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# Technical Memo

## Air Quality Program

February 14, 2019

To: 460 Rulemaking Stakeholders

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Subject: Deriving ASILs for mixtures of dioxin-like compounds and mixtures of polycyclic aromatic hydrocarbon

We established ASILs for each individual TAP listed in WAC 173-460-150. ASILs were established based on toxicity information specific to each chemical. In some cases, emissions of mixtures of pollutants that cause toxicity through similar mechanisms can be grouped. Ecology used established methods for evaluating toxic equivalence of mixtures of dioxin-like compounds based on the toxicity of 2,3,7,8-tetrachlorodibenzo(p)dioxin, and mixtures of carcinogenic polycyclic aromatic hydrocarbons relative to benzo(a)pyrene. In these cases, we derived an ASIL for each individual chemical and the toxic equivalent of mixtures.

## ASIL for mixtures of dioxin-like compounds

Several dioxin-like compounds may be emitted from a source as a mixture. These compounds may cause toxicity through similar mechanisms, but they differ in their toxic potency. To assess risk from combined exposure to these similar pollutants, EPA and other regulatory agencies use an approach based on toxic equivalent factors (TEF) of each dioxin-like compound relative to 2,3,7,8-tetrachlorodibenzo(p)dioxin. A 2,3,7,8-tetrachlorodibenzo(p)dioxin toxic equivalent (TEQ) exposure concentration of a mixture is determined by multiplying the concentration of each dioxin-like compound by its TEF and then summing these weighted concentrations:

$$TEQ = \sum_{i=1}^{n} (C_i \times TEF_i)$$

Using this approach, we developed an ASIL for the mixture of these pollutants. We used EPA's Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessments of 2,3,7,8-tetrachlorodibenzo(p)dioxin and Dioxin-Like Compounds to derive the ASIL based on the 2,3,7,8-tetrachlorodibenzo(p)dioxin TEQ (EPA, 2010a). The ASIL for this mixture will be used in situations when more than one dioxin-like compound is emitted from a source that is undergoing review under WAC 173-460.

The following table shows the TEFs for each dioxin-like chemical and the ASILs for each compound based on OEHHA's unit risk factor for 2,3,7,8-tetrachlorodibenzo-p-dioxin (38 per $\mu g/m^3$), and the ASIL for the mixture of dioxin-like compounds [i.e., 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TEQ)].

| **Compound** | **CAS** | **TEF** (Toxicity Equivalence Factor) | **ASIL** ($\mu g/m^3$) |
|---|---|---|---|
| **2,3,7,8-Tetrachlorodibenzo-p-dioxin (TEQ)** | **mixture** | **NA** | **2.6E-08** |
| Polychlorinated dibenzo-p-dioxins (PCDDs) | | | |
| 2,3,7,8-Tetrachlorodibenzo-p-dioxin | 1746-01-6 | 1 | 2.6E-08 |
| 1,2,3,7,8-Pentachlorodibenzo-p-dioxin | 40321-76-4 | 1 | 2.6E-08 |
| 1,2,3,4,7,8-Hexachlorodibenzo-p-dioxin | 39227-28-6 | 0.1 | 2.6E-07 |
| 1,2,3,6,7,8 Hexachlorodibenzo-p-dioxin | 57653-85-7 | 0.1 | 2.6E-07 |
| 1,2,3,7,8,9-Hexachlorodibenzo-p-dioxin | 19408-74-3 | 0.1 | 2.6E-07 |
| 1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin | 35822-46-9 | 0.01 | 2.6E-06 |
| 1,2,3,4,6,7,8,9-Octachlorodibenzo-p-Dioxin | 3268-87-9 | 0.0003 | 8.8E-05 |
| | | | |
| **Polychlorinated dibenzofurans (PCDFs)** | | | |
| 2,3,7,8-Tetrachlorodibenzofuran | 51207-31-9 | 0.1 | 2.6E-07 |
| 1,2,3,7,8-Pentachlorodibenzofuran | 57117-41-6 | 0.03 | 8.8E-07 |
| 2,3,4,7,8-Pentachlorodibenzofuran | 57117-31-4 | 0.3 | 8.8E-08 |
| 1,2,3,4,7,8-Hexachlorodibenzofuran | 70648-26-9 | 0.1 | 2.6E-07 |
| 1,2,3,6,7,8-Hexachlorodibenzofuran | 57117-44-9 | 0.1 | 2.6E-07 |
| 1,2,3,7,8,9-Hexachlorodibenzofuran | 72918-21-9 | 0.1 | 2.6E-07 |
| 2,3,4,6,7,8-Hexachlorodibenzofuran | 60851-34-5 | 0.1 | 2.6E-07 |
| 1,2,3,4,6,7,8-Heptachlorodibenzofuran | 67562-39-4 | 0.01 | 2.6E-06 |
| 1,2,3,4,7,8,9-Heptachlorodibenzofuran | 55673-89-7 | 0.01 | 2.6E-06 |
| 1,2,3,4,6,7,8,9-Octachlorodibenzofuran | 39001-02-0 | 0.0003 | 8.8E-05 |
| | | | |
| **Polychlorinated biphenyls (PCBs)** | | | |
| 3,3',4,4'-Tetrachlorobiphenyl | 32598-13-3 | 0.0001 | 2.6E-04 |
| 3,4,4',5-Tetrachlorobiphenyl | 70362-50-4 | 0.0003 | 8.8E-05 |

