Short-Term Guideline Concentrations for Air Toxics

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State of Oregon
Department of Environmental Quality

Background

The Oregon Health Authority (OHA) and Oregon Department of Environmental Quality (DEQ) have developed short-term guideline concentrations (SGCs) presented in this document (Table 1). They are intended to help state agencies evaluate health risks from short-term exposures to ambient concentrations of air toxics measured over short periods of time ranging from 24 hours to several days or weeks.

Disclaimers

Some of the SGCs were adopted as acute toxicity reference values as part of Cleaner Air Oregon program rules in November of 2018. The Cleaner Air Oregon rulemaking process included extensive public comment and input. Only those SGCs adopted as part of Cleaner Air Oregon have regulatory implications. The rest are advisory screening levels. As information in this document is somewhat outdated, acute toxicity reference values adopted in Cleaner Air Oregon rules should be preferentially used rather than an SGC wherever there is a discrepancy between the two.

General Approach to Selection of Short-Term Guideline Concentrations

In 2016, OHA and DEQ toxicologists collaborated to compile existing federal and state human health benchmarks for 15 chemicals that have either been measured above chronic screening levels near known sources. Table 1 below presents these SGCs together with assumed average lengths of exposure (or "averaging periods") ranging from one hour to one year and the underlying justification behind each. The agencies considered benchmarks, guidelines, and action levels from federal and state agencies. We summarized the critical studies used, the health endpoints evaluated, the animal species tested, the intended averaging period, and the uncertainty factors applied for each benchmark value. We then reviewed the available benchmarks and applied the following guiding principles to select the SGC values most strongly supported by current science and best practices:

- **Give weight to federal Minimal Risk Levels**. When available, give careful consideration to Acute Minimal Risk Levels (MRLs) developed by the Agency for Toxic Substances and Disease Registry (ATSDR), because of their relevance in terms of the averaging time, the route of exposure, and the population they are designed to protect.

- **Use chronic values when relevant.** Use chronic values when derived for relevant endpoints that have the potential to occur with repeated short-term exposures (e.g. sensitive fetal or childhood developmental processes, lung fibrosis).

- **Only use values derived for non-cancer endpoints.** Cancer usually develops after repeated exposures over a longer exposure period, so one or occasional short-term exposures to high concentrations of a carcinogen would not be expected to result in cancer.

- **Avoid extrapolating (calculating) SGCs from chronic values.** Avoid short-term values that are time adjusted from chronic values because the justification behind specific time adjustments is often obscure and the chronic endpoints are not always reflective of potential acute endpoints. OHA and DEQ made an exception for manganese because the source toxicology literature clearly spelled out the adjustment from subchronic to chronic averaging times, which made removal of this factor for short-term exposures simple and transparent.

- **Avoid values extrapolated from occupational exposure limits**. Workplace exposures to people are generally much higher than exposures to nearby populations from industrial air emissions. Occupational exposure limits are also not always set with the most sensitive or vulnerable people in mind. Information about how occupational exposure limits are derived and set is often not readily available (see second to last bullet below). Therefore, SGCs in this document are not based on extrapolated values from occupational exposure limits unless no other option is viable (e.g. selenium).

- **Avoid values derived from route-to-route extrapolation.** The SGCs do not, for example, use inhalation values derived from ingestion studies.

- **Rely on clearly documented values.** In order to make the derivation of SGCs fully transparent, only use selected values for which clear documentation is available.

- **Round final numerical values.** Round final SGC values to avoid implying that numbers reflect a greater degree of precision than they actually do.

Specific Rationale for Lead and Total Chromium Screening Levels
For two chemicals, lead and total chromium, a slightly modified approach was required. For lead we simply propose adopting the federal National Ambient Air Quality Standard (NAAQS) as our short-term screening level. As a criteria pollutant, lead has a federal standard that is well supported by scientific evidence. It would be inappropriate to consider any short-term screening values for lead that are above this federal standard for chronic exposures. Furthermore, in the case of lead, a chronic exposure value is appropriate for a short-term screening value due to the sensitivity of the developing brain to lead exposure.

