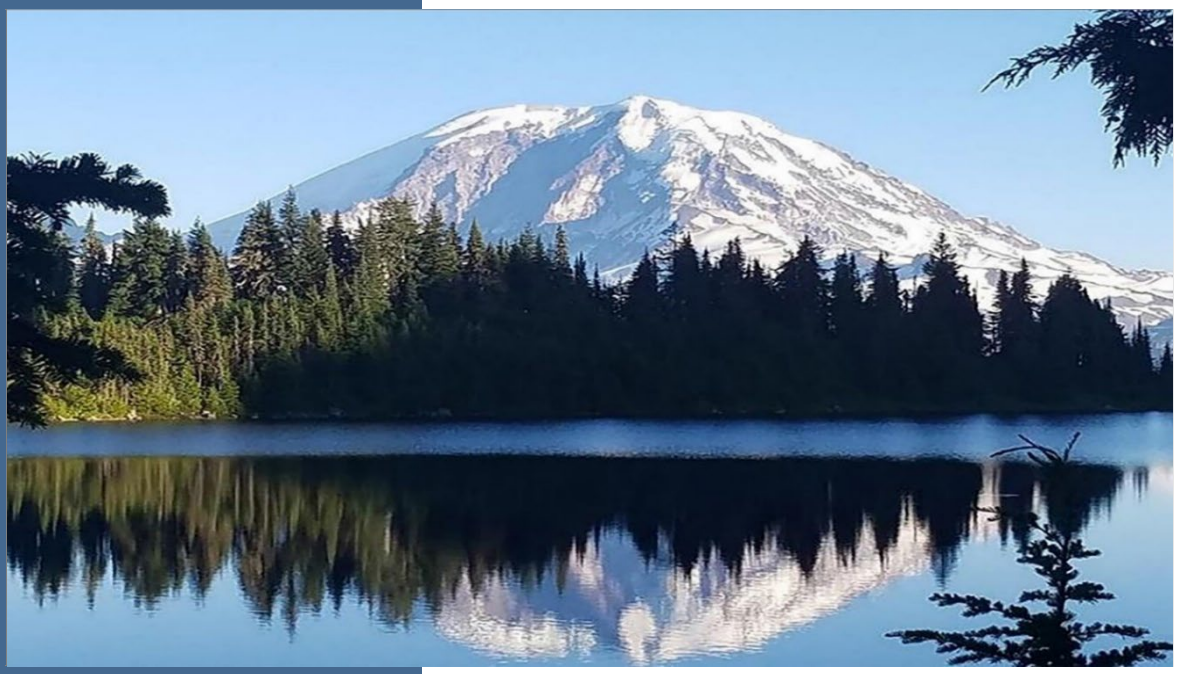


Responsiveness Summary: 6PPD Hazard Criteria

Public Comment Period
June 14, 2023, to July 14, 2023

Hazardous Waste and Toxics Reduction Program
Washington State Department of Ecology
Olympia, Washington

October 2023, Publication 23-04-061

DEPARTMENT OF ECOLOGY
State of Washington

Publication Information

This document is available on the Department of Ecology's website at:
https://apps.ecology.wa.gov/publications/summarypages/2304061.html

Cover photo credit

- Standard Ecology image, 2019

Contact Information

Hazardous Waste and Toxics Reduction Program

P.O. Box 47600
Olympia, WA 98504-7600
Phone: 360-407-6700
Website: Washington State Department of Ecology[1]

ADA Accessibility

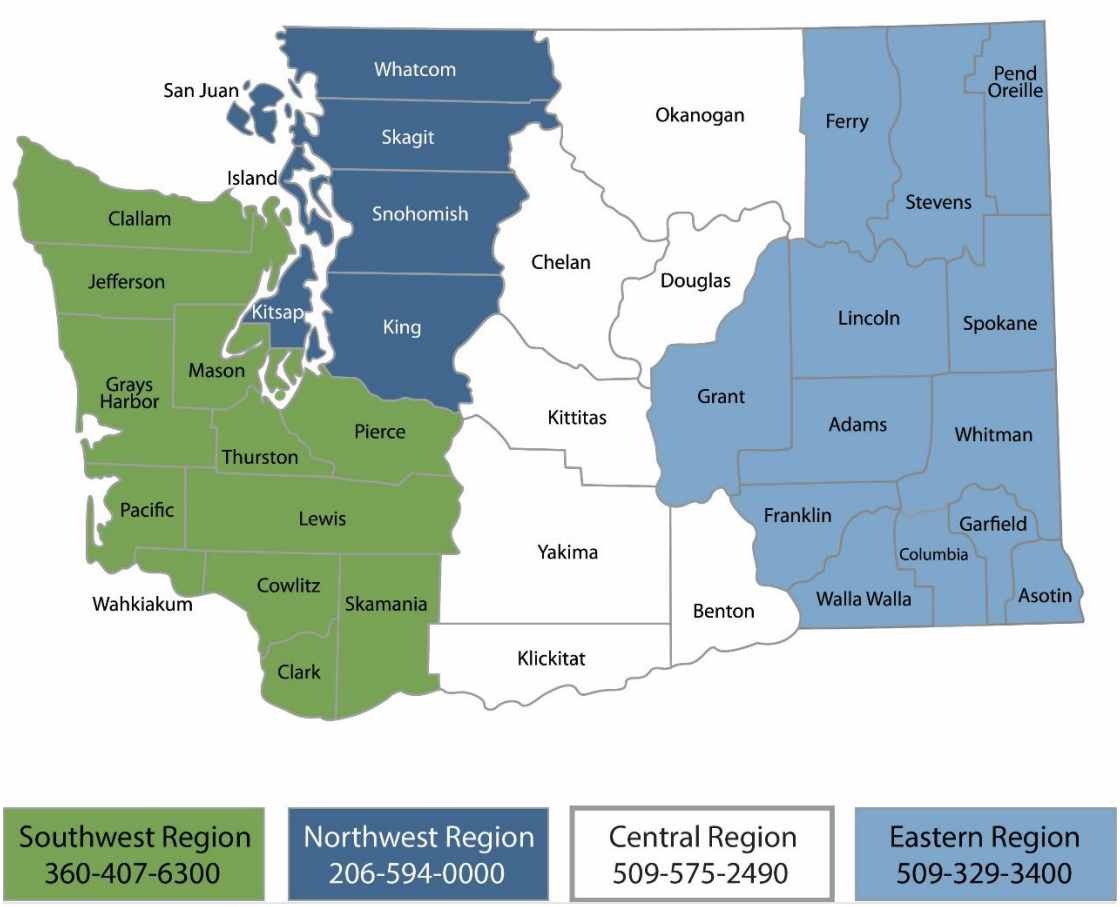
The Department of Ecology is committed to providing people with disabilities access to information and services by meeting or exceeding the requirements of the Americans with Disabilities Act (ADA), Section 504 and 508 of the Rehabilitation Act, and Washington State Policy #188.

To request an ADA accommodation, contact Ecology by phone at 360-407-6700 or email at hwtrpubs@ecy.wa.gov. For Washington Relay Service or TTY call 711 or 877-833-6341. Visit Ecology's website[2] for more information.

[1] www.ecology.wa.gov/contact
[2] www.ecology.wa.gov/accessibility

Department of Ecology's Regional Offices

Map of Counties Served



Region	Counties served	Mailing Address	Phone
Southwest	Clallam, Clark, Cowlitz, Grays Harbor, Jefferson, Mason, Lewis, Pacific, Pierce, Skamania, Thurston, Wahkiakum	PO Box 47775 Olympia, WA 98504	360-407-6300
Northwest	Island, King, Kitsap, San Juan, Skagit, Snohomish, Whatcom	PO Box 330316 Shoreline, WA 98133	206-594-0000
Central	Benton, Chelan, Douglas, Kittitas, Klickitat, Okanogan, Yakima	1250 W Alder St Union Gap, WA 98903	509-575-2490
Eastern	Adams, Asotin, Columbia, Ferry, Franklin, Garfield, Grant, Lincoln, Pend Oreille, Spokane, Stevens, Walla Walla, Whitman	4601 N Monroe Spokane, WA 99205	509-329-3400
Headquarters	Across Washington	PO Box 46700 Olympia, WA 98504	360-407-6000

Responsiveness Summary: 6PPD Hazard Criteria

Public Comment Period
June 14, 2023, to July 14, 2023

Hazardous Waste and Toxics Reduction Program
Washington State Department of Ecology
Olympia, WA

October 2023 | Publication 23-04-061

Table of Contents

6PPD Hazard Criteria for Alternatives Assessment

The Washington State Legislature tasked the Department of Ecology with performing an Alternatives Assessment on 6PPD in motor vehicle tires to identify compounds with the potential to replace 6PPD in these products.

To set a transparent standard for identifying safer alternatives during this Alternatives Assessment, we developed hazard criteria. These criteria set specific guidelines so we review appropriate data and evaluate each chemical's safety in the same way. Hazard criteria enable us to be consistent when deciding if a chemical is a safer alternative to 6PPD.

We are opting to use criteria for safer alternatives similar to those created for the Safer Products for Washington (Safer Products) program. Additionally, we propose three additions to better protect sensitive species:

1. Alternatives must have data on acute aquatic toxicity to coho salmon and rainbow trout,[3] as well as data on two other trophic levels.
2. Alternatives must have data on the toxicity of transformation products after exposure to ozone.
3. We will place a limit on the acute toxicity lethal concentration 50 (LC_{50}) values[4] allowed in the minimum criteria (>0.1 mg/L).

After developing 6PPD Alternatives Assessment hazard criteria, we opened them up for public comment.

Public Comment Period Summary

We held a comment period between June 14, 2023, and July 14, 2023, to receive feedback on the 6PPD Hazard Criteria for a 6PPD Alternatives Assessment. During the comment period, we received 10 comments. Individuals from academic institutions, industry, federal and local government, and the general public submitted input.

We carefully reviewed and considered each comment. We made the following modifications to the 6PPD Alternatives Assessment hazard criteria[5] based on this comment period:

- Updated Table 1 and removed the original Table 2 (which compared the toxicity of 6PPD to other chemicals). Our changes to Table 1 added more relevant and up-to-date literature and examples. Table 2 was no longer needed given these updates.

[3] We added a data requirement for acute aquatic toxicity to rainbow trout based on feedback received during our public comment period.
[4] Lethal concentration 50 (LC_{50}) measures the amount of a substance that kills 50% of a sample population after exposure to a toxin.
[5] https://apps.ecology.wa.gov/publications/SummaryPages/2304036.html

- Included clarifying language to show we are examining mammalian and human health endpoints, and that we are closely following Safer Products criteria.
- Reduced emphasis on bioaccumulative properties throughout the document.
- Added example methods for ozonation and toxicity testing, emphasizing that the methods are examples only and not required.
- Added a new requirement to the first addition where testing on rainbow trout is now mandatory. Rainbow trout studies can be *in-vivo* or *in-vitro.*
- Updated references to incorporate additional research and new literature.

We have included the 6PPD Hazard Criteria that went out for public comment in Appendix A: 6PPD Hazard Criteria for Public Comment Period.

You can read submitted comments and our responses below. To view comments in their original format, see Appendix B: Comments in Original Format.

Comments and Responses

Comment from Tao Li

It is nice to see the approach to address long-term concerns in the selection for alternatives.

For evaluating these alternatives, one would need to use 6PPD and 6PPDQ as references. That means we need to know the hazardous endpoints and Greenscreen scores for them.

It is also known that 6PPD and 6PPDQ are actually chiral chemicals, suggesting there are actually four chemicals under two names. For proper evaluation, they should be investigated separately.

Response to Tao Li

Thank you for submitting your comment to Ecology.

We agree that 6PPD GreenScreen® scores are important for performing an Alternatives Assessment. We have already included GreenScreen® scores and other relevant document links within the hazard criteria document. The 6PPD GreenScreen® includes data from 6PPD-quinone since it is a transformation product. Chirality[6] is interesting, but we are looking at toxicity of alternatives compared to a racemic[7] mixture. As a result, we will not be looking at chirality in this assessment.

Comment from Edward Kolodziej

Global research has demonstrated how ubiquitous tire-rubber derived chemical contaminants can be, both environmentally and also with very substantial human exposures. Given the very substantial potential for human exposure to tire rubber derived compounds, I recommend that

[6] Molecule containing a mirror image that cannot be superimposed on one another.
[7] 1:1 mixture of mirror image molecules that cannot be superimposed on one another.

any prospective 6PPD alternatives also be required to collect and submit experimental data comparing human toxicity endpoints against 6PPD results (as a baseline for comparison) for a full range of human health toxicity endpoints using in vitro assays or other common chemical toxicity screening procedures. It is very important to consider not just ecological endpoints, but also human health endpoints as well for the data driven process of finding 6PPD alternatives.

