Derivation of Comparison Values for Evaluation of Ambient Air Chemical Concentrations Collected by Mobile Monitoring Instruments

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Acronyms and Abbreviations

Acronyms and Abbreviations	Definitions
ACGIH	American Conference of Governmental Industrial Hygienists
AEGL	acute exposure guideline level
AHBCV	acute health-based comparison value
AMCV	air monitoring comparison value
ASPECT	airborne spectral photometric environmental collection technology
ATSDR	Agency for Toxic Substances and Disease Registry
BMC	benchmark concentration
C	ceiling value
CalEPA	California Environmental Protection Agency
DOSH or Cal/OSHA	California Division of Occupational Safety and Health
DUVAS	differential ultra-violet absorption spectrometer
^{EM}HBAL	health-based action levels for exposure mitigation
^{EM}HBAL$_{10min}$	10-minute exposure mitigation health-based action level
^{EM}HBAL$_{1hr}$	1-hour exposure mitigation health-based action level
^{EM}HBAL$_{1sec}$	1-second exposure mitigation health-based action level
HBAL	health-based action levels
HEC	human equivalent concentration
iBDIL	instantaneous baseline-derived investigation level
iHBAL	instantaneous health-based action level
iHPIL	instantaneous health-protective investigation level
LOAEL	lowest-observed-adverse-effect-level
MOE	margin of exposure
MRL	minimal risk level
N	baseline noise
NIOSH	National Institute for Occupational Safety and Health
NOAEL	no-observed-adverse-effect-level
OSHA	Occupational Safety and Health Administration

Acronyms and Abbreviations	Definitions
PBPK	physiologically-based pharmacokinetic
ppb	parts per billion
ppbv	parts per billion by volume
PTR-MS	proton transfer reaction mass spectrometer
RfC	reference concentration
RfD	reference dose
S/N	signal to noise
SIFT-MS OR SIFT	selected ion flow tube-mass spectrometer
STEL	short-term exposure limit
TAGA	trace atmospheric gas analyzer
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency
UF	uncertainty factor

Executive Summary

Background

The Texas Commission on Environmental Quality (TCEQ) has several ambient air monitoring instruments in specialized vehicles that can collect instantaneous data while in-motion (termed mobile monitoring) for activities such as field investigations and emergency events. The two primary instruments are the Selected Ion Flow Tube-Mass Spectrometer (SIFT-MS or SIFT)[1] and the Differential Ultra-Violet Absorption Spectrometer (DUVAS).[2] These instruments can provide accurate, real-time, instantaneous concentrations (typically in 1-30 second intervals) of select chemicals in ambient air while the vehicle is in motion. These instruments produce important information for assessing air quality in areas near emergency events (e.g., industrial accidents, natural disasters such as hurricanes, etc.) and during investigations. The DUVAS instrument also provides monitoring staff with concentration-based, color-coded maps (called caterpillar trails) in real-time, which can be used as a practical tool to geographically map concentrations of targeted chemicals for evaluation by agency staff and to help communicate concentration data to the public. Both the SIFT and DUVAS can be used to rapidly identify abnormally high concentrations of targeted chemicals in ambient air and help expedite efforts to address them. However, evaluating these instantaneous measurements to determine abnormal levels and/or potential health concern offers some challenges, which are addressed herein.

Instantaneous data present unique challenges for interpretation, primarily due to their very short sample duration. Historically, concentrations with very short sampling durations (i.e., 1-30 seconds) have not been evaluated for the potential to cause adverse health or welfare (e.g., vegetation) effects because there is a lack of relevant toxicity studies with equivalent or very brief exposure durations. Health-based comparison values have historically been based on a chronic exposure duration (e.g., United States Environmental Protection Agency [USEPA] reference concentrations [RfCs] and reference doses [RfDs]), with some agencies such as the TCEQ also developing short-term/acute health-based comparison values (e.g., TCEQ's 1-hour air monitoring comparison values [AMCVs]). In addition, field staff conducting the monitoring need to be able to continuously review incoming instantaneous air monitoring data and short-term averages so they may take appropriate actions in the field. There is also a need to provide context and meaning to these data to facilitate risk communication to the public.

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[1] SIFT-MS or SIFT – Selected-Ion Flow-Tube Mass Spectroscopy from Syft Technologies; the SIFT uses ultra-soft, precisely controlled chemical ionization coupled with mass spectrometric detection to rapidly quantify volatile organic compounds and permanent gases.

[2] DUVAS – Differential UV Absorption Spectroscopy instrument from DUVAS Technologies; the DV3000 offers real time, constant, simultaneous measurement of multiple gaseous species detectable using ultraviolet spectroscopy.

Types of mobile monitoring comparison values

To develop comparison values for mobile monitoring data that are reliable screening tools, it is necessary to have a good understanding of the collection and interpretation challenges of the data and how the data needs to be used. Based on these considerations, the TCEQ developed four different types of fit-for-purpose air data screening levels. These levels can be used in near real-time to help the TCEQ, the USEPA, and others to take actions to identify and characterize sources, initiate stationary monitoring or collection of canister samples to obtain longer duration measurements for toxicity evaluations, and/or mitigate exposure to staff when chemical concentrations are at higher levels. This document derives values specifically for use by monitoring staff and field investigators (a general public focus is outside the scope of this document). These screening levels are:

- instantaneous baseline-derived investigation levels (iBDILs)
- instantaneous health-protective investigation levels (iHPILs)
- instantaneous health-based action levels (iHBALs)
- exposure mitigation health-based action levels (^{EM}HBALs), associated with different short-term concentration durations:
    - 10-minute exposure mitigation health-based action level ($^{EM}HBAL_{10min}$)
    - 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$)
    - 1-second exposure mitigation health-based action level ($^{EM}HBAL_{1sec}$)

Baseline-derived comparison values

One use for the mobile monitoring comparison values is to identify the presence of an abnormally high concentration of any monitored chemical in the ambient air, so that a follow-up source investigation/characterization and any necessary emission mitigation can be implemented. To identify an abnormally high level of a chemical,[3] the baseline level of the chemical needs to be established first. A chemical baseline is considered to include both the low-level concentrations of that chemical in the environment, as well as the electronic and mechanical "noise" generated by the monitoring instrument. Therefore, the baseline concentration level is specific to each chemical and to the instrument being used. Before applying the SIFT and DUVAS instrument-specific baseline comparison values to other instantaneous sampling instruments (e.g., the USEPA Trace Atmospheric Gas Analyzer [TAGA] or the proton transfer reaction mass spectrometer [PTR-MS]), the appropriateness of these comparison values for other instruments will need to be evaluated.

After identifying chemical- and instrument-specific baselines, the instantaneous baseline derived investigation levels (iBDILs) were set at levels 10-times higher than the identified baseline. Setting the iBDIL 10-times higher than the baseline is intended to ensure that the

[3] Concentrations more than 10-fold higher than chemical- and instrument-specific baseline concentrations were considered "abnormal".

agency investigates abnormally high chemical concentrations in ambient air, while balancing the need to avoid using agency resources to investigate potentially spurious increases in chemical concentrations. The iBDIL values are not related to the toxicity of a chemical, although the majority of the iBDIL values that have been derived for the monitored chemicals thus far have been lower than toxicity-based comparison values.

Health-based comparison values

Other comparison values were derived to provide context in terms of potential chemical toxicity, and so included health-based, fit-for-purpose levels, that if exceeded could prompt longer duration stationary monitoring (i.e., 10 minutes to 1 hour) or consideration of exposure mitigation by staff.

Acute health-based comparison values (AHBCVs) are based on chemical-specific toxicity data and are typically developed for comparison to concentrations with 1-hour averaging times (e.g., TCEQ's 1-hour AMCVs), not 1-30 second averaging times. However, these 1-hour values can be utilized to help derive screening values for mobile monitoring data of different durations, including instantaneous measurements. The TCEQ used criteria that were fit-for-purpose for selection of AHBCVs (derived by TCEQ or other state or federal agencies) (See Appendix D) that are appropriate for use in emissions-related investigations and emergency response events. Those AHBCVs then served as the basis for the health-based mobile monitoring comparison values.