| Compound | CAS | TEF (Toxicity Equivalence Factor) | ASIL ($\mu g/m^3$) |
|---|---|---|---|
| 2,3,3',4,4'-Pentachlorobiphenyl | 32598-14-4 | 0.00003 | 8.8E-04 |
| 2,3,4,4',5-Pentachlorobiphenyl | 74472-37-0 | 0.03 | 8.8E-07 |
| 2,3',4,4',5-Pentachlorobiphenyl | 31508-00-6 | 0.00003 | 8.8E-04 |
| 2',3,4,4',5-Pentachlorobiphenyl | 65510-44-3 | 0.00003 | 8.8E-04 |
| 3,3',4,4',5-Pentachlorobiphenyl | 57465-28-8 | 0.1 | 2.6E-7 |
| 2,3,3',4,4',5-Hexachlorobiphenyl | 38380-08-4 | 0.00003 | 8.8E-04 |
| 2,3,3',4,4',5'-Hexachlorobiphenyl | 69782-90-7 | 0.00003 | 8.8E-04 |
| 2,3',4,4',5,5'-Hexachlorobiphenyl | 52663-72-6 | 0.00003 | 8.8E-04 |
| 3,3',4,4',5,5'-Hexachlorobiphenyl | 32774-16-6 | 0.00003 | 8.8E-04 |
| 2,3,3',4,4',5,5'-Heptachlorobiphenyl | 39635-31-9 | 0.00003 | 8.8E-04 |

## ASIL for mixtures of carcinogenic polycyclic aromatic hydrocarbons

Several carcinogenic PAH may be emitted from a source as a mixture. Because these chemicals may cause toxicity in a similar manner, agencies have used an approach to consider the potencies of several PAH compounds relative to the toxicity of benzo(a)pyrene. EPA and California's Office of Environmental Health Hazard Assessment (OEHHA) have evaluated relative potency factors for various PAHs.

In 1993, EPA produced Provisional Guidance for Quantitatie Risk Assessment of Polycyclic Aromatic Hydrocarbons (EPA, 1993). This document provided relative potencies for 7 PAH compounds [including benzo(a)pyrene]. EPA revisited and expanded their evaluation of PAH relative potency factors in 2010, but the document has not been finalized, and is labeled as do not cite or quote (EPA 2010b).

In 2009, OEHHA included a summary of cancer potencies and PEFs for 25 PAH compounds in the Technical Support Document for Candcer Potency Factors Appendix B (OEHHA, 2009). These same values appear in OEHHA's Appendix G of the 2015 Guidance Manual for Preparation of Health Risk Assessments (OEHHA, 2015).

For the purpose of deriving ASILs and providing a framework for considering the combined toxicity of a a mixture of PAHs, Ecology will use the potency equivalency factors (PEFs) reported by OEHHA and the latest unit risk factor for benzo(a)pyrene developed by USEPA (EPA 2017). The ASIL for this mixture will be used in situations when more than one dioxin-like compound is emitted from a source that is undergoing review under WAC 173-460.