Constraining transformation product assessments to -1-ozonation mixtures only-1- may miss very substantial and important products formed by other reaction systems. Key products formed by any typical environmental process should be evaluated too. Extending mixture screening to other reactive environmental processes such as hydrolysis, photolysis, etc should be used to fully determine key products and their toxicity potential.

I also recommend consideration of sublethal endpoints for 6PPD alternatives, including growth, reproduction, and biological/ecological function. It is becoming clear that sublethal impacts also are occurring for 6PPD and 6PPD-quinone exposures thta contribute substantially to their environmental risk profile (even for -1-insensitive organisms-1-, and constraining ecological safety to lethal endpoints can allow for replacements to be more toxic with respect to major sublethal endpoints. -1-Safer-1- should be extended to ALL possible endpoints, both lethal and sublethal, to be consistent with current knowledge of where adverse impacts on aquatic organisms arise.

Response to Edward Kolodziej

Thank you for submitting your comment to Ecology.

We agree that human and environmental health endpoints are important to consider when looking for a potential alternative to 6PPD. For this reason, we have already included both within our hazard criteria. Our criteria are based on the Safer Products for Washington criteria for identifying safer alternatives, which looks at these endpoints. We acknowledge this may not have been clear within the original document and have added clarifying language.

We also agree that other transformation products are of concern. However, our main goal with this assessment is to find “safer” alternatives to 6PPD. Typically, a safer parent compound is the best indicator of safer overall transformation products. Due to the lack of information on other 6PPD transformation products, we cannot perform a comparison to all transformation products.

Sublethal impacts are concerning, and we are requiring some sublethal endpoints as per criteria laid out in Safer Products for Washington. However, we are not requiring any additional criteria. We have not seen evidence that 6PPD and 6PPD-q have significantly higher hazards in these areas compared to other chemicals of concern.

Comment from Hui Peng

The Hazard Criteria document reads great, but here are several quick thoughts:

1. Except for ozone reactions, all other hazard criteria proposed here were developed for conventional chemicals. However, when it comes to antioxidants, I believe it is essential

to assess both PBT/vPvB characteristics and toxicity of their oxidation products by using nontargeted analysis to identify major reaction products, and then synthesize the products for subsequent experiments. This assessment should involve a combination of experimental data and modeling approaches. The reason for this is that antioxidants can undergo rapid oxidation, transforming into potentially more toxic or persistent compounds within a matter of minutes or days. This has been observed in the case of 6PPD and 6PPD-Quinone.[1] This is also true for other antioxidants including organophosphites (converted to organophosphates,[2] or thiophosphates[3] in minutes or days), and sulfur-containing antioxidants[4].

2. If PPD compounds are being considered as potential replacement chemicals, conducting tests on coho salmon could be risky and may result in the introduction of a regrettable alternative. The main reason for this concern is the lack of understanding regarding the toxicity mechanism of 6PPD-Q (6PPD-Quinone). Specifically, the protein target responsible for its toxicity remains unidentified. It is possible that a particular PPD-quinone, such as IPPD-Q, may not exhibit toxicity towards coho salmon, but could be toxic to other fish species with slightly different protein binding pockets. To move forward in a responsible manner, there are two possible approaches: 1) Testing a broader range of fish species, including those known to be sensitive to the toxicity of 6PPD-Q, such as rainbow trout, brook trout, white-spotted char, and others[5, 6]; 2) Conducting an in-depth investigation to identify the specific toxicity mechanism (timeline is hard to predict).

Hui Peng

2023/07/10

Reference

1. Tian, Z.; Zhao, H.; Peter, K. T.; Gonzalez, M.; Wetzel, J.; Wu, C.; Hu, X.; Prat, J.; Mudrock, E.; Hettinger, R.; Cortina, A. E.; Biswas, R. G.; Kock, F. V. C.; Soong, R.; Jenne, A.; Du, B.; Hou, F.; He, H.; Lundeen, R.; Gilbreath, A.; Sutton, R.; Scholz, N. L.; Davis, J. W.; Dodd, M. C.; Simpson, A.; McIntyre, J. K.; Kolodziej, E. P. A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. Science 2021, 371, (6525), 185-189.
2. Liu, R.; Mabury, S. A. Organophosphite Antioxidants in Indoor Dust Represent an Indirect Source of Organophosphate Esters. Environ Sci Technol 2019, 53, (4), 1805-1811.
3. Chen, W. Z.; Almuhtaram, H.; Andrews, R. C.; Peng, H. Unanticipated Thio-oxidation of Organophosphite Chemical Additives in PVC Microplastics Following In-Situ Weathering. ChemRxiv 2023.
4. Yang, D.; Liu, Q.; Wang, S.; Bozorg, M.; Liu, J.; Nair, P.; Balaguer, P.; Song, D.; Krause, H.; Ouazia, B.; Abbatt, J. P. D.; Peng, H. Widespread formation of toxic nitrated bisphenols indoors by heterogeneous reactions with HONO. Science advances 2022, 8, (48), eabq7023.

5. Brinkmann, M.; Montgomery, D.; Selinger, S.; Miller, J. G. P.; Stock, E.; Alcaraz, A. J.; Challis, J. K.; Weber, L.; Janz, D.; Hecker, M.; Wiseman, S. Acute Toxicity of the Tire Rubber-Derived Chemical 6PPD-quinone to Four Fishes of Commercial, Cultural, and Ecological Importance. Environ. Sci. Technol. Lett. 2022, 9, 333-338.
6. Hiki, K.; Yamamoto, H. The Tire-Derived Chemical 6PPD-quinone Is Lethally Toxic to the White-Spotted Char Salvelinus leucomaenis pluvius but Not to Two Other Salmonid Species. Environ. Sci. Technol. Lett. 2022, 9, (12), 1050-1055.

Response to Hui Peng

Thank you for submitting your comment to Ecology.

1) We believe that the work, funds, and time required to synthesize and test all possible transformation products for potential alternatives is prohibitive and would detract from getting safer alternatives in use on the road. Our main goal with this assessment is to find "safer" alternatives to 6PPD. Typically, a safer parent compound is the best indicator of safer transformation products overall.

2) We agree there is a benefit to requiring tests on additional species and have received multiple comments to this end. We have decided to include rainbow trout as a fourth required organism due to their common use as a test species. It is difficult to decide how many species are enough, but requiring toxicity data across multiple trophic levels will allow us to identify sensitivity across a variety of organisms.

Comment from Jennifer Lanksbury

King County's Water and Land Resources Division (WLRD) would like to thank the Washington State Department of Ecology (Ecology) for the opportunity to comment on Ecology's 6PPD Alternative Assessment Hazard Criteria.

WLRD safeguards King County's water and land resources by providing services that protect public health and safety and yield significant environmental benefits. WLRD provides flood control services, stormwater management, and other natural resource management services throughout the county. WLRD manages the stormwater program for unincorporated areas, houses three salmon recovery forums, restores habitat, monitors water quality, and controls noxious weeds. Additionally, WLRD operates King County's Environmental Lab and Science sections, which provide environmental monitoring, data analysis, and management and modeling services to partners, jurisdictions, and residents throughout the region.

We support the Ecology hazard criteria developed in the 6PPD Alternative Assessment Hazard Criteria. However, we do have a couple comments, which we think would strengthen the criteria:

- Expand the -1-second addition-1- to include more environmental factors: The -1-second addition-1- (page 8) used for the 6PPD Alternative Assessment (AA) indicates any

alternative chemical must have data showing acute toxicity information for transformation products when the potential alternative is exposed to ozone. We are concerned this ozone exposure criterion is too narrowly focused, particularly if potential alternatives are considered outside of the PPD family. We recommend consideration of acute toxicity information for transformation products resulting from exposure to any environmental factors that could cause chemical transformation of the potential alternative (e.g., ozone, variations in pH, heat, UV exposure, etc.) into a more toxic compound.

- Include more information regarding the minimum criteria for special considerations: Under the -1-Process for Identifying a Safer Alternative to 6PPD-1- heading (page 8), Ecology states that if none of the alternative chemicals evaluated in the 6PPD AA meet the minimum criteria, they will evaluate 'special considerations', including the relevance of known and potential exposure routes and the magnitude of exposure. The reader is referred to the Safer Products for Washington (SPWA) Regulatory Determinations Report to the Legislature (June 2022) document for further information on special considerations. We would like to see more specific information regarding how Ecology will judge potential alternatives that fail to meet the minimum criteria. Because this AA is unique and particularly focused, it seems Ecology could more specifically define the minimum criteria for special considerations. For instance, will there be any additional special considerations for the 6PPD AA, other than those currently mentioned in the SPWA document? If so, what will those minimum criteria include? Will the criteria for special considerations be available for comment before the 6PPD AA is conducted?

Thank you for the opportunity to comment on the 6PPD Alternative Assessment Hazard Criteria. Please let us know if you have any questions.

Response to Jennifer Lanksbury

Thank you for submitting your comment to Ecology.

- As we don't know all the transformation products of 6PPD, we are focusing our criteria on known data (i.e., we know that 6PPD ozonation leads to harmful 6PPD-q). We want to emphasize that the best sign of a safe transformation product is a safe parent compound.
- We are purposefully keeping special considerations open-ended so we can evaluate factors like exposure routes, relevance of endpoints, information from our stakeholders, and magnitude of exposure when making a decision. For example, if a chemical does not meet our criteria for "safer" but has a significantly lower magnitude of exposure and significantly reduced effects at the lower concentration, we may identify it as a safer alternative. Although it does not meet all desired criteria, the chemical would still be an improvement to 6PPD moving forward and using it would be better than taking no action.

Comment from Elliot Rossomme

I think that the propose requirements are generally on the modest side of adequate, and that they appropriately address the most pressing aspects of the problems posed by 6PPD and its quinone. Specifically, the toxicity boundary of >0.1 mg/mL seems reasonable to me in light of both the extreme toxicity of 6PPDQ and the concentrations of 6PPD transformations generally found in urban runoff. It would also be defensible to raise this boundary to 1 mg/mL, in my opinion.

That being said, I think the most significant gap in the proposed requirements is the failure to address the upstream implications of using 6PPD in tires. Like many tire ingredients, 6PPD is derived from petroleum feedstocks, and commercial dependence on this anti-degradant (and those like it) contributes to ecological destruction in ways other than the acute toxicity of transformation products. While it raises the regulatory hurdle, the requirements indicated herein would be complemented by the inclusion of a cradle-to-grave life cycle analysis (LCA) to address problems associated with sourcing and manufacture of 6PPD vis-a-vis proposed alternatives.

I don't think it overstates the matter to say that the decision the Washington Department of Ecology makes will have implications for the regulations passed in other U.S. states, federally, and perhaps even globally. Furthermore, the tire industry is and will be investing significant resources into identifying and evaluating 6PPD alternatives. It thus seems likely that the alternative(s) that is (are) selected will be used in tire manufacturing for a long time to come, and regulatory agencies should at least consider, if not impose, requirements that replacements are sustainable from start to finish.

Response to Elliot Rossomme

Thank you for submitting your comment to Ecology.

We plan to take all possible data into account when identifying alternatives, including any known life cycle analyses. However, it may be difficult to source that type of information for 6PPD. Similarly, performing a life cycle analysis on potential alternatives would be difficult, as we do not know the magnitude, or quantity, of use.

Comment from Damani Parran

1) For aquatic toxicity testing with coho salmon, are there specific protocols or OECD guidelines to follow? In addition, will these apply to testing of the 6PPD alternative and transformation products?
2) Are there specific protocols or guidelines to use for testing of transformation products from ozonation?
3) Will there be suggested laboratories that have the capability to conduct toxicology testing in coho salmon?

Response to Damani Parran

Thank you for submitting your comment to Ecology.

We have intentionally left methods and details concerning toxicity testing and ozonation of parent compounds open-ended to encourage more research and data. We have added example methods to the hazard criteria document in case they are helpful. However, we are not requiring these specific methods be used.

That said, we will check all research for best scientific practice.

Ecology does not endorse any particular lab for toxicity testing. We have prior experience with Enthalpy Analytical and Nautilus Environmental. They have indicated availability for testing with coho salmon.

Comment from Bryce Divine

P
Permit number:23-05-3443, Associated permit#23-05-3448
SEPA Environmental Checklist is incomplete. Coal Creek has, in addition to Chinook Salmon, spawning populations of Coho Salmon and Winter Steelhead. All three species are listed as threatened. Noxious Weeds (class A, B, and C) are also present on this property including Japanese Knotweed. It is my opinion that this application should be rejected and perhaps redone so that an accurate assessment of environmental impacts is on the record.