Several types of instantaneous and longer duration health-based mobile monitoring comparison values were derived to provide context to measured concentrations and to help inform actions by mobile monitoring staff. The first is the instantaneous health-protective investigation level (iHPIL), which is conservatively set as equal to the 1-hour AHBCV. An exceedance of an iHPIL could prompt stationary monitoring for up to 1 hour or more, as determined by field staff, with the resulting average concentrations then compared to the mobile monitoring comparison value of appropriate duration discussed below.

To indicate when more immediate or greater action may be required, four health-based action levels (HBALs) were developed. Instantaneous health-based action levels (iHBALs) are set at 3-times the AHBCV. As with the iHPIL, exceedance of the iHBAL triggers the need for stationary sampling, as well as increased vigilance for potential exceedance of an exposure mitigation value (discussed below). When the data can be averaged in the field, an iHBAL exceedance triggers an evaluation for potential toxicity after the first 5-10 minutes of stationary sampling, rather than after 1 hour (as with the iHPIL). Health-based action levels for exposure mitigation (^{EM}HBALs) were developed to help inform field staff of chemical concentrations where they may consider decreasing their exposure. ^{EM}HBALs were derived for three durations: 5-10-minute average ($^{EM}HBAL_{10min}$), 1-hour average ($^{EM}HBAL_{1hr}$), or instantaneous concentrations ($^{EM}HBAL_{1sec}$). The $^{EM}HBAL_{10min}$ is set based on the lesser of: 3-times the AHBCV, one-half an

appropriate 15-minute occupational short-term exposure limit (STEL)[4] if available, or one-half an appropriate occupational ceiling value (C),[5] if available. A 1-hour exposure mitigation health-based action level ($^{EM}HBAL_{1hr}$) was also derived for comparison to 30-minute to 1-hour average concentrations measured while the vehicle is stationary. The $^{EM}HBAL_{1hr}$ is set at 2-times the AHBCV. If the mobile instrument being used is not capable of averaging concentrations for comparison to the 10-minute or 1-hour ^{EM}HBALs, a 1-second exposure mitigation health-based action level ($^{EM}HBAL_{1sec}$) was also derived for comparison with instantaneous concentrations measured while the vehicle is stationary or mobile. The $^{EM}HBAL_{1sec}$ is based on 3-times the $^{EM}HBAL_{1hr}$.

A measured 5-10-minute average concentration that exceeds the $^{EM}HBAL_{10min}$, a 30-minute to 1-hour average concentration that exceeds the $^{EM}HBAL_{1hr}$, or a 1-30 second concentration that exceeds the $^{EM}HBAL_{1sec}$ can trigger evaluation of staff safety (i.e., staff may choose to take steps to mitigate their potential for exposure in the field) and the need to communicate information to regional managers and/or incident command. Importantly, adverse health effects are not expected with a marginal exceedance of any of the mobile monitoring comparison values. Unlike the baseline-derived values, all the fit-for-purpose health-based comparison values (iHPILs, iHBALs, ^{EM}HBALs, and AHBCVs) are applicable across platforms capable of collecting instantaneous measurements.

Table 1 and Table 2 provide a summary of the basis for each of the mobile monitoring comparison values, and Table 1 shows the associated chemical concentration color designation for use with the DUVAS caterpillar trail data visualizations. While these color designations are specific to the DUVAS caterpillar trail output, for consistency in communication they have been adopted for use with all mobile monitoring comparison values, regardless of instrument. Table 3 lists the comparison values for chemicals that are currently measured by the SIFT and DUVAS instruments (i.e., some volatile organic compounds and sulfur dioxide). In addition to the chemicals shown in Table 3, mobile monitoring comparison values were also derived for several other chemicals, as well as for chemicals measured by other monitoring instruments, and the full list can be found in Appendix A.

Altogether, these fit-for-purpose comparison values can help the TCEQ, USEPA, and others in prioritizing resources for identifying sources, characterizing chemical concentrations, and/or mitigating exposure to staff from events that cause chemical releases. All derived mobile monitoring comparison values are intended to be used as guidance. *Field investigators and mobile monitoring staff should use their own discretion when deciding to mitigate exposure, such as when experiencing health effects or intense odors, regardless of measured*

[4] 15-minute short-term exposure limits (STELs) are derived by occupational safety agencies such as the American Conference of Governmental Industrial Hygienists (ACGIH), the Occupational Safety and Health Administration (OSHA), California Division of Occupational Safety and Health (DOSH; also known as Cal/OSHA), and the National Institute for Occupational Safety and Health (NIOSH).

[5] Ceiling value (C) is an occupational exposure level that represents the concentration that shall not be exceeded during any part of the working exposure. Sources of these values include ACGIH, OSHA, and NIOSH.

concentrations. All screening values will provide context to the color-coded, real-time visualization of monitored data and will aid in communicating risk. An illustrative decision guide for both SIFT and DUVAS that highlights the comparison levels and corresponding actions to be taken if an exceedance occurs can be found in Appendix C.

Table 1. Basis of instantaneous mobile monitoring comparison values and recommended actions if exceeded.

Comparison Value (Acronym)	DUVAS Caterpillar Trail Colors [a]	Basis	Recommended Actions with Exceedance
[Concentrations below instantaneous comparison values]	**GREEN**	N/A	No associated action
Instantaneous baseline-derived investigation level (iBDIL)	**ORANGE**	10× baseline level	Source investigation/characterization
Instantaneous health-protective investigation level (iHPIL)	**RED**	1× selected AHBCV	• Stationary monitoring/canister sample collection (30-min to 1-hour) • Source investigation/characterization
Instantaneous health-based action level (iHBAL)	**PURPLE**	3× selected AHBCV	• Increased vigilance for EM concentrations • Stationary monitoring (5-10 min) • Stationary monitoring/canister sample collection (30-min to 1-hour) • Source investigation/characterization

[a] Colors represent values that are greater than or equal to the indicated appropriate comparison value; the DUVAS caterpillar trail color designations have been adopted for use with all of the mobile monitoring comparison values to have consistency in communication.; AHBCV – acute health-based comparison value; DUVAS – Differential Ultra-Violet Absorption Spectrometer; EM – exposure mitigation; and N/A – not applicable.

Table 2. Basis of exposure mitigation values and recommended actions if exceeded.

Comparison Value (Acronym)	Basis	Recommended Actions
10-min health-based action level for exposure mitigation ($^{EM}HBAL_{10min}$)	Lower of 3**×** AHBCV**,** ½ STEL, or ½ C	Consider exposure mitigation for staff
1-hour health-based action level for exposure mitigation ($^{EM}HBAL_{1hr}$)	**2×** AHBCV	Consider exposure mitigation for staff
1-sec health-based action level for exposure mitigation ($^{EM}HBAL_{1sec}$)	**3×** $^{EM}HBAL_{1HR}$	Consider exposure mitigation for staff

AHBCV – acute health-based comparison value; STEL – 15-minute short-term occupational exposure limit; C – ceiling value; and there is no separate DUVAS caterpillar trail designated color for ^{EM}HBAL values.

Table 3. Comparison values for select chemicals measured using mobile monitoring instruments by TCEQ.

Chemical(s) COLOR	CAS No.	iBDIL - DUVAS (ppb) ORANGE	iBDIL - SIFT (ppb) ORANGE	iHPIL (ppb) RED	iHBAL (ppb) PURPLE	$^{EM}HBAL_{10MIN}$ (ppb) N/A	$^{EM}HBAL_{1HR}$ (ppb) N/A	$^{EM}HBAL_{1SEC}$ (ppb) N/A
Acetylene	74-86-2	--	80	25,000	75,000	75,000	50,000	150,000
Benzene	71-43-2	80 [a]	80	180	540	500 [b]	360	1,080
1,3-Butadiene	106-99-0	40 [a]	40	1,700	5,100	2,500 [b]	3,400	10,200
1-Butene	106-98-9	--	110	27,000	81,000	81,000	54,000	162,000
C3-C4 saturated	--	--	960	--	--	--	--	--
Cyclohexane	110-82-7	--	120	1,000	3,000	3,000	2,000	6,000
Ethylbenzene	100-41-4	350	--	20,000	60,000	60,000	40,000	120,000
n-Hexane	110-54-3	--	340	5,400	16,200	16,200	10,800	32,400
Isobutane	75-28-5	--	280	33,000	99,000	99,000	66,000	198,000
n-Octane	111-65-9	--	160	4,100	12,300	12,300	8,200	24,600
Propane	74-98-6	--	540	--	--	--	--	--
Styrene	100-42-5	60 [a]	60	5,100	15,300	10,000 [b]	10,200	30,600
Sulfur dioxide	7446-09-5	70	--	--	--	--	--	--
Toluene	108-88-3	70 [a]	70	4,000	12,000	12,000	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	--	60	5,000 [c]	15,000 [c]	15,000 [c]	10,000 [c]	30,000 [c]
Xylenes	1330-20-7	--	--	5,000	15,000	15,000	10,000	30,000

[a] Based on SIFT;.[b] Based on ½ STEL;.[c] Values based on xylenes AHBCV; DUVAS - Differential Ultra-Violet Absorption Spectrometer; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iBDIL – instantaneous baseline-derived investigation level; iHBAL – instantaneous health-based action level; iHPIL – instantaneous health-protective investigation level; N/A – not applicable; ppb – parts per billion; SIFT- Selected Ion Flow Tube-Mass Spectrometer; and "--"no value available.

