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Appendix D: Selection of acute health-based comparison values (AHBCVs)

Summary

To aid in emergency preparedness and investigations, it is important to have appropriate acute ambient air comparison values in place and available for use in evaluating air concentration data generated by mobile monitoring equipment. The goal here is to identify fit-for-purpose acute ambient air comparison values that result in a more realistic assessment of the potential for acute adverse health effects, which can help to inform decision making during an investigation or a potentially widespread emergency event. The selection of these acute health-based comparison values (AHBCVs) is documented herein. The AHBCVs selected were derived by TCEQ or other state or federal agencies (Table D - 1) The considerations used to select these fit-for-purpose values are described in Section 4.1. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development. It is noted, however, that short-term occupational comparison values for exposure durations shorter than that typically used to develop AHBCVs (i.e., ≤15 minutes (min) versus the ≥1-hour (hr) duration often used for AHBCV development) may also be important considerations for limiting shorter-term exposure for staff during emergency response and investigations.[1]

Table D - 1. Agencies researched in development of Acute Health-Based Comparison Values (AHBCVs).

ACRONYMS	AGENCY
ATSDR	Agency for Toxic Substances and Disease Registry[2]
AZ DHS	Arizona Department of Health Services[3]
CALEPA	California Environmental Protection Agency[4]

[1] For example, an important consideration is preventing exceedances of occupational 15-minute short-term exposure limits (STELs) through consideration of ½ the STEL as a comparator value when developing AHBCVs. STELs consider effects that can occur due to elevated shorter-term exposure concentrations such as irritation, irreversible (or chronic) tissue damage, dose-rate-dependent toxic effects, or narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency. Similarly, ½ the occupational ceiling value is also an appropriate comparator value for consideration. Substances with occupational ceiling values are predominantly fast-acting and whose occupational comparison values are more appropriately based on the concentrations associated with the particular response. These substances and their potential health effects are best controlled through use of a ceiling value. Ceiling values and 15-minute STELs should not be exceeded (https://www.acgih.org/science/tlv-bei-guidelines/tlv-chemical-substances-introduction/).

[2] https://www.atsdr.cdc.gov/mrls/index.html

[3] https://agriculturedefensecoalition.org/sites/default/files/pdfs/28A_1999_Arizona_Ambient_Air_Quality_Guidelines_1999_Draft.pdf

[4] https://oehha.ca.gov/chemicals

ACRONYMS	AGENCY
NIOSH	The Centers for Disease Control and Prevention's National Institute for Occupational Safety and Health[5]
NC DEQ	North Carolina Department of Environmental Quality[6]
NY DEC	New York State Department of Environmental Conversation[7]
MI EGLE	Michigan Department of Environment, Great Lakes, and Energy[8]
TCEQ	Texas Commission on Environmental Quality[9]

AHBCVs Derived Using Defined Guidelines Approach

Ammonia

The TCEQ identified six acute ambient air toxicity factors for ammonia from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[6] MI EGLE,[8] CalEPA,[4] and TCEQ.[10] Two of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on an occupational exposure level ((short-term exposure level (STEL) that was divided by uncertainty factors (UF) (i.e., STEL/UF)). The derivation method is unknown for NC DEQ and MI EGLE values. Two of the values, TCEQ and CalEPA, were derived using defined guidelines.

Summary

The two acute (1-hour) air comparison values for ammonia that were identified by TCEQ for use as the AHBCV are the acute CalEPA reference exposure level (REL) of 4,500 parts per billion (ppb) and the short-term TCEQ reference value (ReV) of 850 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 2 and Table D - 3, respectively.

The CalEPA value for ammonia was based on four human studies with multiple doses (30-500 parts per million (ppm)) administered, exposure durations (5 min-120 min) that encompass the 1-hr duration of interest, and a lower total UF was utilized. The TCEQ value was based on a study with 2 doses administered (5 ppm and 25 ppm) and exposure durations of 3 hours (minimal lowest observed adverse effect level (LOAEL) = 5 ppm), somewhat longer than the duration of interest (i.e., 1-hr) but certainly toxicologically relevant. The dosimetry adjustments result in point of departure values of 13.6 ppm and 5 ppm, respectively, from CalEPA and TCEQ. The CalEPA REL used a lower total UF (3), resulting in a lower margin of exposure (MOE)[11] when

[5] https://www.cdc.gov/niosh/npg/npgsyn-a.html

[6] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/AALs.pdf

[7] https://www.dec.ny.gov/docs/air_pdf/dar1.pdf

[8] https://www.egle.state.mi.us/itslirsl/

[9] https://www.tceq.texas.gov/toxicology/esl/list_main.html or https://www.tceq.texas.gov/toxicology/dsd/final#top

[10] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/ammonia.pdf

[11] MOE- Margin of exposure is typically calculated as some comparison value (e.g., RfC, RfD) divided by the actual or projected environmental exposure of interest. While the MOEs of most interest here are

compared to its own point of departure, which is an important general consideration for a AHBCV being fit-for-purpose.[12] However, in this case, the CalEPA REL value (4,500 ppb) is just below the minimal LOAEL identified by the TCEQ. This would cause, for example, the 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$) value (9,000 ppb) derived using documented methods (see Section 5.2.2.2 to be higher than the lowest human equivalent concentration LOAEL ($LOAEL_{HEC}$) or human equivalent concentration benchmark concentration (BMC_{HEC}) value identified (5,000 ppb) across the key studies used to derive the AHBCVs being considered. This is inappropriate since a resulting mobile monitoring comparison value (MMCV) (e.g. the $^{EM}HBAL_{1hr}$) would not be considered health protective (i.e., the MOE would not be > 1 when using the lowest $LOAEL_{HEC}$ or BMC_{HEC} value identified across the AHBCVs being considered for adoption, with MOE here being equal to the lowest $LOAEL_{HEC}$ or BMC_{HEC}/MMCV). Thus, the TCEQ acute ReV of 850 ppb was selected as the AHBCV for ammonia (Table D - 4) and the resulting $^{EM}HBAL_{1hr}$ value (1,700 ppb) was then lower than the $LOAEL_{HEC}$/BMC_{HEC} value.

Table D - 2. Summary table for CalEPA derivation of the acute reference exposure level (REL) for ammonia.

Parameter	Summary
Studies	Industrial Biotest Laboratories (1973); MacEwen et al. (1970); Silverman et al. (1949); Verberk (1977)
Study population	Humans
Exposure method and duration	Inhalation of 30 - 500 ppm; 5 – 120 min
Critical effect(s)	Eye and respiratory irritation
POD	13.6 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	13.6 ppm
Total UFS:	3
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	3
Acute REL	4,500 ppb (3,200 µg/m³)

the differences between the AHBCVs and the lowest concentration at which health effects have been shown to occur across the key studies used for the AHBCVs, for the sake of simplicity and comparison, in tables herein the MOE for each AHBCV it is represented by the total UF applied to the given AHBCV's point of departure.

[12] For the purpose of selecting a AHBCV, there is a preference for acute air comparison levels associated with a lower MOE given that an exceedance of a comparison value with a smaller MOE can be considered more likely to be associated with the potential for actual occurrence of acute adverse health effects and as such is more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects) that should be given priority in the midst of a potentially widespread emergency situation.

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; LOAEL – lowest observed adverse effect Level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL-reference exposure level; and UF – uncertainty factor.

Table D - 3. Summary table for TCEQ derivation of the acute reference value (ReV) for ammonia.

Parameter	Summary
Study	Sundblad et al. (2004)
Study population	12 healthy human volunteers
Exposure method and Duration	Inhalation of 0, 5, or 25 ppm ammonia; 3 hrs, with exercise
Critical effect(s)	Mild, transient upper respiratory symptoms and central nervous system effects (eye discomfort, smell, headache, dizziness, and feelings of intoxication)
POD	5 ppm (minimal LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	5 ppm
Total UFs:	6
LOAEL to NOAEL (L)	2
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute ReV	830 ppb (590 µg/m^3)
TAMIS acute ReV[a]	850 ppb (590 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor. [a]Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in a Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.

Table D - 4. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for ammonia.