Response to Bryce Divine

Thank you for submitting your comment to Ecology. While we appreciate your insights, this public comment period was for our draft 6PPD Alternatives Assessment Hazard Criteria and is not related to any permit applications. You may have submitted your comment to the wrong form.

Comment from Jamie McNutt

Please see the attached comments from the US Tire Manufacturers Association.

July 14, 2023

Washington Department of Ecology
Hazardous Waste and Toxics Reduction Program
PO Box 47600 Olympia, WA 98504-7600

Re: Draft 6PPD Alternatives Assessment Hazard Criteria

I. **Overview**

The U.S. Tire Manufacturers Association (USTMA) and our member companies appreciate the opportunity to provide comments on draft 6PPD Alternatives Analysis ("AA") hazard criteria.[1] USTMA is the national trade association for tire

manufacturers that produce tires in the U.S. and are responsible for more than 291,000 jobs and have an annual economic footprint of $170.6 billion in the United States. USTMA advances a safe and sustainable tire manufacturing industry through a commitment to science-based public policy advocacy. The tires from our member companies make mobility possible and keep the U.S. economy moving.

Separately, Ecology issued a Draft Identification of Priority Chemicals Report to the Legislature, Safer Products for Washington Cycle 2, Implementation Phase 1 ("Draft Report") that proposes to designate 6PPD as a priority chemical. USTMA is submitting separate comments to Ecology on this Draft Report, which are incorporated by reference in these comments.

USTMA would like to emphasize the following comments on Ecology's hazard criteria document:

II. **USTMA requests additional information as to how this draft AA hazard criteria will be used.**

USTMA asks that Ecology include specific details about how the hazard criteria will be used and provide the opportunity for further dialogue and discussion on this topic. Specifically, USTMA is concerned with the statement on page 8 that "if none of the alternative chemicals we evaluate in our 6PPD AA meet the minimum criteria, we will evaluate special considerations." The draft hazard criteria does not specify what is meant by "special considerations." This information is essential to ensure transparency and clarity for all stakeholders. We are also concerned that depending on what the "special considerations" are, Ecology may stray beyond its statutory obligation when it evaluates those considerations.

We agree that defining the hazard criteria for potential alternatives to 6PPD is essential to identify alternatives and avoid regrettable substitutions. However, we urge Ecology to describe in much detail as possible what characteristics a chemical must have in order to be considered a safer alternative and to provide details on the meaning and definition of "special considerations." Further, we ask Ecology to provide specific information as to how the hazard criteria will be used to provide awareness and clarity for all stakeholders.

III. **Given the need to ensure tire safety and performance, USTMA recommends that the hazard criteria include: "Alternatives must ensure continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements."**

The composition and nature of the chemicals present in tires impart a function and the exact composition of tires cannot be modified without great care. It is not a simple process to change the composition of tires; any change could affect the stopping distance of tires, durability, vehicle fuel economy, tire wear, and other safety-related components. 6PPD provides critical functions in manufacturing safe and durable tires. For example, 6PPD in tires provides the following qualities:

- Optimal migration rate/diffusion
    - Adequate solubility and diffusivity in rubber compounds, also referred to as migration and mobility
    - Continuously present at the surface of the tire to ensure protection of the rubber formulations from degradation due to ozone
    - Available in rubber formulation over a tire's entire life cycle to ensure protection of the rubber
- Protection against ozone
    - Readily reactive with ozone to prevent crack formation on the surface of the rubber, but not too reactive in order to prevent premature depletion
- Protection against oxygen
    - Reactive with oxygen to prevent hardening of the rubber, loss of strength, and improve tire wear
- Protection against fatigue
    - Reactive with the free radicals generated by the breaks in polymer during flexing. These free radicals can break the polymer chains and crosslinks in the rubber compound that would lead to a loss of strength
- Manufacturing Impact
    - No adverse effects on the processability of rubber compounds
    - Resistance to temperatures encountered during the tire manufacturing process
- No adverse effects on tire safety and performance

Any potential alternative to 6PPD must provide the same critical functions as 6PPD to ensure tire safety and performance. It is essential that the hazard criteria for potential alternatives to 6PPD include continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements to ensure motorist safety. Again, we ask that Ecology include a fourth criteria that specifies:

1. Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.
2. Alternatives must have data on the toxicity of transformation products after exposure to ozone.
3. We will place a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L).

4. **Alternatives must ensure continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements.**

IV. **USTMA appreciates that Washington Ecology has provided guidelines for the testing that will be required to assess identification of potential alternatives to 6PPD, but recommends that it is premature to establish a limit**

In the draft hazard criteria, Ecology states, "to set a transparent standard for identifying safer alternatives, we opted to use criteria for safer alternatives similar to those created for the Safer Products for Washington program, but with three additions to better protect sensitive species."

- Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.
- Alternatives must have data on the toxicity of transformation products after exposure to ozone.
- We will place a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L)."

Outlining the testing that will be required to assess potential alternatives is essential to drive progress on identifying potential alternatives to 6PPD. USTMA thanks Ecology for outlining in the guidance the testing that will be required to assess potential alternatives. However, inclusion of a limit at this point may limit adoption of a potentially safer alternative. Thus, USTMA believes that it is premature to set a limit on the acute toxicity requirement for an alternative. USTMA members are actively engaged in evaluating potential alternatives to 6PPD. Because evaluation of potential alternatives is still underway and a specific alternative has not yet been identified, it is not possible to understand the application concentration or the physiochemical properties of a non-existing chemical to understand what environmentally relevant exposures will be.

V. **USTMA recommends that the final Hazard Criteria consider environmentally relevant levels when considering the Hazard Criteria limit LC 50 for coho**

It would be inaccurate to assume that any replacement chemical would be exposed to the environment at the same levels as 6PPD currently exists. We recommend that the final Hazard Criteria consider that potential alternatives will be different than 6PPD. Any potential alternative to 6PPD in tires may require that the alternative be used at different concentrations than the use of 6PPD in tires and may have different migration rates. This might (depending on other relevant factors) result in different exposure to the environment of the chemical than currently exists for 6PPD. It is important to allow flexibility, based on environmental relevance with a

safety margin, in the limit to account for potentially different environmental levels and exposure pathways with so many unknowns.

VI. **USTMA recommends that Ecology also consider the water solubility of potential alternatives in consideration of the hazard criteria**

When discussing LC50 and chemical concentrations, it is important to consider the solubility of the chemical being tested. What are the criteria for passing if a chemical is unable to meet the LC50 concentration of 100 ug/L for testing? If a chemical is not able to be solubilized in water at that level, then it will not exist in the environment at that level. It an alternative and its transformation products do not have a solubility limit that is at or above 100 ug/L, then testing at 100 ug/L would not be relevant. Please consider including criteria for potential alternatives that will not achieve a concentration of 100 ug/L, considering the requirement of environmentally relevant levels.

VII. **USTMA recommends that exposure conditions be considered as part of the criteria that "Alternatives must have data on the acute toxicity for transformation products after exposure to ozone."**

We recommend that Ecology specify the exposure conditions needed to fulfill the criteria that "alternatives must have data on the acute toxicity for transformation products after exposure to ozone." Exposure conditions should be based on environmentally relevant levels of ozone exposure to ensure real world transformation products are assessed. Additionally, we assume that the LC50 limit of >0.1 mg/L will also apply to transformation products of the alternative and recommend that this be stated explicitly to avoid confusion.

VIII. **USTMA requests clarifications on the experimental data to be developed to assess acute aquatic toxicity to coho salmon**

Ecology has indicated that a suitable 6PPD alternative must meet additional minimum criteria beyond those considered under the Safer Products for Washington Act (SPWA), including "experimental data on acute aquatic toxicity to coho salmon" and "data on two other trophic levels (e.g., daphnia and algae)"

A. USTMA recommends that Ecology provide clarification whether data on daphnia and algae acute toxicity must necessarily be laboratory-generated

Due to the unique importance of this requirement, we request that clarity be provided as to whether data on daphnia and algae acute toxicity must necessarily be laboratory-generated? Additionally, we ask that Ecology also clarify whether data on daphnia and algae must be generated in vivo, or if data from suitable analogs or estimated data may be used for these trophic levels. If in vivo testing is to be required for daphnia and algae, please recommend or

specify the necessary tests and conditions (e.g., OECD 201/202, GLP, analytical verification of the test substance, etc.)

B. USTMA recommends that Ecology provide additional information on the experimental data on acute toxicity to coho salmon for potential alternatives

The Department of Ecology has indicated that they will require 6PPD alternatives to have "experimental data" on acute aquatic toxicity to coho salmon, however, because coho salmon is not a standard laboratory test species, it should be clarified exactly what this entails. Greer et al. (2023; U.S. Geological Survey Western Fisheries Research Center; Seattle, WA), developed an in vitro platform for assessing toxicity in coho salmon, demonstrating that the coho salmon cell line CSE-119 was acutely sensitive to 6PPD-q, while Chinook and sockeye cell lines (CHSE-214 and SSE-5, respectively) were not. This differential toxicity was consistent with in vivo effects in these species. Given the published effectiveness of this assay for predicting acute mortality in coho salmon, and the USEPA's Toxic Substances Control Act's directive to "reduce and replace, to the extent practicable and scientifically justified, the use of vertebrate animals in the testing of chemical substances," does Ecology consider the use of coho salmon CSE-119 cells suitable to fulfill the requirement of "experimental data on acute aquatic toxicity to coho salmon"? If in vivo testing on live coho salmon is indeed deemed a requirement for assessment of a 6PPD alternative, we ask that Ecology specify the protocol for the test as there is currently no internationally accepted methodology for acute toxicity testing with this species. All test conditions, including duration, temperature, light cycle, feeding, water quality parameters, and any other additional testing requirements must be specified to ensure consistency of results.

C. USTMA recommends that Ecology provide additional information regarding which acute toxicity tests will be required for transformation products of potential alternatives.

The Department of Ecology has indicated that "any alternative chemical that meets the minimum criteria must also have data showing acute toxicity information for transformation products". We ask that Ecology specify which acute toxicity tests will be required for transformation products (e.g., coho salmon as with parent compound, daphnia, algae, mammalian, etc.). Considering how many transformation products are unknown, short lived, and do not have commercial standards, how does the Department of Ecology propose testing for transformation products? We recommend that Ecology provide specific guidance for testing for transformation products.

I. **USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Wu et al. 2023 study**

The data presented in Wu et al 2023 do not indicate bioaccumulation. The Department of Ecology has indicated that "6PPDq-dG has the potential for bioaccumulation and genotoxicity within green algae and fish organs and tissue", citing Wu et al 2023. In this study, the authors did not measure bioaccumulation of 6PPDq-dG. The study measured the occurrence (amount) of 6PPDq-dG in tissue as a biomarker for exposure. In their assays, lung cells were exposed for 24h and algal cells were exposed for 72h to 6PPD-q. 6PPDq-dG was measured after exposure and then again after a recovery period (12 and 24h for lung cells, 72h for algal cells). The data shows that after this recovery period, DNA adducts (6PPDq-dG) decreased, which does not indicate persistence. The authors concluded that there are potential repair pathways for this adduct in mammalian and algal cells. Additionally, "DNA adduct levels, measured at any point in time, reflect tissue-specific rates of damage processing that include DNA adduct formation and removal (DNA repair), DNA adduct instability, tissue turnover and other events." (Weston and Poirier, 2005).

The data for Capelin fish referenced in Wu et al 2023 do not indicate bioaccumulation. The authors only measured the occurrence (amount) of 6PPDq-dG in frozen samples collected from a fish market. Without knowledge regarding how much 6PPDq these fish were exposed to or for how long, it is not appropriate to make conclusions about bioaccumulation. Bioaccumulation is measured by calculating the bioconcentration factor (BCF), which is a comparison of the concentration in the fish (or organ) divided by the exposure concentration (e.g., OECD 305).

Please consider including other lines of evidence for bioaccumulation, if they exist for claims regarding the bioaccumulation of 6PPDq. The log Kow value may inform potential bioaccumulation of 6PPDq or other 6PPD transformation products. If bioaccumulation studies exist in the peer-reviewed literature, please consider citing to them as well.

USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Hua et al 2023 study.

The Department of Ecology has indicated that "6PPD-q has also shown some intestinal toxicity in low concentrations and lethality to the common study species Caenorhabditis elegans (Hua et al 2023)." To clarify, lethality was 5% in this study and only at the highest concentration tested (100 ug/L), therefore, the LC50 is much greater than 100 ug/L for this species. Additionally, 100 ug/L is not considered a "low concentration" and is not environmentally relevant (e.g., surface water concentrations range from 0.0012 to 2.3 ug/L in North America (Challis et al 2021, Johannessen et al 2022). No lethality was observed in lower concentrations from this study.

