE was less than 1% of the applied dose in solution after 8 hours of exposure based on Monteiro-Riviere et al. (2000).¹³
- The mean body weight was 71.8 kg for an adult male or female from age 18 to 75.¹⁴

Table Ib provides estimated dermal exposures to NPE for various scenarios (*i.e.*, with and without gloves; open or closed loading; open or closed mixing /washing) based on ingredient exposures measured in the EPA PHED. Assumptions and calculations to derive daily exposures (mg/kg-bw/day) and MOEs are also provided in Table 8b. For workers using granular laundry detergent with no

⁸ US EPA. (1998).

⁹ US EPA. (1998).

¹⁰ US EPA. (1998).

¹¹ US EPA. (2007, July 18).

¹² US EPA. (2007, July 18).

¹³ Monteiro-Riviere et al. (2000).

¹⁴ US EPA. (1998).

gloves and open loading and mixing/washing, a daily absorbed dose of 0.000111mg/kg-bw/day was estimated. The MOE for this exposure based on the same lowest NOEL for NPE9 (50 mg/kg-bw.day) is calculated as approximately 450,000. For workers using liquid laundry detergent with no gloves, open loading /mixing/washing, a daily absorbed dose of 0.137 mg/kg-bw/day was estimated and a corresponding MOE was calculated as approximately 365. For workers using liquid laundry detergent with gloves and open loading /washing/mixing a daily absorbed dose of 0.0011mg/kg-bw/day was estimated and a corresponding MOE of approximately 46,000 was calculated. Finally, for workers using liquid laundry detergent with gloves and closed loading/washing/mixing, a daily absorbed dose of 0.00041mg/kg-bw/day was estimated and a corresponding MOE of approximately 123,000 was calculated.

References for Table IA and IB:

Hendricks, M.H. (1970). Measurement of enzyme laundry product dust levels and characteristics in consumer use. Journal of the American Oil Chemists' Society, 47, 207-211.

Monteiro-Riviere, N.A., Van Miller, J.P., Simon, G., Joiner, R.L., Brooks, J.D., & Riviere, J.E. (2000). Comparative in vitro percutaneous absorption of nonylphenol and nonylphenol ethoxylates (NPE-4 and NPE-9) through human, porcine and rat skin. Toxicology and Industrial Health, 16, 49-57.

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US Environmental Protection Agency (US EPA). (2006, October 24). Chemicals used in water-based washing operations at industrial and institutional laundries - generic scenario for estimating occupational exposures and environmental releases - draft. US Environmental Protection Agency, Washington, DC, USA.

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