Criteria	CalEPA REL	TCEQ ReV
Year derived	1999	2015
Standard practices and procedures used	Yes	Yes
Inhalation key study	4 human inhalation studies, 30 - 500 ppm for 5 - 120 min	Sundblad et al. 2004, humans exposed to 0, 5, or 25 ppm for 3 hrs while exercising
Critical effect(s) relevant to humans	Eye and respiratory irritation	Mild, transient upper respiratory symptoms and CNS effects

Criteria	CalEPA REL	TCEQ ReV
Dose-response	Yes	Yes
POD adjusted to 1 hr	Consolidated 4 studies, 13.6 ppm ($BMCL_{05}$)	5 ppm (minimal LOAEL)
Lower total uncertainty	UF (3) (H = 3); lowest	UF (6) (H = 3, L = 2)
Lower MOE	Yes	No
MMCVS < minimum LOAEL/BMC	No	Yes
1-hr TOX value	4500 ppb	850 ppb
Selected AHBCV		**850 ppb**

AHBCV – acute health-based comparison value; BMC – benchmark concentration; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; CNS – central nervous system; H – Intraspecies uncertainty factor (UF); L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MMCV – mobile monitoring comparison value; MOE – margin of exposure; NOAEL – no observed adverse effect level; POD – point of departure; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Benzene

The TCEQ identified four acute ambient air toxicity factors for benzene, all from state governments: AZ DHS,[3] NY DEC,[7] CalEPA,[13] and TCEQ.[14] Two of the values were not derived using defined guidelines: the AZ DHS value is based on a STEL/UF and the NY DEC adopted the CalEPA value. Two of the values, TCEQ and CalEPA, were derived using defined guidelines. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development.

Summary

The two acute air comparison values for benzene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 8 ppb and the short-term TCEQ ReV of 180 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 5 and Table D - 6, respectively. CalEPA used a pregnant mouse developmental study as the key study, in which a LOAEL of 5 ppm was identified. TCEQ used a male mouse hematotoxicity study as the key study in which a mild LOAEL (10.2 ppm) was identified. The exposure duration for the study used by CalEPA was 4 days longer (6 hrs per day for 10 days, from gestational day 6-15), compared to 6 hrs/day for 6 days for TCEQ. The total exposure duration of 60 hours (vs the 1-hr duration of interest) and higher total UF (600, using a high intrahuman UF of 30) for the CalEPA value made for a very conservative 1-hr REL (8 ppb). By contrast, the study used by TCEQ had a 1.7-fold shorter total exposure duration (36 hours) and the total UF (100) was 6-fold lower. The CalEPA

[13] https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf

[14] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/benzene.pdf

1-hr REL is even lower than the 1-14 day ATSDR[15] minimum risk level (MRL)[16] (9 ppb), although the ATSDR REL is not considered appropriate for a 1-hr AHBCV per the guidelines since it is designed for up to 2 weeks of exposure. The TCEQ 1-hr ReV (180 ppb) was based on a study with an exposure duration more similar to the duration of interest and incorporates lower total uncertainty (total UF of 100) than the CalEPA value (total UF of 600). The weight-of-evidence assessment suggests that the TCEQ ReV (180 ppb) is health-protective with a lower MOE and thus is more fit-for-purpose.[12] Accordingly, the TCEQ ReV (180 ppb) was selected as the AHBCV for benzene (Table D - 7).

Table D - 5. Summary table for CalEPA derivation of the acute reference exposure level (REL) for benzene.

Parameter	Summary
Study	Keller and Snyder (1988)
Study population	Pregnant female Swiss Webster mice
Exposure method and Duration	Inhalation of 0, 5, 10, or 20 ppm benzene; 6 hr/day for 10 days (6-15 days of gestation)
Critical effect(s)	Decreased early nucleated red cell counts
POD	5 ppm (LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	5 ppm
POD_{HEC}	5 ppm (used RGDR= 1, systemic effect)
Total UFs:	600
LOAEL to NOAEL (L)	√10
Interspecies (A)	6
Intraspecies (H)	10 x √10
Database (D)	1
Acute REL	8 ppb (27 µg/m^3)

LOAEL – lowest observed adverse effect level; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Table D - 6. Summary table for TCEQ derivation of the acute reference value (ReV) for benzene.

Parameter	Summary
Studies	Rozen et al. (1984), supported by Dempster and Snyder (1991) and Corti and Snyder (1996)
Study population	C57BL/6J mice (male)

[15] https://www.atsdr.cdc.gov/ToxProfiles/tp3.pdf (page A-3)

[16] ATSDR defines an MRL as an estimate of daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

Parameter	Summary
Exposure method and duration	Inhalation of 0, 10.2, 31, or 301 ppm; 6 hrs per day for 6 days
Critical effect(s)	Decreased peripheral lymphocytes and decreased mitogen-induced blastogenesis of femoral B-lymphocytes
POD	10.2 ppm (LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	18.5 ppm
POD_{HEC}	18.5 ppm (used RGDR = 1, systemic effect)
Total UFs:	100
LOAEL to NOAEL (L)	3
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	1
Acute ReV	180 ppb (580 µg/m^3)

LOAEL – lowest observed adverse effect level; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Table D - 7. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for benzene.

Criteria	CalEPA REL	TCEQ ReV
Year derived	2014	2007
Standard practices and procedures used	Yes	Yes
Inhalation key study	Keller and Snyder, 1988, pregnant mice exposed to 0, 5,10, 20 ppm for 6 hrs/10 days (GD 6-15)	Rozen et al. (1984), male mice exposed to 0, 10.2, 31, 100, 301 ppm, for 6 hrs, 6 days
Critical effect(s) relevant to humans	Decreased early nucleated red cell counts	Decreased peripheral lymphocytes and decreased mitogen-induced blastogenesis of femoral B-lymphocytes
Dose-response	Yes	Yes
POD	5 ppm (mild LOAEL)	10.2 ppm (mild LOAEL)
POD_{HEC}	5 ppm	18.5 ppm
Lower total uncertainty	UF (600) (A = 6, L = 3, H = 30)	UF (100) (A = 3, L = 3, H = 10); lowest
Lower MOE	No	Yes
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	8 ppb	180 ppb

Criteria	CalEPA REL	TCEQ ReV
Selected AHBCV		**180 ppb**

A – Interspecies uncertainty factor (UF); AHBCV – acute health-based comparison value; BMC – benchmark concentration; GD – gestational days; H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; MOE – margin of exposure; MMCV – mobile monitoring comparison value; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

1,3-Butadiene

The TCEQ identified two acute ambient air toxicity factors for 1,3-butadiene that were derived using defined guidelines: TCEQ[17] and CalEPA.[18]

Summary

The two acute air comparison values for 1,3-butadiene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 300 ppb and the short-term TCEQ ReV of 1,700 ppb. The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 8 and Table D - 9, respectively. Both acute values were based on the Hackett et al. (1987) reproductive/developmental study. The TCEQ used original data to perform benchmark dose (BMD) modeling using benchmark dose software (BMDS) Version 1.4.1c, which resulted in a benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation ($BMCL_{1SD}$) of 51.3 ppm and a BMCL with a benchmark response of 5% ($BMCL_{05}$) of 54.7 ppm for decreased extragestational weight gain and for decreased fetal body weight, respectively. CalEPA used a reanalysis of the Hackett et al. (1987) data by Green (2003) to perform BMD using a newer BMDS version (Version 2.3.1). A $BMCL_{05}$ of 17.7 ppm for decreased male fetal weight was derived. The CalEPA $BMCL_{05}$ (17.7 ppm) is lower than the TCEQ $BMCL_{1SD}$ of 51.3 ppm. Additionally, a higher total UF of 100 was used by CalEPA as compared to that by TCEQ (UF of 30). The 1-hr REL was much lower than the TCEQ ReV. Other considerations being similar, the TCEQ ReV of 1,700 ppb used a lower total uncertainty factor (30) than the CalEPA REL (100). The TCEQ ReV is health-protective with a lower MOE and is more fit-for purpose as the AHBCV. For the purpose of selecting an AHBCV, there is a preference for acute air comparison levels associated with a lower MOE given that an exceedance of a comparison value with a smaller MOE can be considered more likely to be associated with the potential for actual occurrence of acute adverse health effects. As such, a lower MOE is more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects) that should be given priority in the midst of a potentially widespread emergency situation. Accordingly, the TCEQ ReV of 1,700 ppb was selected as the AHBCV for 1,3-butadiene (Table D - 10).

[17] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butadiene.pdf

[18] https://oehha.ca.gov/media/downloads/crnr/072613bentcrel.pdf

Table D - 8. Summary table for CalEPA derivation of the acute reference exposure level (REL) for 1,3-butadiene.