USTMA requests that Ecology consider relevant exposure data when describing the available literature on environmental concentrations.

Although we acknowledge the overall lack of reliable exposure data currently available, the reference for detected concentrations of 6PPD-q in Hong Kong urban runoff (Cao et al 2022) on page 6 may be perceived as irrelevant as there are no coho in China.

USTMA requests clarification whether the proposed changes to the "very high" GreenScreen category will result in a shift of subsequent GreenScreen categories.

A comparison table showing the proposed new acute aquatic toxicity LC50 value classifications and how they translate to the current GreenScreen acute aquatic toxicity LC50 value classifications would add clarity to the third addition proposed in the 6PPD AA hazard criteria document.

IX. **USTMA welcomes the opportunity for continued dialogue with Ecology on the development of the hazard criteria.**

USTMA and Ecology share a common goal that potential alternatives to 6PPD in tires ensure driver and environmental safety. Developing clear and environmentally relevant hazard criteria for potential alternatives to 6PPD is essential to avoid regrettable substitutions. We recognize the critical importance and need for clear and environmentally relevant hazard criteria and welcome the opportunity for additional engagement with Ecology to discuss the points raised in our comments. If you have any questions, please contact Jamie McNutt (jmcnutt@ustires.org; 202-682-4845).

Footnotes:

[1] USTMA members include: Bridgestone Americas, Inc., Continental Tire the Americas, LLC; Giti Tire (USA) Ltd.; The Goodyear Tire & Rubber Company; Hankook Tire America Corp.; Kumho Tire Co., Inc.; Michelin North America, Inc.; Nokian Tyres; Pirelli Tire North America; Sumitomo Rubber Industries, Ltd.; Toyo Tire Holdings of Americas Inc. and Yokohama Tire Corporation.

Response to Jamie McNutt

I. Overview

Ecology response: Thank you for submitting your comment to Ecology.

II. USTMA requests additional information as to how this draft AA hazard criteria will be used.

Ecology response: We are purposefully keeping special considerations open-ended so we can evaluate factors like exposure routes, relevance of endpoints, information from our stakeholders, and magnitude of exposure when making a decision. For example, if a chemical does not meet our criteria for "safer" but has a significantly lower magnitude of exposure and significantly reduced effects at the lower concentration, we may identify it as a safer alternative. Although it does not meet all desired criteria, the

chemical would still be an improvement to 6PPD moving forward and using it would be better than taking no action.

III. Given the need to ensure tire safety and performance, USTMA recommends that the hazard criteria include: "Alternatives must ensure continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements."

Ecology response: We agree that safety standards and safety criteria are important when choosing an alternative. However, ensuring compliance with Federal Motor Vehicle Safety Standards would be part of a future performance evaluation within the alternatives assessment. Compliance with performance and safety standards and requirements is not part of the hazard criteria. Hazard criteria are focused on defining safer in terms of toxicity to people and aquatic organisms.

IV. USTMA appreciates that Washington Ecology has provided guidelines for the testing that will be required to assess identification of potential alternatives to 6PPD, but recommends that it is premature to establish a limit

Ecology response: We know that tire wear particles (TWPs) make their way into the environment, so we also expect to find TWP chemicals in the environment. We believe the LC_{50} requirement is set at a level that is safer for aquatic organisms while still being reasonable for chemical development and hazard reduction. We have also included a special considerations section that allows us to choose chemicals that may not meet these limits.

V. USTMA recommends that the final Hazard Criteria consider environmentally relevant levels when considering the Hazard Criteria limit LC 50 for coho

Ecology response: Until an alternative is ubiquitously used in tires, we don't know what kind of concentrations we will see in the environment, no matter what properties the potential alternative has. We must rely on known data (i.e., 6PPD and 6PPD-quinone levels). This hazard criteria aims to find safer chemicals overall, not just those that have less impact on the environment after initial exposure. Special considerations may also allow flexibility with the limits.

VI. USTMA recommends that Ecology also consider the water solubility of potential alternatives in consideration of the hazard criteria

Ecology response: We have added clarifying language concerning water solubility. If a potential alternative or its transformation product are not soluble >100 ug/L, then the toxicity limit is what is achievable at the limit of solubility, following GHS guidelines.[8] However, we are also allowing for this

[8] https://www.ilo.org/legacy/english/protection/safework/ghs/ghsfinal/ghsc14.pdf

within our special considerations, as low water solubility affects exposure routes and mobility of the chemical.

VII. USTMA recommends that exposure conditions be considered as part of the criteria that "Alternatives must have data on the acute toxicity for transformation products after exposure to ozone."

Ecology response: We intentionally left exposure conditions open-ended to encourage a wider variety of data and research. Theoretically, anything formed at higher concentrations of ozone could form at lower concentrations as well, which still allows us to identify anything that could be formed.

We have added clarifying language to explain that transformation products are required to meet the same LC_{50} as parent compounds for aquatic toxicity testing.

VIII. USTMA requests clarifications on the experimental data to be developed to assess acute aquatic toxicity to coho salmon

a. USTMA recommends that Ecology provide clarification whether data on daphnia and algae acute toxicity must necessarily be laboratory-generated

Ecology response: Data must be laboratory generated, and we added clarification to the document. We are not requiring researchers to use any standard methods in order to encourage a wider range of research. That said, we have added example methods for reference in the document.

b. USTMA recommends that Ecology provide additional information on the experimental data on acute toxicity to coho salmon for potential alternatives

Ecology response: We have added clarifying language in the hazard criteria document to mention that we will only allow *in-vitro* testing for rainbow trout. All other toxicity testing must be *in-vivo*. We are not requiring that researchers use standard protocols but have added example methods in the document. We will examine all data for good scientific practices before use.

c. USTMA recommends that Ecology provide additional information regarding which acute toxicity tests will be required for transformation products of potential alternatives.

Ecology response: We added clarifying language to indicate transformation products and their parent compounds have the same toxicity testing requirements.

I. USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Wu et al. 2023 study

Ecology response: We reviewed and edited references.

USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Hua et al 2023 study.

Ecology response: We reviewed and edited references.

USTMA requests that Ecology consider relevant exposure data when describing the available literature on environmental concentrations.

Ecology response: We reviewed and edited references.

USTMA requests clarification whether the proposed changes to the "very high" GreenScreen category will result in a shift of subsequent GreenScreen categories.

Ecology response: We are not changing the scoring of any category. Chemicals with acute aquatic LC_{50} values of <1 mg/L will still score as "very high" for this endpoint. We are putting a limit on the LC_{50} value that we will allow to consider a chemical "safer" by default (LC_{50} must be greater than 0.1 mg/L).

Comment from Neil Smith

Please see the uploaded PDF with comments from Flexsys Inc. Thank you.

July 14, 2023

Via Electronic Filing

Craig Manahan, Ph.D.
6PPD Chemist
Washington State Department of Ecology

RE: Comments of Flexsys on the Washington State Department of Ecology 6PPD Alternatives Assessment Hazard Criteria

Dear Dr. Manahan:

Flexsys appreciates the opportunity to provide comments on the Washington State Department of Ecology (Department of Ecology) 6PPD Alternatives Assessment Hazard Criteria (Draft Criteria)[1]. Flexsys is the largest U.S. producer of tire additives, including vulcanizing agents, antidegradants, and post-vulcanization stabilizers. Our products are well known for their positive impact on the durability and longevity of tires and other rubber goods, which supports passenger safety while reducing waste and saving resources. We strive for resource efficiency in our production processes and we carefully manage the safety of our operations to ensure the well-being of our customers, our employees, and the communities in which we operate. For over fifty years we have set the standard for additive quality and have been focused on chemicals and solutions that make rubber products, including tires, safer, last longer, and perform better. Based on our experience and expertise, we are providing the following comments for consideration.

Flexsys Encourages Stringent Data Standards For 6PPD Replacements

Flexsys supports the development of a transparent set of criteria for identifying safer alternatives to 6PPD in motor vehicle tires. We agree that the existing criteria that have been used by the Safer Products for Washington program should be supplemented, and we support adding the three additional criteria that have been proposed:

1. Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.
2. Alternatives must have data on the toxicity of transformation products after exposure to ozone.
3. Placing a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L).

The approach in the Draft Criteria is practical, flexible and, if implemented as proposed, will help to ensure that 6PPD alternatives are safer. Through this approach the Department of Ecology can successfully ensure protections to human and environmental health.

Flexsys also encourages the Department of Ecology to ensure, consistent with the Safer Products for Washington program, that all known data will be used and considered, even if it is outside of the required elements. We look forward to seeing more clarity from the Department of Ecology on how the additional tests will be performed. For instance, additional details on ozone concentrations and the appropriate length of exposure when subjecting chemicals to ozonation will be important for ensuring consistency. Similarly, standardized protocols describing how leachate from vulcanized rubber compounds, including motor vehicle tires, should be collected would also be helpful to stakeholders that wish to provide the Department of Ecology with additional information. Finally, we encourage the Department of Ecology to consider adding acute aquatic toxicity testing requirements for the predominant transformation products that are identified for all alternatives considered.

Flexsys Welcomes Collaboration With the Department of Ecology

Flexsys appreciates the extensive resources and outreach that the Department of Ecology has provided to stakeholders that are interested in closely following its research on 6PPD and replacements. Flexsys recently signed a Cooperative Research and Development Agreement (CRADA) with the U.S. Department of Agriculture - Agricultural Research Service to explore potential alternatives to 6PPD[2] and would welcome additional collaboration with the Department of Ecology.

As we continue to conduct research on 6PPD and alternatives, we will strive to share information with the Department of Ecology. For instance, we have completed acute aquatic toxicology testing on 77PD and one of its transformation products. We are currently working to publish this information and will share the data in the near term. These results will support the Department of Ecology's approach to ensuring that both parent compounds and transformation products are sufficiently tested.

Thank you for the important work that the Department of Ecology is doing to identify 6PPD alternatives and to ensure that these alternatives will protect public health and the environment. We welcome any questions and further discussion on this important topic. Please contact Diane McVehil at diane.mcvehil@flexsys.com with any questions.

Sincerely,
Neil Smith, Chief Technology and Sustainability Officer, Flexsys

Footnotes:

[1] https://apps.ecology.wa.gov/publications/SummaryPages/2304036.html

[2] See https://flexsys.com/2023/flexsys-announces-6ppd-alternatives-cooperative-research-development-agreement-with-usda-ars/

Response to Neil Smith

- The approach in the Draft Criteria is practical, flexible and, if implemented as proposed, will help to ensure that 6PPD alternatives are safer.

  Ecology response: Thank you for submitting your comments to Ecology. We applaud Flexsys signing a CRADA with USDA and look forward to seeing your results.

- Flexsys also encourages the Department of Ecology to ensure, consistent with the Safer Products for Washington program, that all known data will be used and considered, even if it is outside of the required elements. We look forward to seeing more clarity from the Department of Ecology on how the additional tests will be performed. For instance, additional details on ozone concentrations and the appropriate length of exposure when subjecting chemicals to ozonation will be important for ensuring consistency. Similarly, standardized protocols describing how leachate from vulcanized rubber compounds, including motor vehicle tires, should be collected would also be helpful to stakeholders that wish to provide the Department of Ecology with additional information.

  Ecology response: We are intentionally leaving methods open-ended to encourage a wide variety of research. We have added example methods into the hazard criteria document in case they are helpful. However, we are not requiring researchers use these specific methods. That said, we will check all research for best scientific practice.

- Finally, we encourage the Department of Ecology to consider adding acute aquatic toxicity testing requirements for the predominant transformation products that are identified for all alternatives considered.

  Ecology response: We do not believe additional testing of dominant transformation products is a feasible requirement. We don't want to require that transformation products are all identified, synthesized, and tested because this would add significant time and funding to the development of alternatives. That said, we

encourage this work and would use all data available on transformation products. Our main goal with this assessment is to find safer alternatives to 6PPD. Typically, a safer parent compound is the best indicator of safer overall transformation products. Also, if the mixture of transformation products is safer than 6PPD-q, it is unlikely the individual products are significantly more toxic.

Comment from Christian Gunther

Please do everything in your power to curtail, if not outlaw the use of 6PPD. WA State, for too long, has often -generally- lagged California on environmental standards and restrictions. California has the right idea. Put people over industry, however awkward or impractical the adjustment might seem in the short run. We simply have no right to destroy this planet as a habitat for life. Indeed, the proverbial road we are traveling will wipe us out with the rest of what we ruin. Bold swift action to save non-human life and ours alike can't come too fast. Thank you.

Response to Christian Gunther

Thank you for submitting your comment to Ecology.