Acknowledgments

We would like to acknowledge the efforts of the TCEQ air monitoring and regional staff who contributed to this effort through data gathering, quality assurance, and extensive discussions about what kind of comparison values would be most useful for TCEQ field staff. We further acknowledge the expert input on the MMCV derivations from the staff at EPA Region 6.

The work to derive and document the MMCVs was completed principally by many staff (current and former) in the TCEQ Toxicology, Risk Assessment, and Research Division.

Background

As part of the TCEQ's field investigations and/or response to emergency events (i.e., natural events such as hurricanes and storms; and industrial events such as chemical releases, fires, and similar situations), the Emergency Management Support Section, Monitoring Division, and regional offices all may offer monitoring, oversight, and technical/regulatory assistance to the response. For monitoring support, environmental investigators may be deployed to the affected area with handheld monitoring devices, and/or with specialized vehicles that are equipped with air monitoring instruments that collect instantaneous data for a variety of chemicals. Measurements from these tools are often collected in addition to any nearby stationary ambient air monitoring data, if available, because mobile vans and environmental investigators with handheld instruments can move around an affected area and provide more dynamic data (e.g., moving downwind/upwind of sources). Recent advancements in ambient air mobile monitoring instruments in specialized vehicles allow investigators and monitoring staff to collect instantaneous concentrations while said vehicles are in-motion. These instruments provide an important ambient air monitoring data stream captured in real-time to assess air quality. In addition, depending on the magnitude of the event, other entities (e.g., federal agencies, industry, municipalities) may deploy such resources. For instance, the USEPA may also deploy their Airborne Spectral Photometric Environmental Collection Technology (ASPECT) aircraft to aid in surveillance of the affected area. Collectively, all these data streams are important in the characterization of an event and the affected area(s).

The TCEQ has acquired instrumentation (e.g., Selected Ion Flow Tube-Mass Spectrometer [SIFT-MS or SIFT] and the Differential Ultra-Violet Absorption Spectrometer [DUVAS]) capable of reporting chemical concentrations in ambient air on an instantaneous basis (e.g., 1-30 second concentrations) while in a moving vehicle. These instruments help to geographically map chemical concentrations in areas during field investigations and in the aftermath of emergency events (i.e., industrial fires, hurricanes) by assessing air quality in near real time. This additional data stream can inform the decision-making process of staff in the field. For instance, the data can guide where best to deploy additional agency resources to identify and address chemical releases related to natural and industrial events, as well as to assess when exposure mitigation strategies may need to be considered.

These instantaneous data require appropriate interpretation and necessitate the development of fit-for purpose instantaneous comparison values, in addition to longer duration comparison values (i.e., 5-10 minute and 30-minute to 1-hour) for data that are obtained when the mobile monitoring instrument is stationary. In the past, instantaneous comparison values have not been derived by the TCEQ or other regulatory agencies for a variety of reasons. One reason is that 1-30 second(s) is a historically irrelevant exposure duration both environmentally and occupationally when considering typical air sampling durations (e.g., 24-hour, 8-hour, 1-hour), hence a lack of historical regulatory need. Another reason is the lack of relevant toxicity studies with exposure durations of less than 30-60 minutes. Health-based values are derived using available toxicity data, which can include exposures for hours to days (acute), or months to years (chronic). Using this data, health-based values are often derived for a chronic exposure duration (e.g., 1- to 70-year durations, such as the USEPA reference concentrations [RfCs] and reference doses [RfDs]), and some agencies, such as the TCEQ and CalEPA, have also derived short-term/acute (e.g., 1-hour and 24-hour) health-based comparison values.

In addition to developing comparison values for mobile monitoring that match the measurement durations, the appropriate actions to be taken and the potential need for public risk communication based on the use of these comparison values was also considered.

Altogether, the TCEQ developed four types of fit-for-purpose air data screening levels to be used as comparison values in the evaluation of data collected by mobile monitoring vehicles. The purpose of this document is to explain these mobile monitoring comparison values, how they were derived, and potential actions that may be considered and taken when the comparison values are exceeded.

Section 3 discusses investigation levels that are derived using chemical- and instrument-specific baselines and are independent of chemical-specific toxicity. Section 4 describes the choice of acute air comparison values that are used as the basis for many of the health-based mobile monitoring comparison values. Section 5 describes the derivation of health-based investigation levels, action levels, and levels where exposure mitigation may need to be considered. Appendix A includes a comprehensive list of the chemicals and the mobile monitoring comparison values that TCEQ derived. Altogether, these fit-for-purpose mobile monitoring comparison values can help the TCEQ, USEPA, and other environmental agencies in prioritizing resources for identifying and addressing chemical emission source(s), characterizing chemical concentrations, and/or mitigating exposure to staff from events that cause chemical releases.

Baseline-derived mobile monitoring comparison values

The first type of mobile monitoring comparison value is the instantaneous baseline-derived investigation level (iBDIL). The purpose of the iBDIL is to identify the presence of an abnormally high concentration of any monitored chemical in the ambient air, so that a follow-up source investigation and emission mitigation can be carried out if necessary. To identify an abnormal level of a chemical in the air, the normal baseline level of the chemical needs to be determined first. A chemical baseline is a combination of the measured levels of that chemical in the environment under normal circumstances (i.e., in the absence of a chemical release) plus the

electronic and mechanical “noise” generated by the monitoring instrument. The baseline is both chemical- and instrument-specific; therefore, chemical baseline analyses were conducted using the data for chemicals measured by each of monitoring instruments during mobile monitoring surveys.

Baseline evaluation

The TCEQ mobile monitoring staff conducted surveys for investigations and emergency events in the Beaumont, Houston, and Corpus Christi regions of Texas (TCEQ regions 10, 12, and 14, respectively) starting from 2019 using the SIFT and DUVAS instruments. These TCEQ regions are along the Gulf Coast and contain various industrial, petrochemical, and oil and gas facilities, as well as ports for transport of industrial chemicals and other materials. The data from each mobile monitoring survey included: date, survey ID, time, location, latitude, longitude, detected concentration in parts per billion by volume (ppbv, subsequently referred to as “ppb”) for each chemical monitored, and minimum and maximum concentrations measured for each chemical. To determine the baseline of each chemical for the SIFT and DUVAS, surveys with a wide range of maximum values and from different days and locations were selected. Preference was given to surveys with lower maximum values because those with higher concentrations indicated a potential chemical emission source nearby that would inflate the concentrations above baseline. The time and the corresponding concentration from selected surveys were graphed to evaluate the baseline.

The regular baseline noise (N) of a time-concentration plot is the low-level detections and the inherent noise of the instrument that can be seen over time. TCEQ defined a real concentration peak as a chemical concentration signal (S) that is ≥3-times the level of the baseline detection noise before and after the signal peak (i.e., a signal to noise [S/N] ratio ≥3). The baseline value for a specific chemical and monitoring method was defined as the highest non-signal peak among the monitoring surveys analyzed and is referred to herein as the 1× baseline. This method for determining the 1× baseline value was chosen because it represents the highest concentration in the range of non-signal baseline levels, with the 1× baseline serving as a value from which abnormal levels of chemical can be determined.

