Development of a 24-Hour Health-Protective Air Monitoring Comparison Value For Formaldehyde For Comparison to 24-Hour Monitoring Data In the Barnett Shale Area

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Abstract

The Barnett Shale is a large natural gas reserve encompassing more than 5,000 square miles and covering approximately 26 counties in North Texas. Due to public concern that natural gas compressor stations emit high formaldehyde concentrations, formaldehyde has been of increased public and regulatory interest in recent years. It has also been detected in 24-hour (h) carbon samples collected by the Texas Commission on Environmental Quality (TCEQ) in the Barnett Shale. However, use of these data for evaluating potential health effects is somewhat limited. This is because while they are used to calculate long-term average means for comparison to chronic, health protective air monitoring comparison values (AMCVs), for evaluation of acute exposures the agency generally uses 1-hr AMCVs, which although conservative are not designed to evaluate 24-h results. Thus, the development of a 24-h AMCV would allow the TCEQ to fully evaluate 24-h formaldehyde data for possible health concerns. Critical effect dose-response data for irritation (i.e., eye, upper respiratory tract) from acute and chronic human studies suggest a narrow range for the reported effect levels (i.e., 40-200 ppb acute, >200 ppb chronic), indicating these irritant effects are primarily concentration dependent. The TCEQ conservatively used the same point of departure (POD) that its chronic noncarcinogenic AMCV is based on (NOAEL of 70 ppb) because the exposure duration (8 h/day) is more similar to the 24-h duration of interest than the 24-h exposure durations for the acute studies. Because the 8 h exposure was repeated 15 days per week (6/35 for 30 years), and irritation appears to be primarily concentration dependent, an 8-to-24 h exposure duration adjustment was judged not to be necessary. Dividing the POD of 70 ppb by an uncertainty factor of 3 results in a proposed 24-h health-protective AMCV of 23 ppb. The 24-h AMCV falls between TCEQ’s 1-h (41 ppb) and chronic (8.9 ppb) noncarcinogenic AMCVs. To date, there has been only one exceedance (in 1999) of the proposed formaldehyde 24-h AMCV when compared to Barnett Shale monitored data.

Key Study

The stated purpose of the key study was to determine the mechanisms underlying symptoms (e.g., nasal, in exposed workers (i.e., direct irritation, hyper-reactivity in atopicsthyroid, hyper-reactivity in monocytes, immunologically-mediated type 1 (immediate) reaction to formaldehyde). The rates of symptoms such as eye, nasal, and lower airway discomfort (e.g., cough, wheezing) were found to be elevated in the formaldehyde-exposed workers as compared to the reference (control) group.

In regard to possible underlying mechanisms, the authors concluded that although formaldehyde can induce immunologically mediated type 1 reaction in the nose in certain circumstances, in most cases formaldehyde reduces nasal discomfort through non-specific/nonspecifically mediated hyper-reactivity, which caused nasal discomfort in about 50% of the exposed population. For purposes of the study, they defined hyper-reactivity as significant nasal discomfort/substitution in an environment where not all the exposed subjects experience annoying symptoms and allergic mechanisms can be ruled out. The LOMES and NOAEL from this study based on eye, nasal, and lower airway discomfort are 0.25 mg/m3 (0.21 ppm) and 0.09 mg/m3 (0.07 ppm), respectively. Wilhelmsson and Holmstrom (1992) was used by CalEPA for derivation of the 2008 final 8-h and chronic Reference Exposure Levels (CAREPA 2008).

References


Impact Factors

The TCEQ has historically developed 1-h health-protective and welfare-based (i.e., odor, vegetation) AMCVs for comparison to 1-h air toxics data collected from ambient air monitoring networks as well as comparison to other data (e.g., 80-100 Summer carbon nadirs). The TCEQ also develops chronic (i.e., lifetime) health-protective and welfare-based (i.e., vegetation) AMCVs for comparison to long-term means (i.e., annual averages or longer) based on 8-h air toxics data or every sixth 24-h samples (i.e., Summa canister, Dinair CEP). However, the TCEQ has not historically developed 24-h, Nevada-based AMCVs for comparison to individual 24-h data from its monitoring network.

Only a limited evaluation of the reported 24-h levels is possible without 24-h AMCV because 1-h and chronic (i.e., lifetime) AMCVs are of limited utility and tend to overestimate the effects for this purpose. Regarding use of 1-h AMCVs for comparison, while a 24-h concentration exceeding a conservative 1-h AMCV would be indicative of a potential health concern requiring further evaluation, a 24-h level less than a 1-h AMCV could still be of potential concern if exposure duration is a primary determinant of toxicity and the 1-h AMCV is not sufficiently conservative (i.e., below 24-h levels). Additionally, while use of a chronic AMCV would be very conservative, an 8-to-24 h chronic concentration value by a 24-h level would be of dubious toxicological significance and thus still require an entirely different and appropriately evaluated action limit. Thus, the development of 24-h AMCVs is necessary for the development of health-based exposure limits.

Duration\Dosimetry Adjustments

Duration Adjustment

A 1-to-24 h exposure duration adjustment was judged not to be necessary because the POD conservatively used the same POD that its chronic noncarcinogenic AMCV is based on with exposure 8 h/day, 5 days per week for 10 years, and due to the similarity of the acute and chronic effects lethal irradiation appears to be primarily concentration dependent. Not performing this duration adjustment is consistent with other agencies (e.g., ATSDR 1999, CalEPA 2008).

AMCV Adjustments

The most sensitive or critical endpoint for exposure to formaldehyde is irritation of the eyes and upper respiratory tract (i.e., rhinopharynx, oral cavity, and throat) which are noncarcinogenic effects. Determining a POD and applying appropriate UF is used to derive a ReV for noncarcinogenic effects with a threshold MDA.

Health Effect

Long-Term Exposure

Short-Term Exposure

Air Concentration in parts per billion (ppb)

Table: 24-Hr AMCV Derivation

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<tr>
<th>PODW</th>
<th>0.07 ppm (70 ppb)</th>
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24-Hr ReV = 37 ppb (41 ppb) (23 ppb)

Conclusion:

- The 24-hour health-protective AMCV for formaldehyde is 23 ppb (29 ppb).
- This value falls between the TCEQ acute 1-h ReV (41 ppb) and the chronic noncarcinogenic ReV (8.9 ppb), and is less than the ATSDR acute (1-24 day) MRL (43 ppb).
- No evidence is considered for the adequate protection of public health for the exposure duration and adverse effects considered and would significantly complement TCEQ health effect evaluations of ambient air data, which currently allows 1-hour and chronic (i.e., lifetime) health-protective and welfare-based (i.e., odors, vegetation) AMCVs.