We greatly appreciate your concern surrounding 6PPD in motor vehicle tires. However, we do not have authority under this AA to regulate 6PPD. We want to make sure safer alternatives to 6PPD are available to prevent regrettable substitutions. Currently, California does not regulate 6PPD. If the California Department of Toxic Substances Control identifies safer alternatives, we could use that information in our Alternatives Assessment.

Appendix A: 6PPD Alternatives Assessment Hazard Criteria for Public Comment Period

Abstract

6PPD is an antioxidant and antiozonant used in motor vehicle tires to prevent tire cracking and promote tire longevity. Researchers have determined that 6PPD has aquatic toxicity, reproductive toxicity, environmental persistence, and bioaccumulation potential, making it a chemical of concern. 6PPD ozonation also leads to harmful breakdown products such as 6PPD-quinone (6PPD-q). This chemical has a higher toxicity than 6PPD to aquatic organisms, including species of cultural and environmental significance like the coho salmon (juveniles LC_{50} 0.095 ug/L). Some 6PPD transformation products also have potential for bioaccumulation within fish tissue and organs, which can lead to harmful long-term effects.

The Washington State Legislature has tasked the Department of Ecology with performing an Alternatives Assessment on 6PPD in motor vehicle tires to identify compounds with the potential to replace 6PPD in these products. To set a transparent standard for identifying safer alternatives, we opted to use criteria for safer alternatives similar to those created for the Safer Products for Washington program, but with three additions to better protect sensitive species.

1. Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.
2. Alternatives must have data on the toxicity of transformation products after exposure to ozone.
3. We will place a limit on the acute toxicity LC_{50} values allowed in the minimum criteria (>0.1 mg/L).

Hazard Criteria

Background and Justification

As part of the 2022 state budget[9] the Washington State Legislature assigned the Department of Ecology to conduct a "full safer alternatives assessment (AA) of the 6PPD compounds used in tires. The assessment shall incorporate and evaluate toxicity data of alternatives on Coho and other species." 6PPD (*N*-(1,3-dimethylbutyl)-*N*′-phenyl-*p*-phenylenediamine) is currently used within rubber products such as vehicle tires as an antioxidant and antiozonant; however, data summarized in a chemical hazard assessment of 6PPD[10] have identified 6PPD as:

- A reproductive toxicant.

[9] See substitute senate bill 5693 (38): https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Senate%20Bills/5693-S.pdf?q=20230427092322

[10] https://www.ezview.wa.gov/Portals/_1962/Documents/6ppd/GreenScreenExecutiveSummaryFor6PPD.pdf

- An environmental toxicant of high concern.
- Persistent in the environment.
- Capable of bioaccumulation.
- A skin sensitizing compound.

Use of 6PPD as an antioxidant and antiozonant within tires leads to 6PPD ozonation and the development of several breakdown products, including 6PPD-quinone (6PPD-q) (Zhao et al. 2023). 6PPD-q is more toxic than 6PPD to many aquatic species. For example, a direct comparison study examined the LC_{50} (concentration that kill 50% of exposed organisms) of 6PPD and 6PPD-q on zebrafish larvae. This study found that 6PPD-q has an LC_{50} that is approximately 77% lower than 6PPD after 24 hours of exposure and 70% lower after 96 hours of exposure (Varshney et al. 2022).

Pacific Northwest coho salmon (*Oncorhynchus kisutch)*, a species of cultural and ecological significance, are particularly sensitive to 6PPD-q (juvenile 24hr LC_{50}; 0.000095 mg/L) and susceptible to urban runoff mortality syndrome (i.e., when coho salmon die prior to spawning due to chemical exposure from urban runoff) (Tian et al. 2021; Tian et al. 2022). Further information on acute and chronic toxicity of 6PPD-q to various fish, and how 6PPD-q LC_{50} compares to other chemicals, is available in Tables 1 and 2.

Table 1. LC_{50} values of various fish species exposed to 6PPD-quinone. Obtained from Lo et al. 2023.

Species	LC50 (NG/L)	Life stage	Time (h)	Reference
Oncorhynchus kisutch (coho salmon)	41	Juvenile; ~3 weeks	24	Lo et al. (2023)
Oncorhynchus tshawytscha (Chinook salmon)	<67,306[a]	Juvenile; ~3 weeks	24	Lo et al. (2023)
Oncorhynchus kisutch (coho salmon)	95	Juvenile; 1+ year	24	Tian et al. (2022)
Salvelinus leucomaenis pluvius (white-spotted char)	510	Juvenile; <1 year	24	Hiki and Yamamoto (2022)
Salvelinus fontinalis (brook trout)	590	Juvenile; ~1 year	24	Brinkmann et al. (2022)
Oncorhynchus mykiss (rainbow trout)	1,960	Juvenile; ~ 2 year	24	Brinkmann et al. (2022)
Salvelinus curilus (southern Asian dolly varden)	>10,000[a]	Juvenile; <1 year	24	Hiki and Yamamoto (2022)

Species	LC50 (NG/L)	Life stage	Time (h)	Reference
Oncorhynchus masou masou (masu salmon)	>10,000[a]	Juvenile; <1 year	24	Hiki and Yamamoto (2022)
Salvelinus alpinus (Arctic char)	>12,700[a]	Juvenile; ~ 3 year	24	Brinkmann et al. (2022)
Acipenser transmontanus (white sturgeon)	>12,700[a]	Juvenile; ~ 4.5 year	24	Brinkmann et al. (2022)
Oryzias latipes (Japanese medaka)	>34,000[a]	Juvenile; 41 days	96	Hiki et al. (2021)
Danio rerio (zebrafish)	>54,000[a]	Embryo	96	Hiki et al. (2021)
Danio rerio (zebrafish)	308,670	Embryo	96[b]	Varshney et al. (2022)

[a] Value is greater than the highest concentration tested.

[b] Concentrations were measured for all studies, except for Varshney et al. (2022), which used nominal concentrations. Several species' median lethal concentration (LC_{50}) estimates are greater than the highest concentration tested, including the Lo et al. (2023) Chinook study. For ease of comparison, 24-h LC_{50} values were selected when available.

Table 2. Toxicity comparison of 6PPD-quinone (tested on coho salmon) to toxicity of chemicals of concern on other sensitive species (OP*:* organophosphate*;* OC*:* organochlorine*;* CI*:* confidence interval). Obtained from Tian et al. 2022.

Chemical Class	Name	Most Sensitive Species	LC_{50} (ppb)	95% CI
OP	Parathion	*Orconectes nais*	0.04	0.01—0.2
Quinone	6PPD-q	*O. kisutch*	0.10	0.08—0.11
OC	Mirex	*Procambaris blandingi*	0.10	Not reported
OP	Guthion	*Gammarus fasciatus*	0.10	0.073—0.014
OP	Chlorpyrifos	*Gammarus lacustris*	0.11	Not reported
OC	Endrin	*Perca flavescens*	0.15	0.12—0.18
OC	4,4'-DDT	*O. nais*	0.18	0.12—0.18

Chemical Class	Name	Most Sensitive Species	LC_{50} (ppb)	95% CI
OP	Diazinon	*Ceriodaphia dubia*	0.25	Not reported
Metal	Cadmium	*Oncorhynchus mykiss*	0.35	Not reported
OC	Methoxychlor	*O. nais*	0.50	0.25—1.8
OC	Dieldrin	*Pteronarcella badia*	0.50	0.37—0.67
OP	Malathion	*G. fasciatus*	0.76	0.63—0.92
OC	Toxaphene	*Ictalurus punctatus*	0.8	0.5—1.2

In addition to aquatic toxicity, recent research has identified other concerns around 6PPD-quinone. A 6PPD-q reaction product, 6PPDq-dG, has the potential for bioaccumulation and genotoxicity within green algae (*Chlamydomonas reinhardtii*) and fish organs and tissue (Capelin, *Mallotus villosus*) (Wu et al. 2023). This product forms after exposure to Deoxyguanosine, one of the deoxyribonucleotides that make up DNA. 6PPD-q has also shown some intestinal toxicity in low concentrations and lethality to the common study species *Caenorhabditis elegans* (Hua et al. 2023).

With the known toxicity of 6PPD, and our increasing understanding of 6PPD-quinone's toxicity, it is critical to identify an alternative for use within motor vehicle tires. The Department of Ecology is also separately evaluating stormwater management approaches to prevent toxicity in receiving waters. An Alternatives Assessment (AA) on 6PPD will help us identify alternatives that will protect aquatic species and prevent further environmental contamination. For this assessment, we plan on using the hazard criteria as described in the Safer Products for Washington (SPWA) Regulatory Determinations Report to the Legislature[11] (June 2022), with three additions.

Due to the known effects of 6PPD and 6PPD-q on aquatic species, especially coho salmon, we want to ensure that any alternative identified as safer will have less adverse effects on aquatic species. We know that any chemical used as an anti-degradant in tires will find its way into salmonid spawning streams. Researchers have detected 6PPD-q in the environment at levels such as 0.21-2.43 µg/L in Hong Kong urban runoff affected creeks (Cao et al. 2022) and 4.1-6.1 µg/L in Los Angeles runoff (Tian et al. 2021). These values are extremely toxic to the most sensitive species.

[11] https://apps.ecology.wa.gov/publications/documents/2204018.pdf

Due to the high toxicity of 6PPD and its breakdown products, we must place greater emphasis on aquatic toxicity endpoints compared to other chemicals and products considered under SPWA. In addition, whereas we are protecting against the theoretical potential for adverse impacts from use of priority chemicals with other products identified in SPWA, we know that the current use of 6PPD in tires leads directly to pre-spawn mortality in coho salmon. Recent detection of 6PPD within biomonitoring samples suggest that it could be a hazard for human health as well, where 6PPD and 6PPD-q were identified within human urine samples (Du et al. 2022). Therefore, we aim to find alternatives that have a lower hazard than 6PPD in our endpoints of concern.

Criteria for Safer Alternatives to 6PPD

Safer Products for Washington developed criteria to use in the identification of safer alternatives in the first cycle of priority chemical classes. These criteria include minimum and additional requirements to identify progressively safer alternatives, including:

1. Potential alternative chemical has data on required hazard endpoints, as outlined in Table 3.
2. Data shows that the chemical aligns with the GreenScreen® Benchmark 2 category or better.
3. All known data will be used, even if it is outside of the required endpoints.

Table 3. Hazard endpoint and data requirement for alternate chemicals within Safer Products for Washington Criteria for Safer chemicals.

Hazard endpoint	Requirement
Carcinogenicity	Required
Mutagenicity/Genotoxicity	Required
Reproductive or Developmental Toxicity	Required
Endocrine Disruption	Not required
Acute Toxicity	Not always required*
Single or Repeat Systemic Toxicity	Not always required*
Single or Repeat Neurotoxicity	Not always required*
Skin or Respiratory Sensitization	Required
Skin or Eye Irritation	Not required
Acute or Chronic Aquatic Toxicity	Required
Persistence	Required
Bioaccumulation	Required

*Two of the three required.

SPWA criteria relies on the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) scoring system for aquatic toxicity. The aquatic toxicity of 6PPD-quinone is 1000 times higher than the "very high" score in the GHS scoring system. Therefore, a chemical could be 1000 times better than 6PPD-q and the SPWA (and GHS) scoring systems would not discern the difference. Further, the data requirements for SPWA do not include coho salmon. While 6PPD is toxic to other aquatic species, the toxicity of its breakdown product 6PPD-q to coho salmon is much more severe. Therefore, due to the high toxicity of 6PPD-q to species of concern, we are adding three additions to the criteria used for SPWA for the 6PPD AA.

First Addition

To meet the minimum criteria for safer in the 6PPD AA, we will require chemicals to have experimental data on acute aquatic toxicity to coho salmon. This aligns with a requirement set forth by the Washington State Legislature in the state budget ("The assessment shall incorporate and evaluate toxicity data of alternatives on Coho and other species").[12] We will also require data on two other trophic levels (e.g., daphnia and algae). In comparison, SPWA criteria only requires data on acute or chronic aquatic toxicity and allows us to use modeled data.

Second Addition

Any alternative chemical that meets the minimum criteria must also have data showing acute toxicity information for transformation products when the potential alternative is exposed to ozone. This includes data on transformation products as a group and separately on quinone toxicity. This is because the potential alternative still needs to act as an antiozonant whose purpose is to transform after ozone exposure; therefore, transformation products will, by definition, occur with use. We will evaluate ozonation methods on a case-by-case basis as data is produced, and encourage discussion with the 6PPD project lead or technical team concerning desired ozonation methods before any toxicity testing is conducted.

Third Addition

We will place stricter requirements on acceptable hazard scores for acute aquatic toxicity by placing a strict upper bound on the LC_{50} values allowed in the minimum criteria for the 6PPD AA (>0.1 mg/L).