When analyzing the baseline, some characteristics of the concentration-time measurements were considered when evaluating the suitability of the survey for analysis. Surveys with the following example conditions were excluded from baseline noise analysis: 1) high intensity signals with a long tail, which may distort the baseline; 2) significantly raised baseline where both the high and the low concentrations are much higher than zero; 3) lowest measured concentrations drifting up or down and appearing as a large broad peak rather than a flat line; 4) frequent negative measurements; 5) abrupt changes in baseline levels from low-to-high or high-to-low; and 6) time-concentration plots with many isolated non-peak spikes (i.e., single high intensity signal without peak width). Surveys with a high intensity signal at the very beginning or end of the survey were still considered suitable, but the area near these signals was excluded from the baseline analysis in the event that those signals were measurement artefacts.

Derivation of instantaneous baseline-derived investigation levels (iBDILs) for SIFT and DUVAS monitoring instruments

For the selected surveys, the regular baseline noise was evaluated following the considerations outlined above, and the maximum noise level that was clearly not a signal peak (i.e., the S/N ratio ≤3) was determined. The highest value among all the surveys analyzed (that were not excluded under the considerations above) is the 1× baseline for that chemical and instrument. The chemical-specific iBDIL was set at concentrations 10-times the 1× baseline, because such levels were considered to indicate abnormally high levels that require evaluation. This level is intended to maintain a balance between appropriately investigating abnormally high chemical concentrations in ambient air, while not using agency resources to investigate potentially spurious or insignificant chemical concentrations. The 1× baselines and iBDILs that were determined for the SIFT and DUVAS are shown in Table 4, and specific details for each chemical and instrument evaluation can be found in Appendix B. For chemicals that are measured by both the SIFT and DUVAS instruments, a single iBDIL was selected for use with both instruments to provide consistency for field staff implementing these values. This decision applied to four chemicals (benzene, 1,3-butadiene, styrene, and toluene), and the iBDIL from the SIFT instrument was chosen because the SIFT (which is a more quantitative and precise instrument) had a lower baseline than the DUVAS.

Table 4. Baseline and iBDIL values of chemicals monitored by SIFT and DUVAS instruments.

Chemical(s)	Applicable instrument(s)	SIFT baseline (ppb)	DUVAS baseline (ppb)	iBDIL (ppb)
Acetylene	SIFT	8	N/A	80
Benzene	SIFT, DUVAS	8	14	80 [a]
1,3-Butadiene	SIFT, DUVAS	4	6	40 [a]
1-Butene	SIFT	11	N/A	110
C3-C4 saturated	SIFT	96	N/A	960
Cyclohexane	SIFT	12	N/A	120
Ethylbenzene	DUVAS	N/A	35	350
n-Hexane	SIFT	34	N/A	340
Isobutane	SIFT	28	N/A	280
n-Octane	SIFT	16	N/A	160
Propane	SIFT	54	N/A	540
Styrene	SIFT, DUVAS	6	8	60 [a]
Sulfur dioxide	DUVAS	N/A	7	70
Toluene	SIFT, DUVAS	7	40	70 [a]
Xylenes + Ethylbenzene	SIFT	6	N/A	60

[a] iBDIL derived using baseline from the SIFT instrument; DUVAS - Differential Ultra-Violet Absorption Spectrometer; iBDIL – instantaneous baseline-derived investigation level; N/A – not applicable; ppb – parts per billion; and SIFT-

Selected Ion Flow Tube-Mass Spectrometer.

Derivation of instantaneous baseline-derived investigation levels (iBDILs) for other mobile monitoring instruments

In addition to the SIFT and DUVAS, the TCEQ has other monitoring instruments that are used to evaluate chemical concentrations during in-motion and stationary monitoring surveys. This includes a Picarro[6] instrument that measures hydrogen sulfide, and a nephelometer[7] instrument that measures particulate matter less than 10 micrometers (µm) in diameter (PM_{10}) and particulate matter less than 2.5 µm in diameter ($PM_{2.5}$).

Upon evaluation of the instantaneous hydrogen sulfide concentration data measured using the Picarro during mobile monitoring surveys, it was determined that the baseline levels were inconsistent and highly variable. As such, an iBDIL was not derived for hydrogen sulfide monitored via the Picarro instrument. Further details are provided in Appendix B.

Evaluation of PM_{10} and $PM_{2.5}$ instantaneous concentrations measured via nephelometer demonstrated that the instrument noise was very low (in the range of 20 ng/m^3), in comparison to the measured PM concentrations (in the µg/m^3 range). However, the measured concentrations of PM could vary substantially on a day-to-day basis, and sometimes within a single day. Such variability is consistent with the known variance in ambient PM concentrations, but it precludes the identification of a constant baseline for derivation of an iBDIL. As such, an iBDIL was not derived for PM_{10} or $PM_{2.5}$ monitored via the nephelometer instrument. Further details are provided in Appendix B.

Acute health-based comparison values (AHBCVs)

For emergency and investigational preparedness, it is important to have appropriate ambient air comparison values in place prior to the occurrence of an event. Acute ambient air comparison values for evaluating the potential for adverse health effects of exposure to the general public, monitoring staff, and field investigators are one of the most immediate needs in these situations. These values can help first responders, federal, state, and local governmental regulatory authorities, and others to:

- Primarily, assess the potential for acute health effects to monitoring staff and field investigators in the near-term.

[6] Picarro – A gas concentration analyzer that uses Cavity Ring-Down Spectroscopy technology from Picarro to provide precise measurement of methane (CH_4) and hydrogen sulfide (H_2S) at parts per billion (ppb) sensitivity.

[7] 2-WIN Nephelometer – A Two Wavelength Integrating Nephelometer from Ambilabs; it determines particulate concentration by measuring the total scatter from aerosols and using a selectable wavelength for either PM_{10} or $PM_{2.5}$ at µg/m^3 level.

- Secondarily, help prioritize the responses to environmental impacts occurring due to unintended industrial releases, especially during a widespread event (e.g., a natural disaster).
- Thirdly, inform decision-making on the potential need and urgency of mitigating public exposure.

To best inform the needs discussed above, this document focuses on the perspective of the monitoring staff and field investigators (a public exposure focus is generally outside the scope of this document). The acute ambient air comparison values utilized (hereafter referred to as acute health-based comparison values or AHBCVs) should be both scientifically sound and fit-for-purpose. Such values can inform an assessment in real time for both the potential for acute adverse health effects and subsequent decision-making (e.g., the need for exposure mitigation, appropriate prioritization of environmental concerns, etc.). After these values were selected, they were used as the basis for the derivation of the health-based mobile monitoring comparison values.

Considerations for selection of AHBCVs

AHBCVs to be used in emergency response and investigational situations should be health-protective (i.e., set at levels below which adverse health effects are expected to occur) and fit-for-purpose, without being unduly conservative. Available acute (1-hour) health-based comparison values were reviewed in the context of developing the health-protective comparison values to be used in evaluation of data collected instantaneously. The USEPA acute exposure guideline levels (AEGLs) were considered for use, but all AEGLs represent levels where health effects are expected to occur. Even the AEGL-1 values, which are for the least severe effects, are not health-protective comparison values. [8] Although AEGLs are of short duration (10- or 30-minutes, 1-, 4-, or 8-hours), they do not represent health-protective concentrations (where effects are not expected to occur). Because of this, AEGLs cannot be used as comparison values meant to protect the general public, monitoring staff, and field investigators from acute health effects. Consequently, AEGLs are not considered further for derivation of health-protective comparison values. On the other hand, while the Agency for Toxic Substances and Disease Registry (ATSDR) “acute” inhalation minimal risk levels (MRLs) are protective for acute exposure (i.e., ≤24 hours), these values are derived to be health-protective for up to 14 days of exposure and are therefore unduly conservative for evaluation of mobile monitoring data that is of shorter duration (e.g., perhaps no more than a few hours in duration), which are more relevant to an emergency response. Consequently, the acute MRLs may be considered for adoption if air sampling results from much longer durations require a health effects evaluation; however, the acute MRLs are not considered for adoption herein unless they are based on

[8] AEGLs are dictated by the severity of the toxic effects caused by the exposure, with AEGL-1 values being the least severe, but potentially still involving notable discomfort, irritation, or certain asymptomatic non-sensory effects. Effects associated with AEGL-1 values are not disabling and are transient and reversible upon cessation of exposure.

acute effects that occur over a duration of perhaps an hour or several hours, but less than a day.