Parameter	Summary
Study	Hackett et al. (1987)
Study population	Cd-1 mice (18-21 pregnant mice per dose group)
Exposure method and Duration	0, 40, 200, and 1,000 ppm on GD 6-15 for 6 hr/day; 6 hr
Critical effect(s)	Lower male fetal weight at GD 18
POD	17.7 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	No adjustment because the critical effect was a maternal/developmental endpoint
POD_{HEC}	29.7 ppm (17.7 ppm x 1.68 DAF)
Total UFs:	100
Interspecies (A)	√10
Intraspecies (H)	10 x √10
Acute REL	300 ppb (660 µg/m^3)

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; DAF – Dosimetric Adjustment Factor; GD – gestational days; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 9. Summary table for TCEQ derivation of the acute reference value (ReV) for 1,3-butadiene.

Parameter	Summary
Study	Hackett et al. (1987)
Study population	CD-1 mice (18-21 pregnant mice per dose group)
Exposure method and Duration	0, 40, 200, and 1,000 ppm on GD 6-15 for 6 hr/day; 6 hr
Critical effect(s)	Reduction in extragestational weight gain and fetal body weight; developmental toxicity
POD	51.3 ppm ($BMCL_{1SD}$)
Extrapolation to 1 hr (POD_{ADJ})	No adjustment because the critical effect was a maternal/developmental endpoint
POD_{HEC}	51.3 ppm
Total UFs:	30
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	1
Acute ReV	1,700 ppb (3,700 µg/m^3)

$BMCL_{1SD}$ – benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation; GD – gestational days; LOAEL- lowest observed adverse effect level; N/A – not applicable; NOAEL- no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC}

– point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 10. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for 1,3-butadiene.

Criteria	CalEPA REL	TCEQ ReV
Year Derived	2013	2008
Standard practices and procedures used	Yes	Yes
Inhalation key study	Hackett et al. (1987), pregnant female CD-1 mice, 0, 40, 200, or 1000 ppm 1,3-butadiene for 6 hr/d on GD 6-15	Hackett et al. (1987), pregnant female CD-1 mice, 0, 40, 200, or 1000 ppm 1,3-butadiene for 6 hr/d on GD 6-15
Critical effect(s) relevant to humans	Lower male fetal weight on GD 18	Reduction in extragestational weight gain and fetal body weight; developmental toxicity
Dose-response	Yes	Yes
POD	$BMCL_{05}$ (17.7 ppm)	$BMCL_{1SD}$ (51.3 ppm)
POD_{HEC}	29.7 ppm	51.3 ppm
Lower total uncertainty	UF (100) (A = 3, H = 30)	UF (30) (A = 3; H = 10); lowest
Lower MOE	No	Yes
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	300 ppb	1,700 ppb
Selected AHBCV		**1,700 ppb**

A – Interspecies uncertainty factor (UF); AHBCV – Acute health-based comparison value; BMC – benchmark concentration; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; $BMCL_{1SD}$ – benchmark concentration lower confidence limit with a benchmark response of 1 standard deviation; GD – gestational days; ; H – Intraspecies uncertainty factor (UF); LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Butane

The TCEQ[19] ambient air toxicity factor was the only value identified for butane, and the value was derived using defined guidelines. Thus, the acute air comparison value for butane selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 92,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 11.

[19] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butanes.pdf

Table D - 11. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for isobutane.

Parameter	Summary
Study	Hoffman 2008
Study population	Male and female SD CD rats (10/sex/group)
Exposure method and duration	Exposure via inhalation at 0, 90, 900, or 9,000 ppm (target concentrations) for 6 h/d, 7 d/week for two weeks
Critical effect(s)	Free-standing NOAEL
POD	9,197 ppm (free-standing NOAEL, mean analytical concentration)
Extrapolation to 1 hr (POD_{ADJ})	9,197 ppm
Total UFs:	100
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	92,000 ppb (220,000 µg/m3)
Selected AHBCV	**92,000 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

1-Butene

The TCEQ's[20] ambient air toxicity factor was the only value identified for 1-butene, and it was derived using defined guidelines. Thus, the acute air comparison value for 1-butene selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 27,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 12.

Table D - 12. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for 1-butene.

Parameter	Summary
Study	American Chemistry Council (2003)
Study population	Sprague Dawley male and female rats
Exposure method and duration	Inhalation of 0, 524, 2,062, or 8,271 ppm; 6 hr/day, 7 days/week for approximately 42 days
Critical effect(s)	Free-standing NOAEL, no observed effects in parental or in offspring generation. High concentrations produce central nervous system effects.

[20] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butene-1.pdf

Parameter	Summary
POD	8,271 ppm (free-standing NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	8,271 ppm (no adjustment since the POD was a free-standing NOAEL)
POD_{HEC}	8,271 ppm (used RGDR = 1; systemic effects)
Total UFs:	300
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	10
Acute ReV	27,000 ppb (62,000 µg/m^3)
Selected AHBCV	**27,000 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Chlorine

The TCEQ identified five acute ambient air toxicity factors for chlorine from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[21] CalEPA,[4] and TCEQ.[22] Three of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on a STEL/UF; the NC DEQ value was based on a STEL and adjusted to 1 hr. Two of the values, TCEQ and CalEPA, were derived using defined guidelines. Toxicity factors that are derived using defined guidelines are preferred for AHBCV development.

Summary

The two acute air comparison values for chlorine that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 70 ppb and the short-term TCEQ ReV of 50 ppb**.** The basis for the derivation of the CalEPA and TCEQ AHBCV can be found in Table D - 13 and Table D - 14, respectively. CalEPA and TCEQ used the same key study and critical effects for chlorine. TCEQ considered 0.5 ppm to be a no observed adverse effect level (NOAEL) (selected as POD) and 1 ppm to be the LOAEL for sensory irritation without pulmonary function changes after 1 hr of exposure. CalEPA, however, considered the 30-min 1 ppm exposure to be a NOAEL for itching or burning of the throat and selected it as the POD. Both TCEQ and CalEPA use the same UF of 10, but a duration adjustment was applied for 30- min to 1 hr for the CalEPA REL, while no duration adjustment was applied to the TCEQ ReV. Although a duration adjustment can introduce some uncertainty, in this case the CalEPA REL MOE is lower than the MOE for the

[21] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Chlorine_7782-50-5_risk.pdf

[22] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/chlorine.pdf

TCEQ value, making the health-protective CalEPA REL more fit-for-purpose. Therefore, the CalEPA REL of 70 ppb is selected as the AHBCV for chlorine (Table D - 15).

Table D - 13. Summary table for CalEPA derivation of the acute reference exposure level (REL) for chlorine.

Parameter	Summary
Study	Anglen (1981)
Study population	31 adult volunteers
Exposure method and duration	Inhalation of 0, 0.5, 1, or 2 ppm chlorine gas; 15 min to 8 hr
Critical effect(s)	Itching or burning of the throat
POD	1 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	0.71 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	70 ppb (210 µg/m³)

LOAEL – lowest observed adverse effect level; **N/A – not applicable;** NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 14. Summary table for TCEQ derivation of the acute reference value (ReV) for chlorine.

Parameter	Summary
Study	Anglen (1981)
Study population	31 human volunteers (ages 20-32 years)
Exposure method and duration	Inhalation of 0, 0.5, 1, or 2 ppm chlorine gas; 15 min to 8 hr
Critical effect(s)	Sensory irritation
POD	0.5 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	N/A
Total UFs:	10
Intraspecies (H)	10
Database (D)	1
Acute ReV	50 ppb (140 µg/m³)
TAMIS acute ReV [a]	48 ppb (140 µg/m³)

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per

billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Table D - 15. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for chlorine.

Criteria	CalEPA REL	TCEQ ReV
Year derived	1999	2017
Standard practices and procedures used	Yes	Yes
Inhalation key study	Anglen (1981), humans exposed to 0, 0.5, 1, or 2 ppm for 15 min to 8 hr	Anglen (1981), humans exposed to 0, 0.5, 1, or 2 ppm for 15 min to 8 hr
Critical effect(s) relevant to humans	Itching or burning of throat	Sensory irritation
Dose-response	Yes	Yes
POD	1 ppm	0.5 ppm
POD_{HEC}	0.71 ppm	0.5 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)
Lower MOE	Yes	No
MMCVs < minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	70 ppb	48 ppb
Selected AHBCV	**70 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Ethylbenzene

The TCEQ identified two acute ambient air toxicity factors for ethylbenzene from state governments: AZ DHS[3] and TCEQ.[23] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison value for ethylbenzene that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 20,000 ppb**.** TCEQ developed the toxicity factor following guidelines, which is preferred, thus the TCEQ 1-hr acute ReV of 20,000 ppb was selected as the AHBCV for ethylbenzene. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 16.