6PPD-quinone has an LC_{50} value towards coho salmon of ~0.1 ug/L (Tian et al. 2022). Due to the extreme toxicity of 6PPD-q, even chemicals that are 1000 times less toxic would still score as a very high hazard for this endpoint. Therefore, during the 6PPD AA, chemicals with LC_{50} values of less than 0.1 mg/L (100ug/L) will not pass the minimum criteria to be identified as a safer alternative to 6PPD.

[12] See substitute senate bill 5693 (38): https://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/Senate%20Bills/5693-S.pdf?q=20230427092322

Chemicals with LC_{50} values of greater than 0.1mg/L may pass the minimum criteria defined for 6PPD alternatives, provided they meet the requirements in other endpoints, even though they would still score as very high for acute aquatic toxicity.

Process for Identifying a Safer Alternative to 6PPD

6PPD does not meet the minimum criteria outlined in SPWA criteria (Table 3) for safer. 6PPD scored as a GreenScreen® Benchmark 1 chemical in a hazards assessment[13] and demonstrates human and environmental hazards post-exposure that are not consistent with our minimum criteria for safer. Using SPWA criteria, alternatives to 6PPD must meet minimum criteria for safer (Figure 1).

However, we want to emphasize that if none of the alternative chemicals we evaluate in our 6PPD AA meet the minimum criteria, we will evaluate special considerations (Figure 1). Therefore, just because a chemical does not meet the minimum criteria for safer does not mean that we cannot find a safer alternative in the 6PPD AA. For example, we may consider a chemical that does not meet our minimum criteria to be safer than 6PPD if the chance of exposure is lower than 6PPD and 6PPD-q. When assessing exposure potential, we consider the relevance of known and potential exposure routes and the magnitude of exposure. You can find details on special considerations and evaluations on exposure pathways in the SPWA criteria document.

[13] https://www.ezview.wa.gov/Portals/_1962/Documents/6ppd/6PPD%20Alternatives%20Technical%20Memo.pdf

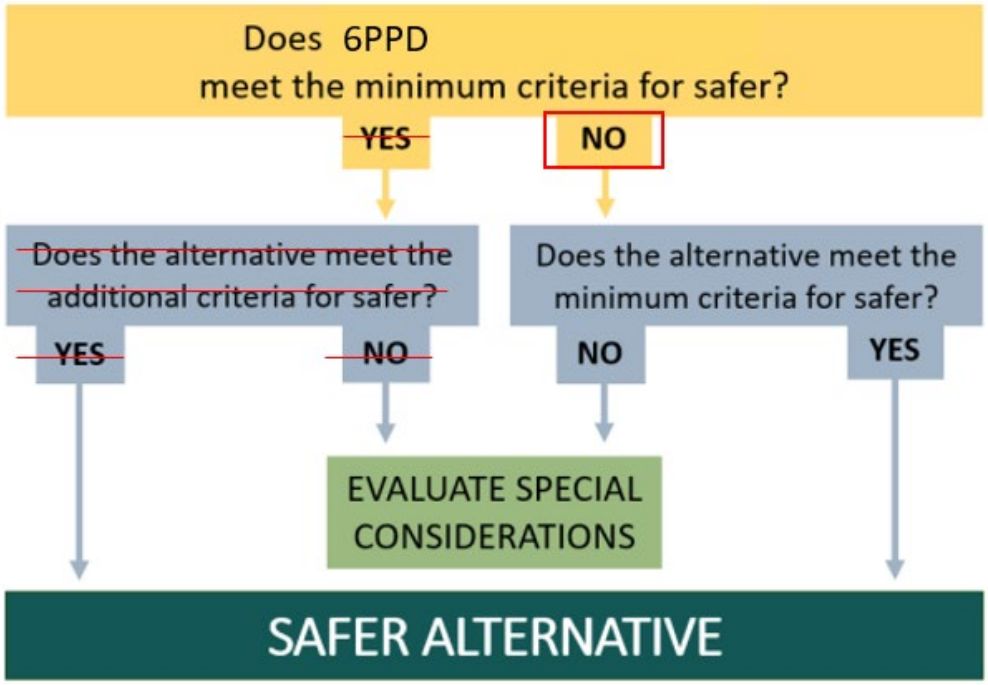


Figure 1: Flowchart demonstrating how we will identify safer alternatives to 6PPD for the 6PPD Alternatives Assessment. Because we know 6PPD does not meet the minimum criteria for safer, we are evaluating whether alternatives meet the minimum criteria. If yes, it meets the requirements as a safer alternative. If no, we will evaluate special considerations.

References

Brinkmann, M., D. Montgomery, S. Selinger, J.G.P. Miller, E. Stock, A.J. Alcaraz et al. 2022. Acute toxicity of the tire rubber-derived chemical 6PPD-quinone to four fishes of commercial, cultural, and ecological importance. *Environmental Science and Technology Letters* 9(4): 333-338. doi: 10.1021/acs.estlett.2c00050.

Cao, G., W. Wang, J. Zhang, P. Wu, X. Zhao, Z. Yang et al. 2022. New evidence of rubber-dervied quinones in water, air, and soil. *Environmental Science and Technology* 56 (7): 4142-4150. doi: 10.1021/acs.est.1c07376.

Du, B., L. Bowen, Y. Li, M. Shen, L. Liu, and L. Zeng. 2022. First report on the occurrence of N-(1,3-Dimethylbutyl)-N′-phenyl-p-phenylenediamine (6PPD) and 6PPD-Quinone as pervasive pollutants in human urine from South China. *Environmental Science and Technology Letters* 9(12): 1056-1062. doi: 10.1021/acs.estlett.2c00821.

Hiki, K., K. Asahina, K. Kato, T. Yamagishi, R. Omagari, Y. Iwasaki et al. 2021. Acute toxicity of a tire rubber-derived chemical, 6PPD quinone to freshwater fish and crustacean species. *Environmental Science and Technology Letters* 8(9): 779-784. doi: 10.1021/acs.estlett.1c00453.

Hiki, K., and H. Yamamoto. 2022. The tire-derived chemical 6PPD-quinone is lethally toxic to the white-spotted char *Salvelinus leucomaenis pluvius* but not to two other Salmonid species. *Environmental Science and Technology Letters* 9(12): 1050–1055. doi: 10.1021/acs.estlett.2c00683.

Hua, X., X. Feng, G. Liang, J. Chao, and D. Wang. 2023. Long-term exposure to tire-derived 6-PPD quinone causes intestinal toxicity by affecting functional state of intestinal barrier in *Caenorhabditis elegans*. *Science of the Total Environment* 861: 160591. doi: 10.1016/j.scitotenv.2022.160591.

Lo, B.P., V.L. Marlatt, X, Liao, S. Reger, C. Gallilee, A.R.S. Ross et al. 2023. Acute toxicity of 6PPD-Quinone to early life stage juvenile chinook (*Oncorhynchus tshawytscha*) and Coho (*Oncorhynchus kisutch*) salmon. *Environmental Toxicology* 42(4): 815-822. doi: 10.1002/etc.5568.

Tian, Z., H. Zhao, K.T. Peter, M. Gonzalez, J. Wetzel, C. Wu et al. 2021. A ubiquitous tire rubber–derived chemical induces acute mortality in coho salmon. *Science* 371 (6525): 185-189. doi: 10.1126/science.abd6951.

Tian, Z., M. Gonzalez, C.A. Rideout, H.N. Zhao, X. Hu, J. Wetzel et al. 2022. 6PPD-Quinone: Revised toxicity assessment and quantification with a commercial standard. *Environmental Science and Technology Letters* 9(2): 140-146. doi: 10.1021/acs.estlett.1c00910.

Varshney, S., A.H. Gora, P. Siriyappagouder, V. Kiron, and P.A. Olsvik. 2022. Toxicological effects of 6PPD and 6PPD quinone in zebrafish larvae. *Journal of Hazardous Materials* 424(C): 127623. doi: 10.1016/j.jhazmat.2021.127623.

Wu, J., G. Cao, F. Zhang, and Z. Cai. 2023. A new toxicity mechanism of N-(1,3-Dimethylbutyl)-N'-phenyl-p-phenylenediamine quinone: Formation of DNA adducts in mammalian cells and aqueous organisms. *Science of the Total Environment* 866: 161373. doi: 10.1016/j.scitotenv.2022.161373.

Zhao, H.N., X. Hu, Z. Tian, M. Gonzalez, C.A. Rideout, K.T. Peter et al. 2023. Transformation products of tire rubber antioxidant 6PPD in heterogenous gas-phase ozonation: identification and environmental occurrence. *Environmental Science and Technology* 57(14): 5621-5632. doi:10.1021/acs.est.2c08690.

Appendix B. Comments in Original Format

This appendix shows the original format of comments we received. The content in this section is also contained in the main body of the report. If you are using a screen reader to access this information, please refer to the main body, as this appendix is repetitive and not tagged.

Tao Li

It is nice to see the approach to address long-term concerns in the selection for alternatives.

For evaluating these alternatives, one would need to use 6PPD and 6PPDQ as references. That means we need to know the hazardous endpoints and Greenscreen scores for them.

It is also known that 6PPD and 6PPDQ are actually chiral chemicals, suggesting there are actually four chemicals under two names. For proper evaluation, they should be investigated separately.

Edward Kolodziej

Global research has demonstrated how ubiquitous tire-rubber derived chemical contaminants can be, both environmentally and also with very substantial human exposures. Given the very substantial potential for human exposure to tire rubber derived compounds, I recommend that any prospective 6PPD alternatives also be required to collect and submit experimental data comparing human toxicity endpoints against 6PPD results (as a baseline for comparison) for a full range of human health toxicity endpoints using in vitro assays or other common chemical toxicity screening procedures. It is very important to consider not just ecological endpoints, but also human health endpoints as well for the data driven process of finding 6PPD alternatives.

Constraining transformation product assessments to -1-ozonation mixtures only-1- may miss very substantial and important products formed by other reaction systems. Key products formed by any typical environmental process should be evaluated too. Extending mixture screening to other reactive environmental processes such as hydrolysis, photolysis, etc should be used to fully determine key products and their toxicity potential.

I also recommend consideration of sublethal endpoints for 6PPD alternatives, including growth, reproduction, and biological/ecological function. It is becoming clear that sublethal impacts also are occurring for 6PPD and 6PPD-quinone exposures thta contribute substantially to their environmental risk profile (even for -1-insensitive organisms-1-, and constraining ecological safety to lethal endpoints can allow for replacements to be more toxic with respect to major sublethal endpoints. -1-Safer-1- should be extended to ALL possible endpoints, both lethal and sublethal, to be consistent with current knowledge of where adverse impacts on aquatic organisms arise.

The Hazard Criteria document reads great, but here are several quick thoughts:

1. Except for ozone reactions, all other hazard criteria proposed here were developed for conventional chemicals. However, when it comes to antioxidants, I believe it is essential to assess both PBT/vPvB characteristics and toxicity of their oxidation products by using nontargeted analysis to identify major reaction products, and then synthesize the products for subsequent experiments. This assessment should involve a combination of experimental data and modeling approaches. The reason for this is that antioxidants can undergo rapid oxidation, transforming into potentially more toxic or persistent compounds within a matter of minutes or days. This has been observed in the case of 6PPD and 6PPD-Quinone.[1] This is also true for other antioxidants including organophosphites (converted to organophosphates,[2] or thiophosphates[3] in minutes or days), and sulfur-containing antioxidants[4].
2. If PPD compounds are being considered as potential replacement chemicals, conducting tests on coho salmon could be risky and may result in the introduction of a regrettable alternative. The main reason for this concern is the lack of understanding regarding the toxicity mechanism of 6PPD-Q (6PPD-Quinone). Specifically, the protein target responsible for its toxicity remains unidentified. It is possible that a particular PPD-quinone, such as IPPD-Q, may not exhibit toxicity towards coho salmon, but could be toxic to other fish species with slightly different protein binding pockets. To move forward in a responsible manner, there are two possible approaches: 1) Testing a broader range of fish species, including those known to be sensitive to the toxicity of 6PPD-Q, such as rainbow trout, brook trout, white-spotted char, and others[5, 6]; 2) Conducting an in-depth investigation to identify the specific toxicity mechanism (timeline is hard to predict).