Chromium is a complex metal that can exist in multiple forms. Trivalent chromium has relatively low toxicity and is an essential nutrient for good human health. Hexavalent chromium generally has a high toxicity but also exists in at least two forms. One form of hexavalent chromium that can occur in air is chromic acid aerosol mists. This form is primarily associated with chrome plating facilities where pieces of hot metal are dipped in baths of chromic acid. This is the most toxic form of hexavalent chromium. Another form of hexavalent chromium that can exist in air is a dichromate particulate. This form of hexavalent chromium is still more toxic than trivalent chromium but significantly less toxic than chromic acid aerosol mists. Some types of DEQ air monitoring only measure total chromium without distinguishing between any of these forms. Another type of DEQ monitoring is able to specifically measure hexavalent chromium, but no air monitoring methods available to DEQ can distinguish between the two forms of hexavalent chromium. Distinguishing between chromic acid aerosol mist and dichromate particulate requires some knowledge about the source of hexavalent chromium.

Peer Review Process

In 2017, DEQ and OHA presented an earlier version of this document and set of tables to five reviewers that are external to DEQ and OHA. DEQ and OHA selected reviewers based on their expertise in the field of toxicology, especially related to air toxics. Their comments were either incorporated into the current version of this document or addressed in a DEQ and OHA response. Peer reviewer comments and agency responses are available upon request (email cleanerair@deq.state.or.us). The reviewers were:

- Bruce Hope, Ph.D. Toxicologist – Member of Air Toxics Science Advisory Committee and retired from DEQ and Ch2MHill
- Julie Wroble[1], Toxicologist, EPA Region 10
- Michael Stewart[2], Ph.D., Environmental Protection Specialist – EPA Office of Air Quality Planning and Standards
- Fredrick Berman, Ph.D., DVM – Toxicologist, Oregon Health & Science University
- William Lambert, Ph.D. Epidemiologist, Oregon Health & Science University and Member of Air Toxics Science Advisory Committee

Short-Term Guideline Concentrations (SGCs)

Table 1 below lists SGCs along with the uncertainty factors, rationale, and exposure periods used in their derivation. SGCs are levels of toxic substances in air that pose a 'negligible risk' to humans. Scientists derive these levels using evidence of harm from epidemiological and toxicological studies in humans and animals. Levels that cause health problems in the studies are adjusted to account for uncertainty inherent in the data to provide a cautious 'negligible risk level' that is substantially below levels known to cause harm. Scientists use uncertainty factors to increase the margin of safety by accounting for things like less complete toxicity testing results, possible differences in responsiveness between humans and animals, and variation in susceptibility among individual humans. The air concentrations that actually caused harm in the underlying toxicity studies are divided by these uncertainty factors to produce the air concentrations OHA and DEQ use as SGCs (See equation 1). As an example, the concentration of acetone that actually caused health effects in the original toxicity study was 9 times higher than the 62,000 micrograms per cubic meter (µg/m^3) SGC in Table 1 below.

Equation 1. Derivation of Short-term Guideline Concentrations

$$SGC = \frac{Lowest\ tested\ concentration\ from\ toxicological\ study}{Uncertainty\ Factors}$$

Information in the column with the heading "Rationale and length of exposure in underlying toxicological study" describes the health effects observed in the original toxicological studies. The information in parenthesis explains how long test subjects were exposed in the original

[1] The views expressed by Julie Wroble in her comments are hers, and do not represent the official views or policies of the U.S. EPA.

[2] The views expressed by Michael Stewart in his comments are his, and do not represent the official views or policies of the U.S. EPA.

toxicological study. This information may be helpful in interpreting the applicability of SGCs to ambient air monitoring data averaged over different amounts of time.

Table 1. Summary of Short-Term Guideline Concentrations

COMPOUND	SHORT-TERM GUIDELINE CONCENTRATION (µg/m^3)	Total Uncertainty Factors	RATIONALE AND LENGTH OF EXPOSURE IN UNDERLYING TOXICOLOGICAL STUDY
Acetone	62,000	9	ATSDR acute MRL based on neurological effects in human subjects. (4 hours single exposure)
Arsenic	0.2	1000	OEHHA acute REL based on developmental effects in mice. (4 hours per day; 4 days)
Beryllium	0.02	10	EPA RfC, also used as 24-hour value by Rhode Island and Michigan. Based on irreversible sensitization leading to chronic beryllium disease in human workers occupationally exposed. (5 months to 10 years)
Cadmium	0.03	300	ATSDR acute MRL based on lung inflammation in rodents. (6.2 hours per day; 5 days per week; 2 weeks)
Chromium (hexavalent), Chromic Acid Mist	0.005	100	ATSDR intermediate MRL based on respiratory effects observed in chrome plating workers. (30 days to 30 years)
Chromium (hexavalent), Dichromate Particulate	0.3	30	ATSDR intermediate MRL based on early signs of respiratory inflammation observed in rats. (22 hours per day; 7 days per week; 30 days)
Chromium (total)	---		No value recommended.
Hydrogen sulfide	98	30	ATSDR acute MRL, which is derived from data on short-term respiratory effects in human subjects with asthma. (Single 30-minute exposure)
Lead	0.15	NA[3]	This is the federal NAAQS, which is based on extensive analysis by the EPA. The NAAQS for lead is based on a 3-month rolling average. However, this federal standard for subchronic exposure is appropriate for short-term health concerns because the critical endpoint of neurodevelopment may be impacted over relatively short-term exposures.