[23] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/ethylbenzene.pdf

Use of the 1-hr ReV for ethylbenzene ultimately results in a 10-minute exposure mitigation health-based action level ($^{EM}HBAL_{10min}$) of 60,000 ppb, and a $^{EM}HBAL_{1hr}$ 1-hr of 40,000 ppb. In this case, the 10-minute and 1-hr acute exposure guideline level (AEGL)-1 values[24] for ethylbenzene (33,000 ppb) are lower than the $^{EM}HBAL_{10min}$ (60,000 ppb) and the $^{EM}HBAL_{1hr}$ (40,000 ppb). While AEGL values are typically not considered appropriate for selection of an AHBCV since they are characterized by EPA to be threshold levels at which health effects are expected to occur, and are generally significantly higher than the 1-hr ReV as well as the comparison values derived based on it, in this case the AEGL-1 values for ethylbenzene were evaluated further since they were lower than the two mobile monitoring comparison values. These AEGL-1 values were based on a study (Bardodej and Bardodejova 1961) wherein eleven individuals were exposed to 180 ppm ethylbenzene for 8 hours, with some individuals complaining of irritation of the upper respiratory tract and eyes, as well as headache, and sleepiness towards the end of the exposure; transient feelings of drunkenness were also reported. The study LOAEL is 180 ppm. No effects were reported at the study NOAEL of 100 ppm. This study provides no actual basis for the expectation of adverse effects at the 10-minute and 1-hr AEGL-1 value of 33,000 ppb (33 ppm), or at any of the mobile monitoring comparison levels (20,000-60,000 ppb) based on the TCEQ 1-hr ReV. Given the results of the underlying study (e.g., effects towards the end of the 8-hr exposure), the most appropriate, but still conservative, comparison is to the $^{EM}HBAL_{1hr}$ of 40,000 ppb. The MOE between the study LOAEL (180 ppm) and the $^{EM}HBAL_{1hr}$ (40,000 ppb or 40 ppm) is 4.5, which suggests that the $^{EM}HBAL_{1hr}$ and similarly derived values are not expected to cause adverse health effects, but rather are adequately health-protective for use in emergency situations and as such are fit-for-purpose. The AEGL-1 values for ethylbenzene were not considered further.

Table D - 16. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylbenzene.

Parameter	Summary
Study	Cappaert et al. (2000)
Study population	32 Wag/Rij rats
Exposure method and duration	Inhalation exposures of 0, 300, 400, and 550 ppm; 8 hr/day for 5 days
Critical effect(s)	Ototoxicity
POD	300 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	600 ppm
POD_{HEC}	600 ppm (used RGDR= 1, systemic effect)
Total UFs:	30
LOAEL to NOAEL (L)	N/A

[24] AEGL -the United States Environmental Protection Agency's Acute Exposure Guideline Levels for Airborne Chemicals (https://www.epa.gov/aegl/access-acute-exposure-guideline-levels-aegls-values#chemicals)

Parameter	Summary
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	1
Acute ReV	20,000 ppb (86,000 µg/m^3)
Selected AHBCV	**20,000 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; RGDR – regional gas deposition ratio; ReV – reference value; and UF – uncertainty factor.

Ethylene dichloride

The TCEQ identified two acute ambient air toxicity factors for ethylene dichloride from state governments: AZ DHS[3] and TCEQ.[25] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison values for ethylene dichloride that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 550 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 17.

Table D - 17. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylene dichloride.

Parameter	Summary
Study	Hotchkiss et al. (2010)
Study population	Male and female Fischer 344 rats, acute inhalation and acute neurotoxicity studies
Exposure method and duration	Inhalation of 0, 50, 100, 150, 200, 600, or 2,000 ppm; 4 or 8 hrs
Critical effect(s)	Sight degeneration and necrosis of olfactory epithelium
POD	50 ppm (NOEL)
Extrapolation to 1 hr (POD_{ADJ})	100 ppm
POD_{HEC}	100 ppm (used RGDR= 1, systemic effect)
Total UFs:	180
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	6
Acute ReV	550 ppb (2,200 µg/m^3)
TAMIS ReV [a]	540 ppb (2,200 µg/m^3)

[25] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/edc.pdf

Parameter	Summary
Selected AHBCV	**540 ppb**

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; NOEL – no observed effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; RGDR – regional gas deposition ratio; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Ethylene glycol

The TCEQ identified three acute ambient air toxicity factors for ethylene glycol from state governments: NY DEC,[7] MI EGLE,[26] and TCEQ.[27] The NY DEC value is based on a STEL/UF, while the MI EGLE and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for ethylene glycol that were identified by TCEQ for use as the AHBCV are the MI EGLE initial threshold screening level (ITSL) of 1,900 ppb and the short-term TCEQ ReV of 590 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 18. The MI EGLE ITSL and TCEQ ReV used the same key study, critical effects, and POD (LOAEL) for ethylene glycol. TCEQ considered 29 ppm to be a NOAEL and 55 ppm to be the LOAEL for sensory irritation without pulmonary function changes after 1 hr of exposure. There was no duration adjustment performed by MI EGLE or TCEQ. MI EGLE used a lower UF of 30, while TCEQ used a higher UF of 90 by applying an additional database UF of 3. Therefore, the MI 1-hr ITSL of 1,900 ppb has a lower total UF and MOE, is more fit-for-purpose, and was selected as the AHBCV for ethylene glycol (Table D - 19).

Table D - 18. Summary table for TCEQ derivation of the acute reference value (ReV) for ethylene glycol.

Parameter	Summary
Study	Wills et al. (1974)
Study population	24 human volunteers
Exposure method and duration	Inhalation at 0.8-75 mg/m^3, 188, 244, 308 mg/m^3 (aerosol); Unclear duration, likely 1 hr
Critical effect(s)	Respiratory irritation
POD	140 mg/m^3
Extrapolation to 1 hr (POD_{ADJ})	140 mg/m^3
Total UFs:	90
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A

[26] https://www.egle.state.mi.us/aps/downloads/ATSL/107-21-1/107-21-1_1hr_ITSL.pdf

[27] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/eg.pdf

Parameter	Summary
Intraspecies (H)	10
Database (D)	3
Acute ReV	590 ppb (1500 µg/m^3)

N/A – not applicable; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ReV – reference value; and UF – uncertainty factor.

Table D - 19. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for ethylene glycol.

Criteria	TCEQ ReV	MI EGLE
Year derived	2016	2017
Standard practices and procedures used	Yes	Yes
Inhalation key study	Wills et al. 1974, humans exposed to 0.8-75, 188, 244, 308 mg/m^3 for 1 hr	Wills et al. 1974, humans exposed to 0.8-75, 188, 244, 308 mg/m^3 for 1 hr
Critical effect(s) relevant to humans	Respiratory irritation	Respiratory irritation
Dose-response	Yes	Yes
POD	140 mg/m^3	140 mg/m^3
POD_{ADJ}	140 mg/m^3	140 mg/m^3
Lower total uncertainty	UF (90) (H = 10, L = 3, D = 3)	UF (30) (H = 10, L = 3); lowest
Lower MOE	No	Yes
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	1,500 µg/m^3 (590 ppb)	4,700 µg/m^3 (1900 ppb)
Selected AHBCV		**1,900 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; D – Database uncertainty factor (UF); H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ReV – reference value; and UF – uncertainty factor.

Ethylene oxide

The TCEQ identified four acute ambient air toxicity factors for ethylene oxide from state governments: AZ DHS,[3] NY DEC,[7] and TCEQ.[28] The AZ DHS value is based on a STEL/UF, and the derivation method is unknown for NY DEC. The TCEQ value was derived using defined guidelines, which is preferred for AHBCV development.

[28] www.tceq.texas.gov/downloads/toxicology/dsd/final/eto.pdf/view

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Summary

The acute air comparison values for ethylene oxide that was identified by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 910 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 20.

Table D - 20. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for ethylene oxide.

Parameter	Summary
Study	Snellings et al. (1982)
Study population	Fischer F344 Rats (female)
Exposure method and duration	Inhalation of 0, 10, 33, or 100 ppm; 6 hrs/day for 10 days (GDs 6 – 15)
Critical effect(s)	Developmental effects (decreased fetal body weight)
POD	45.12 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	81.99 ppm
POD_{HEC}	81.99 ppm (used RGDR= 1, systemic effect)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	910 ppb (1.7 mg/m^3)
Selected AHBCV	**910 ppb**

AHBCV – acute health-based comparison value; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; GD – gestational days; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Formaldehyde

The TCEQ identified acute ambient toxicity factors for formaldehyde from state governments: AZ DHS,[3] NC DEQ,[6] NY DEC,[7] MI EGLE,[8] CalEPA,[29] and TCEQ[30]. There was also one value from ATSDR[31] with an applicable exposure duration. The AZ DHS value is based on a STEL/UF and the

[29] https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf
[30] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/formaldehyde.pdf
[31] https://www.atsdr.cdc.gov/ToxProfiles/tp111.pdf

NC DEQ value is based on a TLV/UF. The derivation method is unknown for the NY DEC value. The MI EGLE value is a 24-h comparison value and the derivation method is unknown.