To identify acute ambient air comparison values that result in a more realistic assessment of the potential for acute adverse health effects, as well as inform decision making and priority-setting during an investigation or emergency response, the following characteristics were identified as important guiding considerations:

- Standard practices: Preference for available acute ambient air comparison values derived using standard practices and procedures (e.g., under USEPA, TCEQ, or similar toxicity factor derivation guidance).
- Acute inhalation basis: Preference for an inhalation study as the basis, wherein inhalation exposure was adequately characterized and the exposure duration/regimen was similar to that of the acute health effects assessment (e.g., a single exposure of a few hours).[9]
- Appropriate duration adjustment: Similarly, preference for values where any duration adjustments for the comparison value are to an exposure duration similar to that of the acute health effects assessment (e.g., 1 hour).
- Adverse, human-relevant, dose-response: Critical health effect(s) used as the basis for the acute ambient air comparison value should clearly be both adverse and relevant to humans, with a preference for a clear dose-response over multiple doses. Such health effect endpoints are preferred over those where no chemical effects were seen (i.e., a free-standing no-observed-adverse-effect-level [NOAEL]), or where all the tested doses showed a health effect (i.e., a free-standing lowest-observed-adverse-effect-level LOAEL]).
- True short-term effect: Critical effect(s) should clearly be a true short-term effect wholly attributable to short-term exposure to the chemical in question.[10]
- Less uncertainty: Preference for acute ambient air comparison values associated with less total uncertainty (e.g., lower total uncertainty factor (UF), physiologically-based

[9] Acute is defined here as exposure to a chemical for less than or equal to 24 hours, although studies with repeated exposures over several days with a sufficiently similar total exposure duration may be utilized in some instances. Using study results from weeks, months (subchronic), or years (chronic) of exposure generally is not appropriate for acute health-based risk assessment, unless for example it can be reasonably demonstrated that the effect(s) are not due to the cumulative effect of repeated daily toxic insult or accumulation of the putative toxic parent and/or chemical metabolite(s) over time.

[10] For example, not from a study in which humans or laboratory animals were exposed subchronically or chronically on a daily basis and the effect(s) may be due to the cumulative effect of repeated daily toxic insult and/or accumulation of the putative parent and/or toxic chemical metabolites over time, or not from a study in which co-exposure may have confounded the cause-and-effect relationship.

pharmacokinetic [PBPK] modeling for interspecies extrapolation, smaller duration adjustment required for the acute duration of interest, etc.).[11]

- Human data: A preference for human data over laboratory animal data, in the absence of some overriding factor (e.g., the only available epidemiological studies do not have quantitative exposure estimates, or a study in which co-exposure may have confounded the cause-and-effect relationship).
- Lowest margin of exposure: There is a strong preference for selecting the acute health-based air comparison value associated with the lowest margin of exposure (MOE). Although a MOE may be calculated in different ways (e.g., RfC/lifetime exposure level), here the primary MOE of interest is the difference between the selected comparison value and the concentration at which health effects have been shown to occur, with a lower MOE indicating a smaller difference between the two. Selecting the lowest MOE ideally means utilizing the lowest study human equivalent concentration (HEC) LOAEL ($LOAEL_{HEC}$) or benchmark concentration (BMC_{HEC}) among the key studies. Values that were derived using lower UFs (discussed above) will also typically have a lower MOE. Although still health-protective, exceedance of a comparison value with a lower MOE carries a greater potential for the occurrence of an acute adverse health effect than a comparison value with a higher MOE. As such the lower-MOE values are more conducive to identifying emissions representing a real-world environmental health issue (i.e., exposures associated with a greater probability of acute effects), which should be given priority during an emergency situation. An overriding consideration is that the selected AHBCV must result in MMCV values, particularly those for appreciable exposure durations (10 minutes, 1-hour), with an MOE greater than 1 to demonstrate any level of health protection, with MOE ideally being defined as equal to the lowest $LOAEL_{HEC}/BMC_{HEC}$ value identified across the AHBCVs being considered divided by the relevant (i.e., non-instantaneous) MMCV values resulting from the derivation procedures herein. See Appendix D for an example of how this overriding consideration can determine the AHBCV selected (i.e., for ammonia).

Because acute studies with an exposure duration of an hour to less than 24 hours are frequently lacking, an ideal acute air comparison value may not be available for selection. However, the considerations listed above may be used together as part of a weight-of-evidence judgment for choosing the most appropriate available ambient air comparison value to assess the potential for acute adverse health effects and subsequent development of comparison values for evaluation of data collected instantaneously.

[11] There is greater confidence in air comparison values with less uncertainty, including greater confidence in their ability to result in a more realistic assessment of health hazard and the potential for adverse health effects (e.g., greater confidence that exceedance of the comparison value could have real-world health consequences).

Selected AHBCVs

The 26 chemicals listed in Table 5 were evaluated using the considerations outlined above to select the fit-for-purpose AHBCVs. These 26 chemicals were assessed due to the analysis capabilities of the SIFT and DUVAS and/or importance during industrial emission events. Although some of the chemicals listed in Table 5 have 1-hour TCEQ AMCVs that were developed using TCEQ's guidelines for toxicity factors (TCEQ 2015)[12], these 1-hour AMCVs were not always selected as an AHBCV, based on the considerations listed in the previous section (e.g., other values might have a lower MOE). As noted above, the AHBCVs were selected to be fit-for-purpose for use in investigational and emergency response situations and are considered health-protective (i.e., set at levels below which health effects are expected to occur) without being unduly conservative. The selected AHBCVs can more realistically inform both the potential for acute adverse health effects and subsequent decision-making (e.g., the need for exposure mitigation, appropriate prioritization of environmental concerns, etc.). Appendix D provides additional details on the evaluation and selection of each AHBCV.

Table 5. Acute health-based comparison values and source of value selected for each chemical.

Compound	CAS No.	Value (ppb)	Source
Acetylene [a]	74-86-2	25,000	TCEQ
Ammonia	7664-41-7	850	TCEQ
Benzene	71-43-2	180	TCEQ
1,3-Butadiene	106-99-0	1,700	TCEQ
Butane	106-97-8	92,000	TCEQ
1-Butene	106-98-9	27,000	TCEQ
Chlorine	7782-50-5	70	CalEPA
Cyclohexane[a]	110-82-7	1,000	TCEQ
Ethylbenzene	100-41-4	20,000	TCEQ
Ethylene dichloride	107-06-2	540	TCEQ
Ethylene glycol	107-21-1	1,900	MI EGLE
Ethylene oxide	75-21-8	910	TCEQ
Formaldehyde	50-00-0	44	CalEPA
n-Hexane	110-54-3	5,400	TCEQ

[12] TCEQ 2015 Guidelines to develop toxicity factors. RG-442: Texas Commission on Environmental Quality (TCEQ).

Compound	CAS No.	Value (ppb)	Source
Hydrochloric acid	7647-01-0	440	TCEQ
Hydrogen sulfide	7783-06-4	70	ATSDR
Isobutane	75-28-5	33,000	TCEQ
n-Octane	111-65-9	4,100	TCEQ
Propane	74-98-6	Simple asphyxiant [b]	TCEQ
Propylene	115-07-1	Simple asphyxiant [b]	TCEQ
Sodium hydroxide	1310-73-2	5	CalEPA
Styrene	100-42-5	5,100	TCEQ/CalEPA
Sulfuric acid	7664-93-9	30	CalEPA
Toluene	108-88-3	4,000	TCEQ
Vinyl chloride	75-01-4	72,000	CalEPA
Xylenes	1330-20-7	5,000	CalEPA

[a] AHBCV derived by dividing an occupational exposure level by uncertainty factors (UFs), not by using the full process outlined in the TCEQ guidelines (no other agency had an applicable comparison value for use).; [b] As noted in TCEQ Guidelines to Develop Toxicity Factors (TCEQ 2015), simple asphyxiants are chemicals that only pose an inhalation health risk if exposure occurs in an enclosed space where the gas is present at concentrations that displace oxygen in the air, reducing oxygen levels in the air to levels below those necessary for normal breathing. No health-based comparison values were derived for simple asphyxiant chemicals.; ATSDR – Agency for Toxic Substances and Disease Registry; CalEPA – California Environmental Protection Agency; MI EGLE – Michigan Department of Environment, Great Lakes, and Energy; ppb – parts per billion; and TCEQ - Texas Commission on Environmental Quality.

Health-based mobile monitoring comparison values

Two primary types of health-based mobile monitoring comparison values were derived using the AHBCVs or applicable occupational exposure limits (OELs) as their basis. TCEQ used a tiered approach for deriving values that are progressively closer to levels where health effects may occur, with associated actions that are reflective of the decreased margin between exposure and effect.