Hui Peng

2023/07/10

Reference

1. Tian, Z.; Zhao, H.; Peter, K. T.; Gonzalez, M.; Wetzel, J.; Wu, C.; Hu, X.; Prat, J.; Mudrock, E.; Hettinger, R.; Cortina, A. E.; Biswas, R. G.; Kock, F. V. C.; Soong, R.; Jenne, A.; Du, B.; Hou, F.; He, H.; Lundeen, R.; Gilbreath, A.; Sutton, R.; Scholz, N. L.; Davis, J. W.; Dodd, M. C.; Simpson, A.; McIntyre, J. K.; Kolodziej, E. P. A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon. *Science* **2021,** *371*, (6525), 185-189.
2. Liu, R.; Mabury, S. A. Organophosphite Antioxidants in Indoor Dust Represent an Indirect Source of Organophosphate Esters. *Environ Sci Technol* **2019,** *53*, (4), 1805-1811.
3. Chen, W. Z.; Almuhtaram, H.; Andrews, R. C.; Peng, H. Unanticipated Thio-oxidation of Organophosphite Chemical Additives in PVC Microplastics Following In-Situ Weathering. *ChemRxiv* **2023**.
4. Yang, D.; Liu, Q.; Wang, S.; Bozorg, M.; Liu, J.; Nair, P.; Balaguer, P.; Song, D.; Krause, H.; Ouazia, B.; Abbatt, J. P. D.; Peng, H. Widespread formation of toxic nitrated bisphenols indoors by heterogeneous reactions with HONO. *Science advances* **2022,** *8*, (48), eabq7023.
5. Brinkmann, M.; Montgomery, D.; Selinger, S.; Miller, J. G. P.; Stock, E.; Alcaraz, A. J.; Challis, J. K.; Weber, L.; Janz, D.; Hecker, M.; Wiseman, S. Acute Toxicity of the Tire Rubber-Derived Chemical 6PPD-quinone to Four Fishes of Commercial, Cultural, and Ecological Importance. *Environ. Sci. Technol. Lett.* **2022,** *9*, 333-338.
6. Hiki, K.; Yamamoto, H. The Tire-Derived Chemical 6PPD-quinone Is Lethally Toxic to the White-Spotted Char Salvelinus leucomaenis pluvius but Not to Two Other Salmonid Species. *Environ. Sci. Technol. Lett.* **2022,** *9*, (12), 1050-1055.

Jennifer Lanksbury

King County's Water and Land Resources Division (WLRD) would like to thank the Washington State Department of Ecology (Ecology) for the opportunity to comment on Ecology's 6PPD Alternative Assessment Hazard Criteria.

WLRD safeguards King County's water and land resources by providing services that protect public health and safety and yield significant environmental benefits. WLRD provides flood control services, stormwater management, and other natural resource management services throughout the county. WLRD manages the stormwater program for unincorporated areas, houses three salmon recovery forums, restores habitat, monitors water quality, and controls noxious weeds. Additionally, WLRD operates King County's Environmental Lab and Science sections, which provide environmental monitoring, data analysis, and management and modeling services to partners, jurisdictions, and residents throughout the region.

We support the Ecology hazard criteria developed in the 6PPD Alternative Assessment Hazard Criteria. However, we do have a couple comments, which we think would strengthen the criteria:

• Expand the -1-second addition-1- to include more environmental factors: The -1-second addition-1- (page 8) used for the 6PPD Alternative Assessment (AA) indicates any alternative chemical must have data showing acute toxicity information for transformation products when the potential alternative is exposed to ozone. We are concerned this ozone exposure criterion is too narrowly focused, particularly if potential alternatives are considered outside of the PPD family. We recommend consideration of acute toxicity information for transformation products resulting from exposure to any environmental factors that could cause chemical transformation of the potential alternative (e.g., ozone, variations in pH, heat, UV exposure, etc.) into a more toxic compound.

• Include more information regarding the minimum criteria for special considerations: Under the -1-Process for Identifying a Safer Alternative to 6PPD-1- heading (page 8), Ecology states that if none of the alternative chemicals evaluated in the 6PPD AA meet the minimum criteria, they will evaluate 'special considerations', including the relevance of known and potential exposure routes and the magnitude of exposure. The reader is referred to the Safer Products for Washington (SPWA) Regulatory Determinations Report to the Legislature (June 2022) document for further information on special considerations. We would like to see more specific information regarding how Ecology will judge potential alternatives that fail to meet the minimum criteria. Because this AA is unique and particularly focused, it seems Ecology could more specifically define the minimum criteria for special considerations. For instance, will there be any additional special considerations for the 6PPD AA, other than those currently mentioned in the SPWA document? If so, what will those minimum criteria include? Will the criteria for special considerations be available for comment before the 6PPD AA is conducted?

Thank you for the opportunity to comment on the 6PPD Alternative Assessment Hazard Criteria. Please let us know if you have any questions.

Elliot Rossomme

I think that the propose requirements are generally on the modest side of adequate, and that they appropriately address the most pressing aspects of the problems posed by 6PPD and its quinone. Specifically, the toxicity boundary of >0.1 mg/mL seems reasonable to me in light of both the extreme toxicity of 6PPDQ and the concentrations of 6PPD transformations generally found in urban runoff. It would also be defensible to raise this boundary to 1 mg/mL, in my opinion.

That being said, I think the most significant gap in the proposed requirements is the failure to address the upstream implications of using 6PPD in tires. Like many tire ingredients, 6PPD is derived from petroleum feedstocks, and commercial dependence on this anti-degradant (and those like it) contributes to ecological destruction in ways other than the acute toxicity of transformation products. While it raises the regulatory hurdle, the requirements indicated herein would be complemented by the inclusion of a cradle-to-grave life cycle analysis (LCA) to address problems associated with sourcing and manufacture of 6PPD vis-a-vis proposed alternatives.

I don't think it overstates the matter to say that the decision the Washington Department of Ecology makes will have implications for the regulations passed in other U.S. states, federally, and perhaps even globally. Furthermore, the tire industry is and will be investing significant resources into identifying and evaluating 6PPD alternatives. It thus seems likely that the alternative(s) that is (are) selected will be used in tire manufacturing for a long time to come, and regulatory agencies should at least consider, if not impose, requirements that replacements are sustainable from start to finish.

Damani Parran

1) For aquatic toxicity testing with coho salmon, are there specific protocols or OECD guidelines to follow? In addition, will these apply to testing of the 6PPD alternative and transformation products?
2) Are there specific protocols or guidelines to use for testing of transformation products from ozonation?
3) Will there be suggested laboratories that have the capability to conduct toxicology testing in coho salmon?

Bryce Divine

P
Permit number:23-05-3443, Associated permit#23-05-3448
SEPA Environmental Checklist is incomplete. Coal Creek has, in addition to Chinook Salmon, spawning populations of Coho Salmon and Winter Steelhead. All three species are listed as threatened. Noxious Weeds (class A, B, and C) are also present on this property including Japanese Knotweed. It is my opinion that this application should be rejected and perhaps redone so that an accurate assessment of environmental impacts is on the record.

Jamie McNutt

Please see the attached comments from the US Tire Manufacturers Association.

July 14, 2023

Washington Department of Ecology
Hazardous Waste and Toxics Reduction Program
PO Box 47600
Olympia, WA 98504-7600

Re: Draft 6PPD Alternatives Assessment Hazard Criteria

I. Overview

The U.S. Tire Manufacturers Association (USTMA) and our member companies appreciate the opportunity to provide comments on draft 6PPD Alternatives Analysis ("AA") hazard criteria.[1] USTMA is the national trade association for tire manufacturers that produce tires in the U.S. and are responsible for more than 291,000 jobs and have an annual economic footprint of $170.6 billion in the United States. USTMA advances a safe and sustainable tire manufacturing industry through a commitment to science-based public policy advocacy. The tires from our member companies make mobility possible and keep the U.S. economy moving.

Separately, Ecology issued a Draft Identification of Priority Chemicals Report to the Legislature, Safer Products for Washington Cycle 2, Implementation Phase 1 ("Draft Report") that proposes to designate 6PPD as a priority chemical. USTMA is submitting separate comments to Ecology on this Draft Report, which are incorporated by reference in these comments.

USTMA would like to emphasize the following comments on Ecology's hazard criteria document:

II. USTMA requests additional information as to how this draft AA hazard criteria will be used.

USTMA asks that Ecology include specific details about how the hazard criteria will be used and provide the opportunity for further dialogue and discussion on this topic. Specifically, USTMA is concerned with the statement on page 8 that "if none of the alternative chemicals we evaluate in our 6PPD AA meet the minimum criteria, we will evaluate special considerations." The draft hazard criteria does not specify what is meant by "special considerations." This information is essential to ensure transparency and clarity for all stakeholders. We are also concerned that depending on what the "special considerations" are, Ecology may stray beyond its statutory obligation when it evaluates those considerations.

We agree that defining the hazard criteria for potential alternatives to 6PPD is essential to identify alternatives and avoid regrettable substitutions. However, we urge Ecology to describe in as

[1] USTMA members include: Bridgestone Americas, Inc., Continental Tire the Americas, LLC; Giti Tire (USA) Ltd.; The Goodyear Tire & Rubber Company; Hankook Tire America Corp.; Kumho Tire Co., Inc.; Michelin North America, Inc.; Nokian Tyres; Pirelli Tire North America; Sumitomo Rubber Industries, Ltd.; Toyo Tire Holdings of Americas Inc. and Yokohama Tire Corporation.

much detail as possible what characteristics a chemical must have in order to be considered a safer alternative and to provide details on the meaning and definition of "special considerations." Further, we ask Ecology to provide specific information as to how the hazard criteria will be used to provide awareness and clarity for all stakeholders.

III. Given the need to ensure tire safety and performance, USTMA recommends that the hazard criteria include: "Alternatives must ensure continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements."

The composition and nature of the chemicals present in tires impart a function and the exact composition of tires cannot be modified without great care. It is not a simple process to change the composition of tires; any change could affect the stopping distance of tires, durability, vehicle fuel economy, tire wear, and other safety-related components. 6PPD provides critical functions in manufacturing safe and durable tires. For example, 6PPD in tires provides the following qualities:

- Optimal migration rate/ diffusion
    - Adequate solubility and diffusivity in rubber compounds, also referred to as migration and mobility
    - Continuously present at the surface of the tire to ensure protection of the rubber formulations from degradation due to ozone
    - Available in rubber formulation over a tire's entire life cycle to ensure protection of the rubber
- Protection against ozone
    - Readily reactive with ozone to prevent crack formation on the surface of the rubber, but not too reactive in order to prevent premature depletion
- Protection against oxygen
    - Reactive with oxygen to prevent hardening of the rubber, loss of strength, and improve tire wear
- Protection against fatigue
    - Reactive with the free radicals generated by the breaks in polymer during flexing. These free radicals can break the polymer chains and crosslinks in the rubber compound that would lead to a loss of strength
- Manufacturing Impact
    - No adverse effects on the processability of rubber compounds
    - Resistance to temperatures encountered during the tire manufacturing process
- No adverse effects on tire safety and performance

Any potential alternative to 6PPD must provide the same critical functions as 6PPD to ensure tire safety and performance. It is essential that the hazard criteria for potential alternatives to 6PPD include continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements to ensure motorist safety. Again, we ask that Ecology include a fourth criteria that specifies:

- *Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.*
- *Alternatives must have data on the toxicity of transformation products after exposure to ozone.*
- *We will place a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L)."*

- ***Alternatives must ensure continued compliance with Federal Motor Vehicle Safety Standards and other performance and safety requirements.***

IV. USTMA appreciates that Washington Ecology has provided guidelines for the testing that will be required to assess identification of potential alternatives to 6PPD, but recommends that it is premature to establish a limit

In the draft hazard criteria, Ecology states, "to set a transparent standard for identifying safer alternatives, we opted to use criteria for safer alternatives similar to those created for the Safer Products for Washington program, but with three additions to better protect sensitive species."

- Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.
- Alternatives must have data on the toxicity of transformation products after exposure to ozone.
- We will place a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L)."

Outlining the testing that will be required to assess potential alternatives is essential to drive progress on identifying potential alternatives to 6PPD. USTMA thanks Ecology for outlining in the guidance the testing that will be required to assess potential alternatives. However, inclusion of a limit at this point may limit adoption of a potentially safer alternative. Thus, USTMA believes that it is premature to set a limit on the acute toxicity requirement for an alternative. USTMA members are actively engaged in evaluating potential alternatives to 6PPD. Because evaluation of potential alternatives is still underway and a specific alternative has not yet been identified, it is not possible to understand the application concentration or the physiochemical properties of a non-existing chemical to understand what environmentally relevant exposures will be.

V. USTMA recommends that the final Hazard Criteria consider environmentally relevant levels when considering the Hazard Criteria limit LC 50 for coho

It would be inaccurate to assume that any replacement chemical would be exposed to the environment at the same levels as 6PPD currently exists. We recommend that the final Hazard Criteria consider that potential alternatives will be different than 6PPD. Any potential alternative to 6PPD in tires may require that the alternative be used at different concentrations than the use of 6PPD in tires and may have different migration rates. This might (depending on other relevant factors) result in different exposure to the environment of the chemical than currently exists for 6PPD. It is important to allow flexibility, based on environmental relevance with a safety margin, in the limit to account for potentially different environmental levels and exposure pathways with so many unknowns.