Summary

The three acute air comparison values for formaldehyde that were identified by TCEQ for use as the AHBCV are the ATSDR acute MRL of 40 ppb, the CalEPA REL of 44 ppb, and the short-term TCEQ ReV of 41 ppb. The bases for the derivations of the ATSDR, CalEPA, and TCEQ AHBCV can be found in Table D - 21, Table D - 22, and Table D - 23, respectively. Both ATSDR and TCEQ used the same key study in nonsmoking humans in which approximately half the participants had skin hypersensitivity to formaldehyde (Pazdrak et al. 1993), but TCEQ also used an additional key study in humans in which half the participants had bronchial asthma and suspected respiratory formaldehyde sensitization (Krakowiak et al. 1998). The CalEPA REL was derived based on a different key study in nonsmoking humans with no history of allergy or asthma (Kulle et al. 1987). The LOAEL of 0.4 ppm for nasal and eye irritation and rhinitis was the same POD used by ATSDR and TCEQ. In the key study used by CalEPA (Kulle et al. 1987), the NOAEL and LOAEL for eye irritation were 0.5 ppm and 1.0 ppm, respectively, and for derivation of the AHBCV, CalEPA used a $BMCL_{05}$ of 0.44 ppm based on eye irritation. In the derivation of all three AHBCVs, no duration adjustments were made because the effects seen (nasal and/or eye irritation) are considered to be concentration dependent only. Also, for all three AHBCVs the composite uncertainty factor used was the same. Both ATSDR and TCEQ used a UF_L of 3 and a UF_H of 3, while CalEPA used a UF_H of 10 to account for asthma exacerbation in children. Although the POD used by ATSDR and TCEQ was the same, after application of the composite uncertainty factor the AHBCV derived by TCEQ was slightly larger due to differences in rounding. The MOE for all AHBCVs are the same (10). The AHBCVs are similar and range from 40 to 44 ppb. The CalEPA REL of 44 ppb was selected as the AHBCV (Table D - 24) as it is more fit-for-purpose (e.g., it has a lower MOE calculated as the lowest LOAEL across key studies/REL) while still being health-protective because it is 9-fold lower than the lowest LOAELs identified in the key studies used by ATSDR and TCEQ.

Table D - 21. Summary table for ATDSR derivation of the minimal risk level (MRL) for formaldehyde.

Parameter	Summary
Study	Pazdrak et al. (1993)
Study population	20 human volunteers (9 with skin hypersensitivity to formaldehyde)
Exposure method and duration	Inhalation exposure to placebo (0 ppm) or 0.4 ppm; 2 hr
Critical effect(s)	Nasal and eye irritation
POD	0.4 ppm (minimal LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10

Parameter	Summary
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute MRL	40 ppb (49 µg/m^3)

LOAEL – lowest observed adverse effect level; MRL – minimal risk level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; and UF – uncertainty factor.

Table D - 22. Summary table for CalEPA derivation of the acute reference exposure level (REL) for formaldehyde.

Parameter	Summary
Study	Kulle et al. (1987)
Study population	19 healthy human volunteers
Exposure method and Duration	Inhalation exposure to clean air (0 ppm) or various concentrations ranging from 0.5 to 3 ppm; 3 hr
Critical effect(s)	Mild and moderate eye irritation
POD	0.44 ppm ($BMCL_{05}$)
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute REL	44 ppb (55 µg/m^3)

$BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 23. Summary table for TCEQ derivation of the acute reference value (ReV) for formaldehyde.

Parameter	Summary
Study	Pazdrak et al. (1993) and Krakowiak et al. (1998)
Study population	Pazdrak et al. (1993): 20 human volunteers (9 with skin hypersensitivity to formaldehyde); Krakowiak et al. (1998): 20 human volunteers (10 with bronchial asthma and suspected respiratory formaldehyde sensitization)
Exposure method and duration	Inhalation exposure to placebo (0 ppm) or 0.4 ppm; 2 hr
Critical effect(s)	Eye and nose irritation, symptoms of rhinitis
POD	0.4 ppm (minimal LOAEL)

Parameter	Summary
Extrapolation to 1 hr (POD_{ADJ})	No extrapolation applied
Total UFs:	10
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	1
Acute ReV	41 ppb (50 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 24. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for formaldehyde.

CRITERIA	ATSDR MRL	CALEPA REL	TCEQ REV
Year derived	1999	2008	2008
Standard practices and procedures	Yes	Yes	Yes
Inhalation key study	Pazdrak et al. (1993)	Kulle et al. (1987)	Pazdrak et al. (1993) and Krakowiak et al. (1988)
Critical effect(s) relevant to humans	Nasal and eye irritation	Mild and moderate eye irritation	Eye and nose irritation, symptoms of rhinitis
Dose-response	No	Yes	No
POD	0.4 ppm (free standing LOAEL)	0.44 ppm ($BMCL_{05}$)	0.4 ppm (free standing LOAEL)
POD_{ADJ}	0.4 ppm	0.44 ppm	0.4 ppm
Lower total uncertainty	UF (10) (H = 3, L = 3)	UF (10) (H = 10)	UF (10) (H = 3, L = 3)
Lower MOE	No	Yes [a]	No
1-hr Tox value	40 ppb	44 ppb	41 ppb
Selected AHBCV		**44 ppb**	

[a] Although the MOE for the CalEPA REL based on the $BMCL_{05}$ (0.44 ppm) is 10, the MOE of the CalEPA REL compared to the lowest LOAEL (0.4 ppm) is 9.; AHBCV – Acute health-based comparison value; $BMCL_{05}$ – benchmark concentration lower confidence limit with a benchmark response of 5%; H – Intraspecies uncertainty factor; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MRL- minimal risk level; POD – point of

departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

n-Hexane

The TCEQ identified two acute ambient air toxicity factors for n-hexane from state governments: AZ DHS[3] and TCEQ.[32] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

Summary

The acute air comparison values for n-hexane that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 5,400 ppb, because it was the only value derived using defined guideline methods. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 25.

Table D - 25. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for n-hexane.

Parameter	Summary
Study	Glowa (1991)
Study population	Adult male CD-1 mice
Exposure method and duration	Incrementally increasing exposure inhalation from 100 ppm up to 10,000 ppm; 30 min
Critical effect(s)	Neuroendocrine effects
POD	1,000 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	500 ppm
POD_{HEC}	500 ppm (used RGDR= 1, systemic effect)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	5,400 ppb (19,000 µg/m^3)
Selected AHBCV	**5,400 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per

[32] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/hexane-n.pdf

billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Hydrochloric acid

The TCEQ identified four acute ambient air toxicity factors for hydrochloric acid from state governments: AZ DHS,[3] MI EGLE,[8] NY DEC,[7] and TCEQ.[33] The AZ DHS value is based on a STEL/UF, and the derivation method is unknown for MI EGLE and NY DEC. The TCEQ value was derived using defined guidelines.

Summary

The acute air comparison value for hydrochloric acid that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 440 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 26.

Table D - 26. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for hydrochloric acid.

Parameter	Summary
Study	Stevens et al. (1992)
Study population	10 humans with asthma
Exposure method and duration	Inhalation exposure to 0, 0.8, or 1.8 ppm; 45 min
Critical effect(s)	Upper respiratory symptoms (sore throat, nasal discharge) and lower respiratory symptoms (pulmonary function, cough, chest pain)
POD	1.8 ppm (free-standing NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	1.35 ppm
Total UFs:	3
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	1
Database (D)	3
Acute ReV	450 ppb (660 µg/m^3)
TAMIS ReV [a]	440 ppb (660 µg/m^3)
Selected AHBCV	**440 ppb**

[a] Due to the calculation from µg/m3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in a Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values.; AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm

[33] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/hydrogen_chloride.pdf

– parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Hydrogen sulfide

The TCEQ identified five acute ambient air toxicity factors for hydrogen sulfide from state governments: AZ DHS,[3] NY DEC,[7] NC DEQ,[6] CalEPA,[4] and TCEQ.[9,34] There was also one value from ATSDR[35] with an applicable exposure duration. Three of the state values were not derived using defined guidelines: the AZ DHS value is based on a STEL/UF, while NY DEC and TCEQ have state standards with no documentation of how the standards were derived. The NC DEQ and ATSDR values were derived using defined guidelines. Although the CalEPA state standard was derived using defined guidelines, it was based on an odor threshold for hydrogen sulfide, rather than on health effects, thus making it not fit-for-purpose for use as an AHBCV.