Instantaneous health-protective investigation levels (iHPILs)

The instantaneous health-protective investigation levels (iHPILs) are the first tier of health-based values. The iHPILs are conservatively set equal to the 1-hour AHBCVs. Instantaneous chemical concentrations below the iHPIL represent levels that will not cause health effects. The risk of health effects from instantaneous chemical concentrations that exceed the iHPILs cannot be directly judged, and so could trigger source investigation/characterization as well as stationary monitoring to collect data with longer averaging times (e.g., 30 minutes, 1 hour, etc.). The longer duration samples can then be compared to 1-hour AHBCVs or health-based

mobile monitoring comparison values of appropriate duration. Such values are discussed in the following section. For chemicals that do not have an iBDIL, exceedance of an iHPIL is used as the initial investigation trigger level.

iHPILs for Particulate Matter (PM)

PM_{10} and $PM_{2.5}$ are two of the air pollutants regulated under the National Ambient Air Quality Standards (NAAQS). The NAAQS use four metrics – indicator, form, averaging time, and level – to set primary health-based standards that apply to ambient concentrations of air pollutants, which are requisite to protect public health with an adequate margin of safety. Because PM_{10} and $PM_{2.5}$ are regulated by the NAAQS, other federal and state agencies have not set 1-hour values that can be used as AHBCVs for derivation of mobile monitoring comparison values. However, both PM_{10} and $PM_{2.5}$ have NAAQS that are based on a 24-hour averaging time: for PM_{10} the standard associated with a 24-hour average is set at a level of 150 $\mu g/m^3$, not to be exceeded more than once per year on average over 3 years; and for $PM_{2.5}$ the standard associated with a 24-hour average is set at a level of 35 $\mu g/m^3$ for the 98^{th} percentile, averaged over 3 years. Although data obtained using mobile monitoring instruments for PM cannot be compared to the full parameters of the respective standards, the level of the 24-hr standards (150 and 35 $\mu g/m^3$ for PM_{10} and $PM_{2.5}$, respectively) can be used as approximate health-based comparison values. Because these are 24-hour values instead of 1-hour values, an additional 3-fold factor is applied to the averaging time difference, as explained in section 5.2. Therefore, the iHPILs are set at 105 $\mu g/m^3$ for $PM_{2.5}$ and 450 $\mu g/m^3$ for PM_{10}.

Selected iHPILs

Examples of iHPILs are shown in Table 6 for selected chemicals with an AHBCV. Appendix A provides a complete list of calculated iHPILs.

Table 6. iHPILs calculated for fifteen chemicals and PM.

Chemical	CAS No.	Unit	AHBCV	iHPIL
Acetylene	74-86-2	ppb	25,000	25,000
Benzene	71-43-2	ppb	180	180
1,3-Butadiene	106-99-0	ppb	1,700	1,700
1-Butene	106-98-9	ppb	27,000	27,000
Cyclohexane	110-82-7	ppb	1,000	1,000
Ethylbenzene	100-41-4	ppb	20,000	20,000
n-Hexane	110-54-3	ppb	5,400	5,400
Hydrochloric acid	7647-01-0	ppb	440	440
Isobutane	75-28-5	ppb	33,000	33,000
n-Octane	111-65-9	ppb	4,100	4,100

Chemical	CAS No.	Unit	AHBCV	iHPIL
$PM_{2.5}$	N/A	µg/m^3	35 [a]	105
PM_{10}	N/A	µg/m^3	150 [a]	450
Sodium hydroxide	1310-73-2	ppb	5	5
Styrene	100-42-5	ppb	5,100	5,100
Toluene	108-88-3	ppb	4,000	4,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	ppb	5,000 [b]	5,000 [b]
Xylenes	1330-20-7	ppb	5,000	5,000

[a] NAAQS 24-hour averaging time, used as approximate health-based comparison values; [b] Values are based on AHBCV for xylenes.

Health-based action levels (HBALs)

To ensure emergency and investigational preparedness, it is also important to have health-based action levels (HBALs) that indicate when more rapid or greater action may be required. Two instantaneous and two longer duration HBALs were established with a lower MOE than the iHPILs, to help inform actions by mobile monitoring staff. Furthermore, while not representative of levels that are expected to cause immediate health effects, some of the HBALs discussed in the following sections may also assist TCEQ field staff (who are not first responders) and others in considering exposure mitigation strategies. Depending upon the magnitude and duration of a HBAL exceedance, the strategies may include action(s) deemed necessary to mitigate the potential for adverse human health effects to those impacted by a chemical emissions event.

It is important to note that HBALs are based on the consideration of chemical-specific, direct adverse health effects and do not consider potential odors. Strong and persistent odors have the potential to cause indirect health effects like headache and nausea, regardless of the chemical causing them or how the reported levels of the chemicals being analyzed compare to health-based values. As always, in all circumstances, personnel are encouraged to use their best judgment in determining whether to leave the area, shelter in place, or otherwise mitigate exposure (e.g., reports of headaches, feeling faint, etc.).

Instantaneous health-based action levels (iHBALs)

The next tier of health-based values, with a lower MOE than iHPILs, are instantaneous health-based action levels (iHBALs). A measured instantaneous chemical concentration that exceeds an iHBAL can potentially trigger a more immediate action than for an iHPIL exceedance. The iHBAL is derived based on the concept that if an instantaneous concentration exceeded the iHBAL, an exceedance of a longer-duration, health-based screening level such as the 1-hour AHBCV may also occur. The TCEQ has relied on a robust and historical dataset that has set a precedence for deriving short-term values to protect against long-term concentrations. For example, in air permitting a modeled maximum ground-level *hourly concentration* for the year

that is no more than 10-times a desired annual comparison value helps predict that the *annual chemical concentrations* will remain below that annual value (taking into account considerations such as meteorological variability).[13] In the case of iHBALs, such a basis would entail deriving a 1-30 second duration concentration that, if not exceeded, may be expected to be associated with a hourly concentration that is no higher than the 1-hour AHBCV. Conversely, the iHBAL represents a 1-30 second duration concentration that, if exceeded, might be an indication that 1-hour concentrations would exceed the 1-hour AHBCV. The TCEQ has collected and analyzed instantaneous and hourly concentration data to determine the relationship(s) between instantaneous and hourly concentrations.

Instantaneous vs. hourly data

The temporal difference in sampling between 1-30 seconds and a 1-hour duration is 120- to 3,600-fold. Using data collected for 1,3-butadiene, benzene, toluene, styrene, and xylenes + ethylbenzene from 69 SIFT surveys, the fold difference between the range of the 95th percentile instantaneous values to the 1-hour average of a stationary survey was 0.35 to 6.53 (Table 7). However, the average 95th instantaneous/1-hour average fold difference for these chemicals was 2.27 to 3.62. This suggests that on average, approximately 3-times the 1-hour AHBCV concentration would be representative of an instantaneous 95th percentile value where the hourly average may approximate the 1-hour AHBCV. Therefore, an instantaneous concentration greater than approximately 3-times the 1-hour AHBCV could predict that the hourly average concentration would exceed the 1-hour AHBCV.

Table 7. Ratio of 95th percentile instantaneous values to 1-hour average data for 1,3-butadiene, benzene, toluene, styrene, and xylenes + ethylbenzene from 69 SIFT stationary surveys.

	1,3-Butadiene [a]	Benzene	Toluene	Styrene	Xylenes + Ethylbenzene
Minimum 95th instantaneous/1-hour average	0.35	0.77	1.36	1.54	1.45
Maximum 95th instantaneous/1-hour average	6.53	6.04	4.43	5.26	5.15
Average 95th instantaneous/1-hour average	3.62	2.60	2.31	2.65	2.27

[a] Based on data from 68 surveys, with 1 survey excluded because >90% of the values were zero

[13] USEPA. 1992. Screening procedures for estimating the air quality impact of stationary sources, revised. U.S. ENVIRONMENTAL PROTECTION AGENCY, Office of Air and Radiation, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina. EPA-454/R-92-019.