The following table shows the PEFs for each carcinogenic PAH, ASILs for each compound based on EPA's unit risk factor for benzo(a)pyrene (0.0006 per $\mu g/m^3$), and the ASIL for the mixture of carcinogenic PAHs [i.e., benzo(a)pyrene (TEQ)].

| Common Name | CAS | PEF (Potency Equivalency Factor) | ASIL ($\mu g/m^3$) |
|---|---|---|---|
| **Benzo(a)pyrene (TEQ)** | **mixture** | **NA** | **1.0E-03** |
| | | | |
| 1,6-Dinitropyrene | 42397-64-8 | 0.1 | 1.0E-04 |
| 1,8-Dinitropyrene | 42397-65-9 | 1.0 | 1.0E-03 |
| 1-Nitropyrene | 5522-43-0 | 0.1 | 1.0E-02 |
| 2-Nitrofluorene | 607-57-8 | 0.01 | 1.0E-01 |
| 3-Methylcholanthrene * | 56-49-5 | 5.7 | 1.8E-04 |
| 4-Nitropyrene | 57835-92-4 | 0.1 | 1.0E-02 |
| 5-Methylchrysene | 3697-24-3 | 1.0 | 1.0E-03 |
| 5-Nitroacenaphthene * | 602-87-9 | 0.03 | 3.0E-02 |
| 6-Nitrochrysene | 7496-02-8 | 10 | 1.0E-04 |
| 7,12-Dimethylbenz[a]anthracene * | 57-97-6 | 64.5 | 1.6E-05 |
| 7h-Dibenzo[c,g]carbazole | 194-59-2 | 1.0 | 1.0E-03 |
| Benz[a]anthracene | 56-55-3 | 0.1 | 1.0E-02 |
| Benzo[a]pyrene ** | 50-32-8 | 1.0 | 1.0E-03 |
| Benzo[b]fluoranthene | 205-99-2 | 0.1 | 1.0E-02 |
| Benzo[j]fluoranthene | 205-82-3 | 0.1 | 1.0E-02 |
| Benzo[k]fluoranthene | 207-08-9 | 0.1 | 1.0E-02 |
| Chrysene | 218-01-9 | 0.01 | 1.0E-01 |
| Dibenz[a,h]acridine | 226-36-8 | 0.1 | 1.0E-02 |
| Dibenz[a,h]anthracene * | 53-70-3 | 0.1 | 9.2E-03 |
| Dibenz[a,j]acridine | 224-42-0 | 0.1 | 1.0E-02 |
| Dibenzo[a,e]pyrene | 192-65-4 | 1.0 | 1.0E-03 |
| Dibenzo[a,h]pyrene | 189-64-0 | 10 | 1.0E-04 |
| Dibenzo[a,i]pyrene | 189-55-9 | 10 | 1.0E-04 |
| Dibenzo[a,l]pyrene | 191-30-0 | 10 | 1.0E-04 |
| Indeno[1,2,3-cd]pyrene | 193-39-5 | 0.1 | 1.0E-02 |

Note: Early-life adjustment factor of 1.66 was used in derivation of ASIL

*The PEF for these compounds were estimated from OEHHA's chemical specific unit risk factors relative to OEHHA's unit risk factor for benzo(a)pyrene.

** Index compound

# References

EPA 2003. United States Environmental Protection Agency. Provisional Guidance for Quantitiative Risk Assessment of Polycyclic Aromatic Hydrocarbons. EPA/600/R-93/089. July 1993.

OEHHA 2009. California Environmental Protection Agency Office of Environmental Health Hazard Assessment. Technical Support Document for Cancer Potency Factors Appendix B. June 2009.

EPA 2010a. United States Environmental Protection Agency. Recommended Toxicity Equivalence Factors (TEFs) for Human Health Risk Assessements of 2,3,7,8-Tetrachlorodibenzo(p)dioxin and Dioxin-Like Compounds. EPA/100/R-10/005. December 2010.

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OEHHA 2015. California Environmental Protection Agency Office of Environmental Health Hazard Assessment. Air Toxics Hot Spots Program Risk Assessment Guidelines- Guidance Manual for Preparation of Health Risk Assessments – Appendix G. February 2015.