[3] The National Ambient Air Quality Standard for lead, established by the U.S. Environmental Protection Agency, was derived in a way that did not use uncertainty factors. However, this standard has been well vetted by EPA's

COMPOUND	SHORT-TERM GUIDELINE CONCENTRATION (µg/m³)	Total Uncertainty Factors	RATIONALE AND LENGTH OF EXPOSURE IN UNDERLYING TOXICOLOGICAL STUDY
Manganese	0.3	100	OEHHA chronic REL (0.09 µg/m3) multiplied by the square root of 10. OEHHA applied an uncertainty factor of the square root of 10 to extrapolate the subchronic exposure in the critical study to chronic application. Because this is an SGC, retention of this uncertainty factor is not appropriate. The REL is derived from data on human nervous system effects following occupational exposures. Supporting evidence also indicates that manganese may affect the developing nervous system. (0.2 – 17.7 years)
Methyl ethyl ketone (MEK)	5,000	300	EPA RfC, also used as a 24-hr screening level by both Michigan and Rhode Island. The chronic non-cancer value is appropriate for use as an SGC because the critical endpoint is developmental toxicity. From studies in pregnant rodents evaluating effects of exposure on their offspring. (7 hours per day on gestation days 6-15).
Naphthalene	200	1000	Minnesota acute Health Based Value, reflects respiratory effects in rats and is consistent with odor thresholds related to nausea and vomiting in humans. (single 4-hour exposure in rat study)
Nickel	0.2	30	ATSDR intermediate MRL (rats exposed 6 hours per day; 5 days per week; 13 weeks) and Cal OEHHA acute REL value (mice exposed once for 2 hours). Rhode Island uses this as a 24-hr Ambient Air Level. These levels are derived from rodent data on respiratory effects and immune response.
Selenium	2	NA[4]	Texas's short-term health-based Interim Ambient Monitoring Comparison Value (for air monitoring, not air permitting) and Michigan's Initial Toxicity Threshold Screening Level. Both are based on the same occupational exposure limit.

external scientific advisory committee. Because this standard was designed for application to a 3-month rolling average, there is some added uncertainty when applying it to shorter averaging periods.

[4] The SGC for selenium was adapted from occupational exposure limits for which OHA and DEQ were not able to access underlying information about uncertainty factors. Texas and Michigan both applied an uncertainty factor of

COMPOUND	SHORT-TERM GUIDELINE CONCENTRATION (µg/m³)	Total Uncertainty Factors	RATIONALE AND LENGTH OF EXPOSURE IN UNDERLYING TOXICOLOGICAL STUDY
Styrene	21,000	10	ATSDR acute MRL, based on neurotoxic effects in human volunteer studies. (Four 15-minute exposures over a 6-hour period; repeated once with 2 weeks in between)

List of Acronyms in Short-Term Guideline Concentration Document

ATSDR – Agency for Toxic Substances and Disease Registry

DEQ- Oregon Department of Environmental Quality

EPA – United States Environmental Protection Agency

MRL – ATSDR's Minimal Risk Level – acute MRLs are intended to be applied to exposures lasting up to 2 weeks and intermediate MRLs are intended to be applied to exposures lasting longer than 2 weeks but less than 1 year

NA – Not applicable

NAAQS – National Ambient Air Quality Standard

OEHHA – California Office of Environmental Health Hazard Assessment

OHA – Oregon Health Authority

REL – California's Reference Exposure Level

RfC – EPA's Inhalation Reference Concentration

SGC – Short-term Guideline Concentration

µg/m³ – micrograms per cubic meter

100 to the occupational exposure limit to calculate the number shown here, which they use as a 24-hour screening level.