Conclusions regarding comparisons of instantaneous vs. hourly concentration data

Based on the data analyzed above, a 1-30 second concentration that is greater than approximately 3-times the 1-hour AHBCV might suggest the hourly average could be greater than the 1-hour AHBCV. Based on the analysis above, an instantaneous air concentration greater than 3-times the 1-hour AHBCV is: (1) assumed to be greater than the 95th percentile of the distribution of instantaneous concentrations associated with the 1-hour AHBCV; (2) considered an abnormally high value for a distribution associated with an air concentration equal to the 1-hour AHBCV; and (3) assumed to be part of a distribution associated with a short-term 1-hour concentration that exceeds the short-term 1-hour AHBCV.

Selected iHBALs

Based on the analysis described above, the iHBALs are conservatively calculated to be 3-times the selected 1-hour AHBCV for a given chemical. Examples of iHBALs are shown in Table 8 for selected chemicals with an AHBCV. Appendix A provides a complete list of calculated iHBALs.

Table 8. iHBALs calculated for fifteen chemicals for comparison to samples collected for a duration of 1-30 seconds.

Chemical	CAS No.	AHBCV (ppb)	iHBAL (ppb)
Acetylene	74-86-2	25,000	75,000
Benzene	71-43-2	180	540
1,3-Butadiene	106-99-0	1,700	5,100
1-Butene	106-98-9	27,000	81,000
Cyclohexane	110-82-7	1,000	3,000
Ethylbenzene	100-41-4	20,000	60,000
n-Hexane	110-54-3	5,400	16,200
Hydrochloric acid	7647-01-0	440	1,320
Isobutane	75-28-5	33,000	99,000
n-Octane	111-65-9	4,100	12,300
Sodium hydroxide	1310-73-2	5	15
Styrene	100-42-5	5,100	15,300
Toluene	108-88-3	4,000	12,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [a]	15,000 [a]
Xylenes	1330-20-7	5,000	15,000

[a] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; iHBAL – instantaneous health-based action level; and ppb – parts per billion.

Health-based action levels for exposure mitigation (^{EM}HBALs)

Health-based action levels for exposure mitigation (^{EM}HBALs) are intended to help inform field staff of chemical concentrations where they may consider decreasing their exposure. Although ^{EM}HBALs are set at concentrations higher than the iHPILs and iHBALs (i.e., with a lower MOE), the ^{EM}HBALs are not set at effect levels and as such are still designed to be more conservative than USEPA AEGLs, which are specific concentrations of airborne chemicals at which health effects may occur.[14] ^{EM}HBAL values assume a short-term/acute exposure duration and are derived based on either the 1-hour AHBCV, or on appropriate, available occupational exposure levels (15-minute short-term exposure limits [STELs] or ceiling values [C])[15]. These values are principally derived for comparison to stationary sampling data that can be averaged over longer durations (i.e., 10 minutes or 1 hour). An additional 1-second value was also derived for use with mobile monitoring equipment that is not capable of averaging data for longer durations while in use. Exceedance of an ^{EM}HBAL triggers field staff to consider decreasing their exposure to the measured chemical.

10-minute exposure mitigation health-based action levels (^{EM}HBALs$_{10min}$)

Concentrations collected for 5-10 minutes will be compared to the 10-minute exposure mitigation health-based action levels (^{EM}HBALs$_{10min}$). The ^{EM}HBAL$_{10min}$ is set as the *lowest* of the following values:

- 3× AHBCV[16];
- ½× 15-minute occupational STEL (to help ensure that the STEL is not exceeded). Potential sources of the STEL include: American Conference of Governmental Industrial Hygienists (ACGIH), Occupational Safety and Health Administration (OSHA), California Division of

[14] https://www.epa.gov/aegl/about-acute-exposure-guideline-levels-aegls

[15] For example, helping to prevent exceedances of 15-minute STELs through consideration of ½ the STEL as a comparator value is important as 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 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/).

[16] Using this calculation, the value will somewhat exceed a 1-hour value extrapolated to 5-10 minutes using Haber's law with n=3 under the TCEQ (2015) Guidelines to Develop Toxicity Factors, but it is still conservative given that generally there is a margin of exposure ≥3 even for a 1-hour exposure. A person who chooses to leave an area or otherwise mitigate exposure based on an exceedance of the ^{EM}HBAL$_{10min}$ may or may not be exposed to concentrations that meet/exceed the hourly AHBCV, depending upon the magnitude of exceedance and the promptness of leaving or otherwise mitigating exposure. This calculation generates a concentration that is consistent with the iHBAL concentration.

Occupational Safety and Health (DOSH; also known as Cal/OSHA), or the National Institute for Occupational Safety and Health (NIOSH); or

- ½× occupational ceiling value (C; to help ensure that the ceiling value is not exceeded). Potential sources of the ceiling value include: ACGIH, OSHA, or NIOSH

The lowest of these values is used as the $^{EM}HBAL_{10min}$. Selected examples of $^{EM}HBALs_{10min}$ can be found in Table 9. Appendix A provides additional $^{EM}HBALs_{10min}$ that were calculated and Appendix E provides the STELs and ceiling values available for all chemicals listed in Appendix A.

Table 9. $^{EM}HBALs_{10min}$ calculated for fourteen chemicals for comparison to samples collected for a duration of 5-10 minutes.

Chemical	CAS No.	iHBAL (ppb)	½ STEL (ppb)	½ C (ppb)	$^{EM}HBAL_{10min}$ (ppb)
Acetylene	74-86-2	75,000	--	--	75,000
Benzene	71-43-2	540	500	--	500
1,3-Butadiene	106-99-0	5,100	2,500	--	2,500
1-Butene	106-98-9	81,000	--	--	81,000
Cyclohexane	110-82-7	3,000	--	--	3,000
Ethylbenzene	100-41-4	60,000	62,500	--	60,000
n-Hexane	110-54-3	16,200	--	--	16,200
Hydrochloric acid	7647-01-0	1,320	--	1,000	1,000
Isobutane	75-28-5	99,000	500,000	--	99,000
n-Octane	111-65-9	12,300	187,500	--	12,300
Sodium hydroxide	1310-73-2	15	--	600	15
Styrene	100-42-5	15,300	10,000	--	10,000
Toluene	108-88-3	12,000	75,000	--	12,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	15,000 [a]	75,000 [a]	--	15,000 [a]
Xylenes	1330-20-7	15,000	75,000	--	15,000

[a] Values are based on AHBCV for xylenes; C – ceiling value; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; iHBAL – instantaneous health-based action level; ppb – parts per billion; STEL – 15-minute short-term exposure level; and "--"no value available.

1-hour exposure mitigation health-based action levels ($^{EM}HBALs_{1hr}$)

Concentrations collected and averaged for 30 minutes to 1 hour will be compared to 1-hour exposure mitigation health-based action levels ($^{EM}HBALs_{1hr}$). The $^{EM}HBAL_{1hr}$ is set as the following value:

- 2× AHBCV

This comparison value is still conservative because generally there is a margin of exposure ≥3 for a 1-hour exposure. Examples of $^{EM}HBALs_{1hr}$ can be found in Table 10, and Appendix A provides additional $^{EM}HBALs_{1hr}$ that were calculated.

Table 10. $^{EM}HBALs_{1hr}$ calculated for fourteen chemicals for comparison to samples collected for a duration of 30 minutes to 1 hour.

Chemical	Cas No.	AHBCV (ppb)	$^{EM}HBAL_{1hr}$ (ppb)
Acetylene	74-86-2	25,000	50,000
Benzene	71-43-2	180	360
1,3-Butadiene	106-99-0	1,700	3,400
1-Butene	106-98-9	27,000	54,000
Cyclohexane	110-82-7	1,000	2,000
Ethylbenzene	100-41-4	20,000	40,000
n-Hexane	110-54-3	5,400	10,800
Hydrochloric acid	7647-01-0	440	880
Isobutane	75-28-5	33,000	66,000
n-Octane	111-65-9	4,100	8,200
Sodium hydroxide	1310-73-2	5	10
Styrene	100-42-5	5,100	10,200
Toluene	108-88-3	4,000	8,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [a]	10,000 [a]
Xylenes	1330-20-7	5,000	10,000

[a] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; and ppb – parts per billion.