VI. USTMA recommends that Ecology also consider the water solubility of potential alternatives in consideration of the hazard criteria

When discussing LC50 and chemical concentrations, it is important to consider the solubility of the chemical being tested. What are the criteria for passing if a chemical is unable to meet the LC50 concentration of 100 ug/L for testing? If a chemical is not able to be solubilized in water at that level, then it will not exist in the environment at that level. It an alternative and its transformation products do not have a solubility limit that is at or above 100 ug/L, then testing at 100 ug/L would not be relevant. Please consider including criteria for potential alternatives that will not achieve a concentration of 100 ug/L, considering the requirement of environmentally relevant levels.

VII. USTMA recommends that exposure conditions be considered as part of the criteria that "Alternatives must have data on the acute toxicity for transformation products after exposure to ozone."

We recommend that Ecology specify the exposure conditions needed to fulfill the criteria that "alternatives must have data on the acute toxicity for transformation products after exposure to ozone." Exposure conditions should be based on environmentally relevant levels of ozone exposure to ensure real world transformation products are assessed. Additionally, we assume that the LC_{50} limit of >0.1 mg/L will also apply to transformation products of the alternative and recommend that this be stated explicitly to avoid confusion.

VIII. USTMA requests clarifications on the experimental data to be developed to assess acute aquatic toxicity to coho salmon

Ecology has indicated that a suitable 6PPD alternative must meet additional minimum criteria beyond those considered under the Safer Products for Washington Act (SPWA), including "experimental data on acute aquatic toxicity to coho salmon" and "data on two other trophic levels (e.g., daphnia and algae)".

A. USTMA recommends that Ecology provide clarification whether data on daphnia and algae acute toxicity must necessarily be laboratory-generated

Due to the unique importance of this requirement, we request that clarity be provided as to whether data on daphnia and algae acute toxicity must necessarily be laboratory-generated? Additionally, we ask that Ecology also clarify whether data on daphnia and algae must be generated *in vivo*, or if data from suitable analogs or estimated data may be used for these trophic levels. If *in vivo* testing is to be required for daphnia and algae, please recommend or specify the necessary tests and conditions (e.g., OECD 201/202, GLP, analytical verification of the test substance, etc.)

B. USTMA recommends that Ecology provide additional information on the experimental data on acute toxicity to coho salmon for potential alternatives

The Department of Ecology has indicated that they will require 6PPD alternatives to have "experimental data" on acute aquatic toxicity to coho salmon, however, because coho salmon is not a standard laboratory test species, it should be clarified exactly what this entails. Greer et al. (2023; U.S. Geological Survey Western Fisheries Research Center; Seattle, WA), developed an *in vitro* platform for assessing toxicity in coho salmon, demonstrating that the coho salmon cell line CSE-119 was acutely sensitive to 6PPD-q, while Chinook and sockeye cell lines (CHSE-214 and SSE-5, respectively) were not. This differential toxicity was consistent with *in vivo* effects in these species. Given the published effectiveness of this assay for predicting acute mortality in coho salmon, and the USEPA's Toxic Substances Control Act's directive to "reduce and replace, to the extent practicable and scientifically justified, the use of vertebrate animals in the testing of chemical substances," does Ecology consider the use of coho salmon CSE-119 cells suitable to fulfill the requirement of "experimental data on acute aquatic toxicity to coho salmon"? If *in vivo* testing on live coho salmon is indeed deemed a requirement for assessment of a 6PPD alternative, we ask that Ecology specify the protocol for the test as there is currently no internationally accepted methodology for acute toxicity testing with this species. All test

conditions, including duration, temperature, light cycle, feeding, water quality parameters, and any other additional testing requirements must be specified to ensure consistency of results.

C. USTMA recommends that Ecology provide additional information regarding which acute toxicity tests will be required for transformation products of potential alternatives.

The Department of Ecology has indicated that "any alternative chemical that meets the minimum criteria must also have data showing acute toxicity information for transformation products". We ask that Ecology specify which acute toxicity tests will be required for transformation products (e.g., coho salmon as with parent compound, daphnia, algae, mammalian, etc.). Considering how many transformation products are unknown, short lived, and do not have commercial standards, how does the Department of Ecology propose testing for transformation products? We recommend that Ecology provide specific guidance for testing for transformation products.

I. USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Wu et al. 2023 study

The data presented in Wu et al 2023 do not indicate bioaccumulation. The Department of Ecology has indicated that "6PPDq-dG has the potential for bioaccumulation and genotoxicity within green algae and fish organs and tissue", citing Wu et al 2023. In this study, the authors did not measure bioaccumulation of 6PPDq-dG. The study measured the occurrence (amount) of 6PPDq-dG in tissue as a biomarker for exposure. In their assays, lung cells were exposed for 24h and algal cells were exposed for 72h to 6PPD-q. 6PPDq-dG was measured after exposure and then again after a recovery period (12 and 24h for lung cells, 72h for algal cells). The data shows that after this recovery period, DNA adducts (6PPDq-dG) decreased, which does not indicate persistence. The authors concluded that there are potential repair pathways for this adduct in mammalian and algal cells. Additionally, "DNA adduct levels, measured at any point in time, reflect tissue-specific rates of damage processing that include DNA adduct formation and removal (DNA repair), DNA adduct instability, tissue turnover and other events." (Weston and Poirier, 2005).

The data for Capelin fish referenced in Wu et al 2023 do not indicate bioaccumulation. The authors only measured the occurrence (amount) of 6PPDq-dG in frozen samples collected from a fish market. Without knowledge regarding how much 6PPDq these fish were exposed to or for how long, it is not appropriate to make conclusions about bioaccumulation. Bioaccumulation is measured by calculating the bioconcentration factor (BCF), which is a comparison of the concentration in the fish (or organ) divided by the exposure concentration (e.g., OECD 305).

Please consider including other lines of evidence for bioaccumulation, if they exist for claims regarding the bioaccumulation of 6PPDq. The log Kow value may inform *potential* bioaccumulation of 6PPDq or other 6PPD transformation products. If bioaccumulation studies exist in the peer-reviewed literature, please consider citing to them as well.

USTMA requests that Ecology revise the text in the background section of the document to accurately reflect the findings of the Hua et al 2023 study.

The Department of Ecology has indicated that "6PPD-q has also shown some intestinal toxicity in low concentrations and lethality to the common study species *Caenorhabditis elegans* (Hua et al 2023)." To clarify, lethality was 5% in this study and only at the highest concentration tested (100 ug/L), therefore, the LC50 is much greater than 100 ug/L for this species. Additionally, 100 ug/L is not considered a "low concentration" and is not environmentally relevant (e.g., surface water concentrations range from 0.0012 to 2.3 ug/L in North America (Challis et al 2021, Johannessen et al 2022). No lethality was observed in lower concentrations from this study.

USTMA requests that Ecology consider relevant exposure data when describing the available literature on environmental concentrations.

Although we acknowledge the overall lack of reliable exposure data currently available, the reference for detected concentrations of 6PPD-q in Hong Kong urban runoff (Cao et al 2022) on page 6 may be perceived as irrelevant as there are no coho in China.

USTMA requests clarification whether the proposed changes to the "very high" GreenScreen category will result in a shift of subsequent GreenScreen categories.

A comparison table showing the proposed new acute aquatic toxicity LC50 value classifications and how they translate to the current GreenScreen acute aquatic toxicity LC50 value classifications would add clarity to the third addition proposed in the 6PPD AA hazard criteria document.

IX. USTMA welcomes the opportunity for continued dialogue with Ecology on the development of the hazard criteria.

USTMA and Ecology share a common goal that potential alternatives to 6PPD in tires ensure driver and environmental safety. Developing clear and environmentally relevant hazard criteria for potential alternatives to 6PPD is essential to avoid regrettable substitutions. We recognize the critical importance and need for clear and environmentally relevant hazard criteria and welcome the opportunity for additional engagement with Ecology to discuss the points raised in our comments. If you have any questions, please contact Jamie McNutt (jmcnutt@ustires.org; 202-682-4845).

Neil Smith

Please see the uploaded PDF with comments from Flexsys Inc. Thank you.

July 14, 2023

Via Electronic Filing

Craig Manahan, Ph.D.
6PPD Chemist
Washington State Department of Ecology

RE: Comments of Flexsys on the Washington State Department of Ecology 6PPD Alternatives Assessment Hazard Criteria

Dear Dr. Manahan:

Flexsys appreciates the opportunity to provide comments on the Washington State Department of Ecology (Department of Ecology) 6PPD Alternatives Assessment Hazard Criteria (Draft Criteria).[1] Flexsys is the largest U.S. producer of tire additives, including vulcanizing agents, antidegradants, and post-vulcanization stabilizers. Our products are well known for their positive impact on the durability and longevity of tires and other rubber goods, which supports passenger safety while reducing waste and saving resources. We strive for resource efficiency in our production processes and we carefully manage the safety of our operations to ensure the well-being of our customers, our employees, and the communities in which we operate. For over fifty years we have set the standard for additive quality and have been focused on chemicals and solutions that make rubber products, including tires, safer, last longer, and perform better. Based on our experience and expertise, we are providing the following comments for consideration.

Flexsys Encourages Stringent Data Standards For 6PPD Replacements

Flexsys supports the development of a transparent set of criteria for identifying safer alternatives to 6PPD in motor vehicle tires. We agree that the existing criteria that have been used by the Safer Products for Washington program should be supplemented, and we support adding the three additional criteria that have been proposed:

1. Alternatives must have data on acute aquatic toxicity to coho salmon, as well as data on two other trophic levels.

2. Alternatives must have data on the toxicity of transformation products after exposure to ozone.

3. Placing a limit on the acute toxicity LC50 values allowed in the minimum criteria (>0.1 mg/L).

[1] https://apps.ecology.wa.gov/publications/SummaryPages/2304036.html.

The approach in the Draft Criteria is practical, flexible and, if implemented as proposed, will help to ensure that 6PPD alternatives are safer. Through this approach the Department of Ecology can successfully ensure protections to human and environmental health.

Flexsys also encourages the Department of Ecology to ensure, consistent with the Safer Products for Washington program, that all known data will be used and considered, even if it is outside of the required elements. We look forward to seeing more clarity from the Department of Ecology on how the additional tests will be performed. For instance, additional details on ozone concentrations and the appropriate length of exposure when subjecting chemicals to ozonation will be important for ensuring consistency. Similarly, standardized protocols describing how leachate from vulcanized rubber compounds, including motor vehicle tires, should be collected would also be helpful to stakeholders that wish to provide the Department of Ecology with additional information. Finally, we encourage the Department of Ecology to consider adding acute aquatic toxicity testing requirements for the predominant transformation products that are identified for all alternatives considered.

Flexsys Welcomes Collaboration With the Department of Ecology

Flexsys appreciates the extensive resources and outreach that the Department of Ecology has provided to stakeholders that are interested in closely following its research on 6PPD and replacements. Flexsys recently signed a Cooperative Research and Development Agreement (CRADA) with the U.S. Department of Agriculture - Agricultural Research Service to explore potential alternatives to 6PPD[2] and would welcome additional collaboration with the Department of Ecology.

As we continue to conduct research on 6PPD and alternatives, we will strive to share information with the Department of Ecology. For instance, we have completed acute aquatic toxicology testing on 77PD and one of its transformation products. We are currently working to publish this information and will share the data in the near term. These results will support the Department of Ecology's approach to ensuring that both parent compounds and transformation products are sufficiently tested.

Thank you for the important work that the Department of Ecology is doing to identify 6PPD alternatives and to ensure that these alternatives will protect public health and the environment. We welcome any questions and further discussion on this important topic. Please contact Diane McVehil at diane.mcvehil@flexsys.com with any questions.

Sincerely,

Neil Smith | Chief Technology and Sustainability Officer | Flexsys

[2] See https://flexsys.com/2023/flexsys-announces-6ppd-alternatives-cooperative-research-development-agreement-with-usda-ars/.

Christian Gunther

Please do everything in your power to curtail, if not outlaw the use of 6PPD. WA State, for too long, has often -generally- lagged California on environmental standards and restrictions. California has the right idea. Put people over industry, however awkward or impractical the adjustment might seem in the short run. We simply have no right to destroy this planet as a habitat for life. Indeed, the proverbial road we are traveling will wipe us out with the rest of what we ruin. Bold swift action to save non-human life and ours alike can't come too fast. Thank you.