Summary

The two acute air comparison values for hydrogen sulfide that were identified by TCEQ for use as the AHBCV are the NC DEQ acceptable ambient level (AAL) of 40 ppb and the ATSDR MRL of 70 ppb. The basis for the derivation of the ASTDR MRL can be found in Table D - 27. Both NC and ATSDR used the same key study (Jappinen et al., 1990) of 10 people with asthma exposed to 2 ppm (LOAEL) for up to 30 min to test pulmonary function. The free-standing LOAEL was selected as the POD. No dose-response was observed (because only one dose was tested). While ATSDR is typically excluded as a potential source of acute (≤ 24 hr) values because the MRL's are typically designed to be protective for 14 days, in this case, they did not use a duration adjustment of the 30-min results and so the MRL (70 ppb) was considered for use as a 1-hr AHBCV. ATSDR used a lower total uncertainty factor (30) than that used by NC (UF of 50), even though ATSDR used an additional UF of 3 for database completeness due to concern for the short (30-minute) exposure duration in the principal study, which is within a factor of 2 of the duration of interest (i.e., 1 hr) in the present case. Therefore, the ATSDR acute MRL has a lower MOE, is considered more fit-for-purpose, and was selected as the AHBCV (Table D - 28).

Table D - 27. Summary table for ATDSR derivation of the minimal risk level (MRL) for hydrogen sulfide.

Parameter	Summary
Study	Jappinen et al., 1990
Study population	10 human subjects with asthma
Exposure method and duration	Inhalation of 2 ppm H_2S; 30 min
Critical effect(s)	Significant change in airway resistance and conductivity for 2/10 subjects

[34] https://texreg.sos.state.tx.us/public/readtac$ext.ViewTAC?tac_view=5&ti=30&pt=1&ch=112&sch=B&rl=Y

[35] https://www.atsdr.cdc.gov/toxprofiles/tp114.pdf

Parameter	Summary
POD	2 ppm (free-standing LOAEL)
Extrapolation to 1 hr (POD_{ADJ})	2 ppm
Total UFs:	27
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	3
Database (D)	3
Acute MRL	70 ppb

LOAEL – lowest observed adverse effect level; H_2S – hydrogen sulfide; MRL – minimal risk level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 28. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for hydrogen sulfide.

Criteria	NC DEQ AAL	ATSDR MRL
Year derived	2001	2016
Standard practices and procedures	Yes	Yes
Inhalation key study	Jappinen et al., 1990, humans with asthma exposed to 2 ppm for 30 min	Jappinen et al., 1990, humans with asthma exposed to 2 ppm for 30 min
Critical effect(s) relevant to humans	Significant change in airway resistance and conductivity	Significant change in airway resistance and conductivity
Dose-response	No (only one dose used)	No (only one dose used)
POD	2 ppm (minimal LOAEL)	2 ppm (minimal LOAEL)
POD_{ADJ}	2 ppm	2 ppm
Lower total uncertainty	UF (50) (H = 10, L = 5)	UF (30) (H = 3, L = 3, D = 3); lowest
Lower MOE	No	Yes
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	40 ppb	70 ppb
Selected AHBCV		**70 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; D – Database uncertainty factor (UF); H – Intraspecies UF; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring

comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; and UF – uncertainty factor.

Isobutane

The TCEQ[36] ambient air toxicity factor was the only value identified for isobutane, and the value was derived using defined guidelines. Thus, the acute air comparison value for isobutane selected by TCEQ for use as the AHBCV is the short-term TCEQ ReV of 33,000 ppb. The basis for the derivation of the TCEQ AHBCV can be found in Table D - 29.

Table D - 29. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for isobutane.

Parameter	Summary
Study	Stewart et al. (1977)
Study population	Eight healthy adult male and female humans
Exposure method and duration	Inhalation to 250, 500, or 1,000 ppm; 1 hr, 2 hr, or 8 hr
Critical effect(s)	No effects
POD	1,000 ppm (free-standing NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	1,000 ppm
Total UFs:	30
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	3
Acute ReV	33,000 ppb (78,000 µg/m^3)
Selected AHBCV	**33,000 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

n-Octane

The TCEQ identified two acute ambient air toxicity factors for n-octane from state governments: AZ DHS[3] and TCEQ.[37] The AZ DHS value is based on a STEL/UF, while the TCEQ value was derived using defined guidelines.

[36] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/butanes.pdf

[37] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/octane.pdf

Summary

The acute air comparison value for n-octane that was identified by TCEQ for use as the AHBCV was the short-term TCEQ ReV of 4,100 ppb, because it was the only value derived using defined guideline methods**.** The basis for the derivation of the TCEQ AHBCV can be found in Table D - 30.

Table D - 30. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for n-octane.

Parameter	Summary
Study	Glowa (1991)
Study population	Adult male CD-1 mice
Exposure method and duration	Incrementally increasing exposure inhalation from 100 ppm up to 10,000 ppm; 30 min
Critical effect(s)	Transient behavioral impairment
POD	1,000 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	500 ppm
POD_{HEC}	369 ppm (RGDR = 0.74)
Total UFs:	90
LOAEL to NOAEL (L)	N/A
Interspecies (A)	3
Intraspecies (H)	10
Database (D)	3
Acute ReV	4,100 ppb (19,000 µg/m^3)
Selected AHBCV	**4,100 ppb**

AHBCV – acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; POD_{HEC} – point of departure human equivalent concentration; ppb – parts per billion; ppm – parts per million; ReV – reference value; RGDR – regional gas deposition ratio; and UF – uncertainty factor.

Sodium hydroxide

The TCEQ identified five acute ambient air toxicity factors for sodium hydroxide from state governments: AZ DHS,[3] NY DEC,[7] MI EGLE,[8] CalEPA,[4] and TCEQ.[38] Four of the values were not derived using defined guidelines: the AZ DHS and NY DEC values are based on a STEL/UF, TCEQ's interim 1-hr ESL is based on the NIOSH ceiling limit (CL)/100, and the MI EGLE adopted the CalEPA value. The CalEPA value was derived using defined guidelines.

[38] https://www.tceq.texas.gov/toxicology/esl/list_main.html

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Summary

The acute air comparison value for sodium hydroxide that was identified by TCEQ for use as the AHBCV was the acute CalEPA REL of 5 ppb (8 µg/m^3), because it was the only value derived using defined guideline methods**.** The basis for the derivation of the CalEPA AHBCV can be found in Table D - 31.

Table D - 31. Summary table for CalEPA derivation of the acute reference exposure level (REL) and acute health-based comparison value (AHBCV) for sodium hydroxide.

Parameter	Summary
Study	Ott et al. (1977)
Study population	291 humans occupational
Exposure method and duration	Occupational exposure estimated range of 0.5 – 2 mg/m^3; 8 hr time-weighted average
Critical effect(s)	Subjective reports of mild to moderate-severe irritation of the eyes and skin; mild respiratory irritation
POD	0.5 mg/m^3
Extrapolation to 1 hr (POD_{ADJ})	0.5 mg/m^3
Total UFs:	60
LOAEL to NOAEL (L)	6
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	5 ppb (8 µg/m^3)
Selected AHBCV	**5 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; REL – reference exposure level; and UF – uncertainty factor.

Styrene

The TCEQ identified four acute ambient air toxicity factors for styrene from state governments: AZ DHS,[3] NC DEQ,[39] CalEPA,[40] and TCEQ.[41] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for styrene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 5,100 ppb and the short-term TCEQ ReV of 5,200 ppb. The

[39] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Styrene_100-42-5_risk.pdf

[40] https://oehha.ca.gov/media/downloads/crnr/appendixd2final.pdf

[41] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/styrene.pdf

basis for the derivations of the CalEPA REL and TCEQ ReV can be found in Table D - 32 and Table D - 33, respectively. The CalEPA REL was derived based on the same key study and same application of uncertainty factors and the final values differ by 100 ppb due to rounding in the TCEQ Toxicity Factor Database. Because the value of 5,100 ppb was originally generated by both CalEPA and TCEQ (based on using the NOAEL of 51 ppm and dividing by a total UF of 10), the level of 5,100 ppb was selected as the AHBCV for styrene (Table D - 34).

Table D - 32. Summary table for CalEPA derivation of the acute reference exposure level (REL) for styrene.