1-second exposure mitigation health-based action levels ($^{EM}HBALs_{1sec}$)

For mobile monitoring instruments that are not capable of averaging concentrations for comparison to the 10-minute or 1-hour $^{EM}HBALs$ while in operation, 1-second exposure mitigation health-based action levels ($^{EM}HBALs_{1sec}$) were also derived for comparison with instantaneous concentrations measured while the vehicle is stationary or mobile. The $^{EM}HBAL_{1sec}$ is set as the following value:

- 3× $^{EM}HBAL_{1hr}$

Like the iHBAL, a 1-30 second concentration that is greater than approximately 3-times the $^{EM}HBAL_{1hr}$ might suggest the hourly average could be greater than the $^{EM}HBAL_{1hr}$. Examples of $^{EM}HBALs_{1sec}$ can be found in Table 11. Appendix A provides additional $^{EM}HBALs_{1sec}$ that were calculated.

Table 11. $^{EM}HBALs_{1sec}$ calculated for fifteen chemicals for comparison to samples collected for a duration of 1-30 seconds when longer duration averaging is not available.

Chemical	CAS No.	$^{EM}HBAL_{1hr}$ (ppb)	$^{EM}HBAL_{1sec}$ (ppb)
Acetylene	74-86-2	50,000	150,000
Benzene	71-43-2	360	1,080
1,3-Butadiene	106-99-0	3,400	10,200
1-Butene	106-98-9	54,000	162,000
Cyclohexane	110-82-7	2,000	6,000
Ethylbenzene	100-41-4	40,000	120,000
n-Hexane	110-54-3	10,800	32,400
Hydrochloric acid	7647-01-0	880	2,640
Isobutane	75-28-5	66,000	198,000
n-Octane	111-65-9	8,200	24,600
Sodium hydroxide	1310-73-2	10	30
Styrene	100-42-5	10,200	30,600
Toluene	108-88-3	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	10,000 [a]	30,000 [a]
Xylenes	1330-20-7	10,000	30,000

[a] Values are based on AHBCV for xylenes; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; and ppb – parts per billion.

Summary of calculated iHBALs and $^{EM}HBALs$

Table 12 provides the 1-hour AHBCV and a summary of the calculated iHBALs and $^{EM}HBALs$ for a selection of chemicals. The full list of calculated iHBALs and $^{EM}HBALs$ can be found in Appendix A.

Table 12. Summary of calculated iHBALs and ^{EM}HBALs for fifteen chemicals, including the 1-hour AHBCV for comparison.

Chemical	CAS No.	AHBCV (ppb)	iHBAL (ppb)	$^{EM}HBAL_{10min}$ (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	$^{EM}HBAL_{1sec}$ (ppb)
Acetylene	74-86-2	25,000	75,000	75,000	50,000	150,000
Benzene	71-43-2	180	540	500 [a]	360	1,080
1,3-Butadiene	106-99-0	1,700	5,100	2,500 [a]	3,400	10,200
1-Butene	106-98-9	27,000	81,000	81,000	54,000	162,000
Cyclohexane	110-82-7	1,000	3,000	3,000	2,000	6,000
Ethylbenzene	100-41-4	20,000	60,000	60,000	40,000	120,000
n-Hexane	110-54-3	5,400	16,200	16,200	10,800	32,400
Hydrochloric acid	7647-01-0	440	1,320	1,000 [b]	880	2,640
Isobutane	75-28-5	33,000	99,000	99,000	66,000	198,000
n-Octane	111-65-9	4,100	12,300	12,300	8,200	24,600
Sodium hydroxide	1310-73-2	5	15	15	10	30
Styrene	100-42-5	5,100	15,300	10,000[a]	10,200	30,600
Toluene	108-88-3	4,000	12,000	12,000	8,000	24,000
Xylenes + Ethylbenzene	1330-20-7 + 100-41-4	5,000 [c]	15,000 [c]	15,000 [c]	10,000 [c]	30,000 [c]
Xylenes	1330-20-7	5,000	15,000	15,000	10,000	30,000

[a] Based on ½ STEL; [b] Based on ½ C; [c] Values are based on AHBCV for xylenes; AHBCV – acute health-based comparison value; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iHBAL – instantaneous health-based action level; and ppb – parts per billion.

Comparison of iHBALs and ^{EM}HBALs to federal AEGLs

The USEPA has developed threshold exposure limits for airborne chemicals for the general public that are applicable to emergency exposure periods ranging from 10 minutes to 8 hours. These thresholds, called AEGLs, are intended for use for once-in-a-lifetime or rare exposures to airborne chemicals. These values are used by emergency responders for exposures from chemical spills or other catastrophic events.

There are three AEGL levels, depending on the severity of effects: AEGL-1, AEGL-2, and AEGL-3. The levels represent the airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience health effects that increase in severity from AEGL-1 to AEGL-3. These include:

- AEGL-1 – notable discomfort, irritation, or certain asymptomatic, non-sensory effects. These effects are not disabling and are transient and reversible upon cessation of exposure.
- AEGL-2 – irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
- AEGL-3 – life-threatening health effects or death.

While AEGL values represent threshold levels for the general public, including susceptible subpopulations (e.g., infants, children, the elderly, persons with asthma, and those with other illnesses), it is recognized that some individuals with unique or idiosyncratic responses could experience the effects described at concentrations below the corresponding AEGL.

As shown in Table 13, the TCEQ-derived iHBALs and ^{EM}HBALs are designed to be more conservative and health protective than AEGLs; that is, they are set below levels at which health effects are expected to occur. Appendix F provides the 10- and 60-minute AEGLs available for all chemicals discussed herein.

Table 13. Comparison of calculated iHBALs and ^{EM}HBALs to USEPA AEGLs with similar durations.

Chemical(s)	CAS No.	iHBAL (ppb)	$^{EM}HBAL_{10\ min}$ (ppb)	10 Min AEGL-1 (ppb)	10 Min AEGL-2 (ppb)	10 Min AEGL-3 (ppb)	$^{EM}HBAL_{1hr}$ (ppb)	60 Min AEGL-1 (ppb)	60 Min AEGL-2 (ppb)	60 Min AEGL-3 (ppb)
Acetylene	74-86-2	75,000	75,000	-- [a]	--	--	50,000	--	--	--
Benzene	71-43-2	540	500 [a]	130,000	2,000,000	9,700,000	360	52,000	800,000	4,000,000
1,3-Butadiene	106-99-0	5,100	2,500 [a]	670,000	6,700,000	27,000,000	3,400	670,000	5,300,000	22,000,000
1-Butene	106-98-9	81,000	81,000	--	--	--	54,000	--	--	--
Cyclohexane	110-82-7	3,000	3,000	--	--	--	2,000	--	--	--
Ethylbenzene [b]	100-41-4	60,000	60,000	33,000	2,900,000	4,700,000	40,000	33,000	1,100,000	1,800,000
n-Hexane	110-54-3	16,200	16,200	NR	4,000,000	12,000,000	10,800	NR	2,900,000	8,600,000
Hydrochloric acid	7647-01-0	1,320	1,000 [c]	1,800	100,000	620,000	880	1,800	22,000	100,000
Isobutane	75-28-5	99,000	99,000	--	--	--	66,000	--	--	--
n-Octane	111-65-9	12,300	12,300	--	--	--	8,200	--	--	--
Sodium hydroxide	1310-73-2	15	15	--	--	--	10	--	--	--
Styrene	100-42-5	15,300	10,000 [a]	20,000	230,000	1,900,000	10,200	20,000	130,000	1,100,000
Toluene	108-88-3	12,000	12,000	67,000	1,400,000	10,000,000	8,000	67,000	560,000	3,700,000
Xylenes + Ethylbenzene [d]	1330-20-7 + 100-41-4	15,000	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000
Xylenes	1330-20-7	15,000	15,000	130,000	2,500,000	7,200,000	10,000	130,000	920,000	2,500,000

[a] Based on ½ STEL; [b] iHBAL and ^{EM}HBALs are higher than AEGL-1 because the AEGL-1 study provides no basis for the expectation of adverse effects at the 10-minute and 1-hr values (see Appendix D for additional information).;[c] Based on ½ C; [d] Based on xylenes; AEGL – acute exposure guideline level; $^{EM}HBAL_{1hr}$ – 1-hour exposure mitigation health-based action level; $^{EM}HBAL_{10min}$ – 10-minute exposure mitigation health-based action level; $^{EM}HBAL_{1sec}$ – 1-second exposure mitigation health-based action level; iBDIL – instantaneous baseline-derived investigation level; iHBAL – instantaneous health-based action level; iHPIL – instantaneous health-protective investigation level; NR – not recommended (see AEGL document); ppb – parts per billion; and "--"no value available.