Parameter	Summary
Study	Stewart et al. (1968)
Study population	9 human volunteers
Exposure method and duration	Exposure via inhalation at 51, 216, or 375 ppm for 1 hr, at 116 ppm for 2 hr, or at 99 ppm for 7 hr
Critical effect(s)	Eye and throat irritation
POD	51 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	51 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	**5,100 ppb**

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 33. Summary table for TCEQ derivation of the acute reference value (ReV) and acute health-based comparison value (AHBCV) for styrene.

Parameter	Summary
Study	Stewart et al. (1968)
Study population	9 healthy male volunteers
Exposure method and duration	Exposure via inhalation at 51, 216, or 375 ppm for 1 hr, at 116 ppm for 2 hr, or at 99 ppm for 7 hr
Critical effect(s)	Eye and nasal irritation
POD	51 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	51 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1

Parameter	Summary
Acute ReV	**5,100 ppb (22,000 µg/m^3)**
TAMIS AMCV [a]	5,200 ppb

[a] Due to the calculation from µg/m^3 (microgram per cubic meter) to ppb (parts per billion) in the TAMIS database, ppb values listed in the Development Support Document (DSD) may differ slightly from those listed in the TAMIS database. The TAMIS database values are the official values; however, the DSD value was utilized for this purpose because it is the same as the CalEPA value.; AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; TAMIS – Texas Air Monitoring Information System; and UF – uncertainty factor.

Table D - 34. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for styrene.

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Year derived	2008	2008
Standard practices and procedures	Yes	Yes
Inhalation key study	Stewart et al. (1968)	Stewart et al. (1968)
Critical effect(s) relevant to humans	Eye and throat irritation	Eye and nasal irritation
Dose-response	Yes	Yes
POD	51 ppm (NOAEL)	51 ppm (NOAEL)
POD_{ADJ}	51 ppm	51 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)
Lower MOE	Same	Same
MMCVs < Minimum LOAEL/BMC	Yes	Yes
1-hr Tox value	5,100 ppb	5,100 ppb
Selected AHBCV	**5,100 ppb**	**5,100 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Sulfuric acid

The TCEQ identified six acute ambient air toxicity factors for sulfuric acid from state governments: AZ DHS,[3] NC DEQ,[42] NY DEC,[7] MI EGLE,[8] CalEPA,[4] and TCEQ.[43] Five of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF and TLV/UF, respectively. The TCEQ value is a state standard with no documentation of

[42] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Sulfuric_Acid_risk.pdf

[43] https://texreg.sos.state.tx.us/public/readtac$ext.TacPage?sl=R&app=9&p_dir=&p_rloc=&p_tloc=&p_ploc=&pg=1&p_tac=&ti=30&pt=1&ch=112&rl=41

how the value was derived. NY DEC and MI EGLE adopted the CalEPA value. The CalEPA value was derived using defined guidelines.

Summary

The acute air comparison value for sulfuric acid that was identified by TCEQ for use as the AHBCV is the acute CalEPA REL of 120 µg/m³ (30 ppb), because it was the only value derived using defined guideline methods. The basis for the derivation of the CalEPA REL can be found in Table D - 35.

Table D - 35. Summary table for CalEPA derivation of the acute reference exposure level (REL) and acute health-based comparison value (AHBCV) for sulfuric acid.

Parameter	Summary
Study	Utell et al. (1984)
Study population	17 humans with asthma
Exposure method and duration	Inhalation to 100, 450, or 1000 µg/m³; 16 min
Critical effect(s)	Small changes in airway function
POD	450 µg/m³ (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	120 µg/m³
Total UFs:	1
LOAEL to NOAEL (L)	1
Interspecies (A)	N/A
Intraspecies (H)	1
Acute REL	30 ppb (120 µg/m³)
Selected AHBCV	**30 ppb**

AHBCV – Acute health-based comparison value; LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; REL – reference exposure level; and UF – uncertainty factor.

Toluene

The TCEQ identified five acute ambient air toxicity factors for toluene from state governments: AZ DHS,[3] NC DEQ,[44] NY DEC,[7] CalEPA,[45] and TCEQ.[46] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The derivation method of the NY DEC value is unknown. The CalEPA and TCEQ values were derived using defined guidelines.

[44] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Toluene_risk.pdf

[45] https://oehha.ca.gov/media/downloads/crnr/toluenerel082020.pdf

[46] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/toluene.pdf

Summary

The two acute air comparison values for toluene that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 1,300 ppb and the short-term TCEQ ReV of 4,000 ppb. The bases for the derivations of the CalEPA and TCEQ AHBCV can be found in Table D - 36 and Table D - 37, respectively. CalEPA and TCEQ used the same key study, critical effects, and POD for their toluene values, but the CalEPA total UF was 30 while the TCEQ UF was 10. CalEPA used a UF_H of 30 instead of the common standard UF_H of 10 used by other agencies, including TCEQ. The TCEQ ReV is health-protective with a lower MOE and thus is more fit-for-purpose.[11] Accordingly, the TCEQ ReV was selected as the AHBCV for toluene (Table D - 38).

Table D - 36. Summary table for CalEPA derivation of the acute reference exposure level (REL) for toluene.

Parameter	Summary
Study	Andersen et al. (1983)
Study population	16 healthy male humans
Exposure method and duration	Inhalation of 0, 10, 40, or 100 ppm; 6 hr
Critical effect(s)	Impaired reaction time and symptoms of headache, dizziness, feeling of intoxication, sensory irritation (eye and nose irritation)
POD	40 ppm
Extrapolation to 1 hr (POD_{ADJ})	40 ppm
Total UFs:	30
LOAEL to NOAEL (L)	1
Interspecies (A)	N/A
Intraspecies (H)	30
Acute REL	1,300 ppb (5,000 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 37. Summary table for TCEQ derivation of the acute reference value (ReV) for toluene.

Parameter	Summary
Study	Andersen et al. (1983)
Study population	16 healthy male humans
Exposure method and duration	Inhalation exposures of 0, 10, 40, or 100 ppm; 6 hr
Critical effect(s)	Eye and nose irritation, plus headaches, dizziness, and intoxication
POD	40 ppm (NOAEL)

Parameter	Summary
Extrapolation to 1 hr (POD_{ADJ})	40 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	4,000 ppb (15,000 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 38. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for toluene.

Criteria	CalEPA REL	TCEQ ReV
Year derived	2020	2008
Standard practices and procedures	Yes	Yes
Inhalation key study	Andersen et al. (1983), humans exposed to 0, 10, 40, or 100 ppm for 6 hr	Andersen et al. (1983) humans exposed to 0, 10, 40, or 100 ppm for 6 hr
Critical effect(s) relevant to humans	Eye and nose irritation, plus headaches, dizziness, and intoxication	Eye and nose irritation, plus headaches, dizziness, and intoxication
Dose-response	Yes	Yes
POD	40 ppm (NOAEL)	40 ppm (NOAEL)
POD_{ADJ}	40 ppm	40 ppm
Lower total uncertainty	UF (30) (H=30)	UF (10) (H=10); lowest
Lower MOE	No	Yes
1-hr Tox value	1,300 ppb	4,000 ppb
MMCVs < Minimum LOAEL/BMC	Yes	Yes
Selected AHBCV		**4,000 ppb**

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure POD_{ADJ} – point of departure adjusted for exposure duration; ppb –

parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Vinyl chloride

The TCEQ identified five acute ambient air toxicity factors for vinyl chloride from state governments: AZ DHS,[3] MI EGLE,[8] NY DEC,[7] CalEPA,[4] and TCEQ.[47] The AZ DHS value is based on a STEL/UF and was not derived using defined guidelines. The derivation method of MI EGLE is unknown, while NY DEC adopted the CalEPA value. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for vinyl chloride that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 72,000 ppb and the short-term TCEQ ReV of 26,000 ppb. The basis for the derivation of the CalEPA and TCEQ values can be found in Table D - 39 and Table D - 40, respectively. The CalEPA and TCEQ used the same key study, critical effects, and POD (NOAEL) for their vinyl chloride values, as well as the same total UF of 10. However, a duration adjustment was applied to convert the 7.5-hr exposure to 1 hr for the CalEPA REL. While this can introduce some uncertainty, in this case it makes the MOE lower than that for the TCEQ value, making this health-protective value more fit-for-purpose. Therefore, the CalEPA REL was selected as the AHBCV for vinyl chloride (Table D - 41).

Table D - 39. Summary table for CalEPA derivation of the acute reference exposure level (REL) for vinyl chloride.

Parameter	Summary
Study	Baretta et al., 1969
Study population	4-8 healthy human volunteers
Exposure method and duration	Inhalation of 59, 261, 491, or 493 ppm; 3.5 - 7.5 hr
Critical effect(s)	Subjective reports of mild headaches and dryness of eyes and nose
POD	261 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	715 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	72,000 ppb (180,000 µg/m³)

[47] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/vinyl_chloride.pdf

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 40. Summary table for TCEQ derivation of the acute reference value (ReV) for vinyl chloride.

Parameter	Summary
Study	Baretta et al. (1969)
Study population	4-8 healthy human volunteers
Exposure method and duration	Inhalation of 59, 261, 491, or 493 ppm; 3.5 - 7.5 hr
Critical effect(s)	Mild headache and dryness of eyes and nose
POD	261 ppm (NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	261 ppm (no duration adjustment)
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	26,000 ppb (68,000 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 41. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for vinyl chloride.

Criteria	CalEPA REL/NY AGC	TCEQ ReV
Year derived	1999	2009
Standard practices and procedures	Yes	Yes
Inhalation key study	Baretta et al. (1969), humans exposed to 59, 261, 491, or 493 ppm for 3.5 - 7.5 hr	Baretta et al. (1969), humans exposed to 59, 261, 491, or 493 ppm for 3.5 - 7.5 hr
Critical effect(s) relevant to humans	Mild headache and dryness of eyes and nose	Mild headache and dryness of eyes and nose
Dose-response	Yes	Yes
POD	261 ppm	261 ppm
POD_{ADJ}	715 ppm	261 ppm
Lower total uncertainty	UF (10) (H = 10)	UF (10) (H = 10)
Lower MOE	Yes	No
MMCVs < Minimum LOAEL/BMC	Yes	Yes

Criteria	CalEPA REL/NY AGC	TCEQ ReV
1-hr Tox value	72 ppm	26 ppm
Selected AHBCV	**72,000 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

Xylenes

The TCEQ identified five acute ambient air toxicity factors for vinyl chloride from state governments: AZ DHS,[3] NC DEQ,[48] NY DEC,[7] CalEPA,[4] and TCEQ.[49] Two of the values were not derived using defined guidelines: the AZ DHS and NC DEQ values are based on a STEL/UF. The NY DEC adopted the CalEPA value. The CalEPA and TCEQ values were derived using defined guidelines.

Summary

The two acute air comparison values for xylenes that were identified by TCEQ for use as the AHBCV are the acute CalEPA REL of 5,000 ppb and the short-term TCEQ ReV of 1,700 ppb. The basis for the derivation of the CalEPA and TCEQ values can be found in Table D - 42 and Table D - 43, respectively. The CalEPA value for xylenes was based on the Hastings et al. (1984) study, where multiple doses were administered to healthy human volunteers with an exposure duration of 30 min; a NOAEL (100 ppm) and LOAEL (200 ppm) were established. The TCEQ value is based on the Ernstgard et al. (2002) study, where they administered one concentration (50 ppm) to human volunteers with an exposure duration of 2 hours (LOAEL = 50 ppm). While the dosimetry adjustments result in the same POD_{adj} of 50 ppm for both CalEPA and TCEQ, the CalEPA REL POD exposure duration is closer to the duration of interest (i.e., a 30-min difference as opposed to a 1-hr difference), and a lower total UF (10) was used by CalEPA REL (compared to 30 used by TCEQ). The CalEPA REL of 5,000 ppb is health-protective with a lower MOE compared to the lowest LOAEL (50 ppm) and thus is more fit-for-purpose. Thus, the CalEPA REL of 5,000 ppb was selected as the AHBCV for xylenes (Table D - 44).

Table D - 42. Summary table for CalEPA derivation of the acute reference exposure level (REL) for xylenes.

Parameter	Summary
Study	Hastings et al. (1984) (with support from Carpenter et al. (1975); Nelson et al. (1943))
Study population	50 healthy human volunteers

[48] https://files.nc.gov/ncdeq/Air%20Quality/toxics/haps-taps/htdocs/Xylene_risk.pdf

[49] https://www.tceq.texas.gov/downloads/toxicology/dsd/final/xylenes.pdf

Parameter	Summary
Exposure method and duration	Inhalation of 430, 860, or 1720 mg/m^3 xylene; 30 min
Critical effect(s)	Subjective reports of eye, nose, and throat irritation
POD	430 mg/m^3 (100 ppm; NOAEL)
Extrapolation to 1 hr (POD_{ADJ})	50 ppm
Total UFs:	10
LOAEL to NOAEL (L)	N/A
Interspecies (A)	N/A
Intraspecies (H)	10
Acute REL	5,000 ppb (22,000 µg/m³)

LOAEL – lowest observed adverse effect level; N/A – not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; and UF – uncertainty factor.

Table D - 43. Summary table for TCEQ derivation of the acute reference value (ReV) for xylenes.

Parameter	Summary
Study	Ernstgard et al. (2002)
Study population	28 male and 28 female human volunteers
Exposure method and duration	Inhalation of 0 or 50 ppm; 2 hr
Critical effect(s)	Mild respiratory and subjective neurological effects
POD	50 ppm (LOAEL)
Extrapolation to 1hr (POD_{ADJ})	50 ppm
Total UFs:	30
LOAEL to NOAEL (L)	3
Interspecies (A)	N/A
Intraspecies (H)	10
Database (D)	1
Acute ReV	1,700 ppb (7,400 µg/m^3)

LOAEL – lowest observed adverse effect level; N/A– not applicable; NOAEL – no observed adverse effect level; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; ReV – reference value; and UF – uncertainty factor.

Table D - 44. Comparison table for selection criteria of the acute health-based comparison value (AHBCV) for xylenes.

Criteria	CalEPA REL/ NY AGC	TCEQ ReV
Year derived	1999	2009
Standard practices and procedures	Yes	Yes

Inhalation key study	Hastings et al. (1984), humans exposed to 0, 100, 200, or 400 ppm for 30 min	Ernstgard et al. (2002), humans exposed to 0 or 50 ppm for 2 hrs
Critical effect(s) relevant to humans	Subjective eye/ nose/ throat irritation	Mild respiratory/ subjective neurological effects
Dose-response	Yes	No
POD	100 ppm (NOAEL)	50 ppm (free standing LOAEL)
POD_{ADJ}	50 ppm	50 ppm
Lower total uncertainty	UF (10) (H=10); lowest	UF (30) (H = 10, L = 3)
Lower MOE	Yes	No
MMCVS < minimum LOAEL/BMC	Yes	Yes
1-hr TOX value	5,000 ppb	1,700 ppb
Selected AHBCV	**5,000 ppb**	

AHBCV – Acute health-based comparison value; BMC – benchmark concentration; H – Intraspecies uncertainty factor; L – lowest observed adverse effect level (LOAEL) to no observed adverse effect level (NOAEL) UF; LOAEL – lowest observed adverse effect level; MOE – margin of exposure; MMCV – mobile monitoring comparison value; POD – point of departure; POD_{ADJ} – point of departure adjusted for exposure duration; ppb – parts per billion; ppm – parts per million; REL – reference exposure level; ReV – reference value; and UF – uncertainty factor.

AHBCVs Derived Using OEL/UF Approach

Acetylene

The TCEQ's ambient air toxicity factor was the only value identified for acetylene. The 1-hr ESL was derived based on a NIOSH ceiling value of 2,500 ppm divided by a total UF of 100. Thus, the level of 25,000 ppb is selected as an AHBCV for acetylene.

Cyclohexane

The TCEQ's ambient air toxicity factor was the only value identified for cyclohexane. The 1-hr ESL was derived based on a TLV of 100 ppm divided by a total UF of 100. Thus, the level of 1,000 ppb is selected as an AHBCV for cyclohexane.

AHBCVs Not Derived

C3-C4 Saturated

C3-C4 Saturated is a mixture that includes 3 possible chemicals: propane, isobutane, and butane. There are no toxicity studies available for C3-C4 saturated, and there are no existing toxicity factors to evaluate. Therefore, developing an AHBCV is not possible.

Propane

Propane is a simple asphyxiant that is non-toxic in ambient air, and only causes toxicity in an enclosed space where concentrations are high enough to decrease oxygen levels to critically low amounts. Therefore, an AHBCV is not needed.

Propylene

Propylene is a simple asphyxiant that is non-toxic in ambient air, and only causes toxicity in an enclosed space where concentrations are high enough to decrease oxygen levels to critically low amounts. Therefore, an AHBCV is not needed.

Sulfur Dioxide

Sulfur dioxide is a federally regulated compound that has a national ambient air quality standard (NAAQS). Because of this, an AHBCV was not developed.