Background Report Reference

AP-42 Section Number: 9.13.4

Background Chapter: 4

Reference Number: 6

Title: The Measurement Solution: Using a Temporary Total Enclosure for Capture Efficiency Testing

U.S. EPA

U.S. EPA

August 1991

United States Environmental Protection Agency

Office of Air Quality Planning and Standards Research Triangle Park NC 27711

EPA-450/4-91-020
August 1991

Air

AP-42 Section Reference
Report Sect. 4
Reference 6

EPA

The Measurement Solution: Using a Temporary Total Enclosure for Capture Efficiency Testing

ESD

THE MEASUREMENT SOLUTION

Using a Temporary Total Enclosure for Capture Efficiency Testing

EPA Contract No. 68-DO-0137
Work Assignment 69
ESD Project No. 89/07
MRI Project No. 9800-69

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TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA- 450/4-91-020	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE The Measurement Solution Using a Temporary Total Enclosure for Capture Efficiency Testing		5. REPORT DATE August 1991
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Stephen W. Edgerton, Joanne Kempen, Thomas W. Lapp		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute, 401 Harrison Oaks Boulevard, Suite 350, Cary, North Carolina 27513		10. PROGRAM ELEMENT NO.
		11. CONTRACT/GRANT NO. 68-DO-0137
12. SPONSORING AGENCY NAME AND ADDRESS Emission Standards Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711		13. TYPE OF REPORT AND PERIOD COVERED Final Enabling Document
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

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16. ABSTRACT

This document presents guidance for determining VOC capture efficiency with the gas/gas protocal using a temporary total enclosure.

Permanent total enclosure criteria also are presented. Appendices present sample calculations, the test methods, information on health and safety considerations, and an example case study.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Volatile Organic Compounds Performance Testing Capture Efficiency Temporary Total Enclosure	Determination of VOC Capture Efficiency	

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 153
	20. SECURITY CLASS (This page) Unclassified	22. PRICE

The TTE and exhaust system should be designed and operated to maintain VOC concentrations at or below the PEL in both the temporary exhaust stream and the breathing zone of the workers. However, remember that the PEL is an 8-hour, time-weighted average, so short-term excursions above the PEL in the breathing zone can be tolerated as long as they are balanced by periods below the PEL. Infrequent readings above the PEL need not result in an immediate cessation of testing and removal of the TTE. Of course, for compounds for which an STEL or ceiling has been set, the VOC concentration must not violate these limits.

Monitoring VOC concentrations is complicated by the fact that the monitors typically are not calibrated with the actual compounds that are in use. For example, according to Method 204D (see Appendix B), the VOC concentration in the temporary exhaust stream is to be measured using a flame ionization analyzer (FIA) calibrated with propane. In most cases, the TTE interior is monitored using a sampling line connected to this FIA or to the FIA used to take background readings (also calibrated with propane). Thus, to track worker exposure, one must be able to translate FIA readings "as propane" into the concentrations of the actual compounds being used. Fortunately, the FIA translation can be made with reasonable accuracy provided the identities and relative amounts of the compounds are known.

The FIA works essentially by breaking down organic compounds and counting the carbon atoms. However, the counting is affected by the types of bonds and the noncarbon atoms in the molecule. Therefore, to predict the response an FIA will have to a given compound, the "effective carbon number" (ECN) is used.

For the type of FIA used for source testing, Table C-1 presents one set of parameters that can be used to calculate the ECN for a compound within about ± 20 percent. To use this table, first assign each carbon atom in the compound a value based on the type of bonds it is involved in, then modify this value by the indicated amount for each noncarbon atom bonded to it. The ECN for the compound is the sum of the modified values for all the carbons. To illustrate the use of Table C-1, the ECN's for a few VOC's are derived in Figure C-2.

Experimental results for many compounds and more refined approaches to predicting FIA responses can be found in the scientific literature, such as References 6, 7, and 8. Other possible sources of data on FIA response include data from the instrument manufacturer and experimental data generated in advance of the test by exposing the instrument to known concentrations of the compounds of interest. Note that portable, hand-held FIA's (e.g., OVA's) do not conform to the information presented in Table C-1; another source of response data is needed if such an instrument is used to monitor VOC levels inside a TTE.

TABLE C-1. CONTRIBUTIONS TO EFFECTIVE CARBON NUMBER[a]

Atom	Type	Effective carbon number contribution
C	Aliphatic	1.0
C	Aromatic	1.0
C	Olefinic	0.95
C	Acetylenic	1.30
C	Carbonyl	0.0
C	Nitrile	0.3
O	Ether	-1.0
O	Primary alcohol	-0.6
O	Secondary alcohol	-0.75
O	Tertiary alcohol, esters	-0.25
Cl	Two or more on single aliphatic C	-0.12 each
Cl	On olefinic C	+0.05
N	In amines	Similar to O in corresponding alcohols

[a]Reference 5.

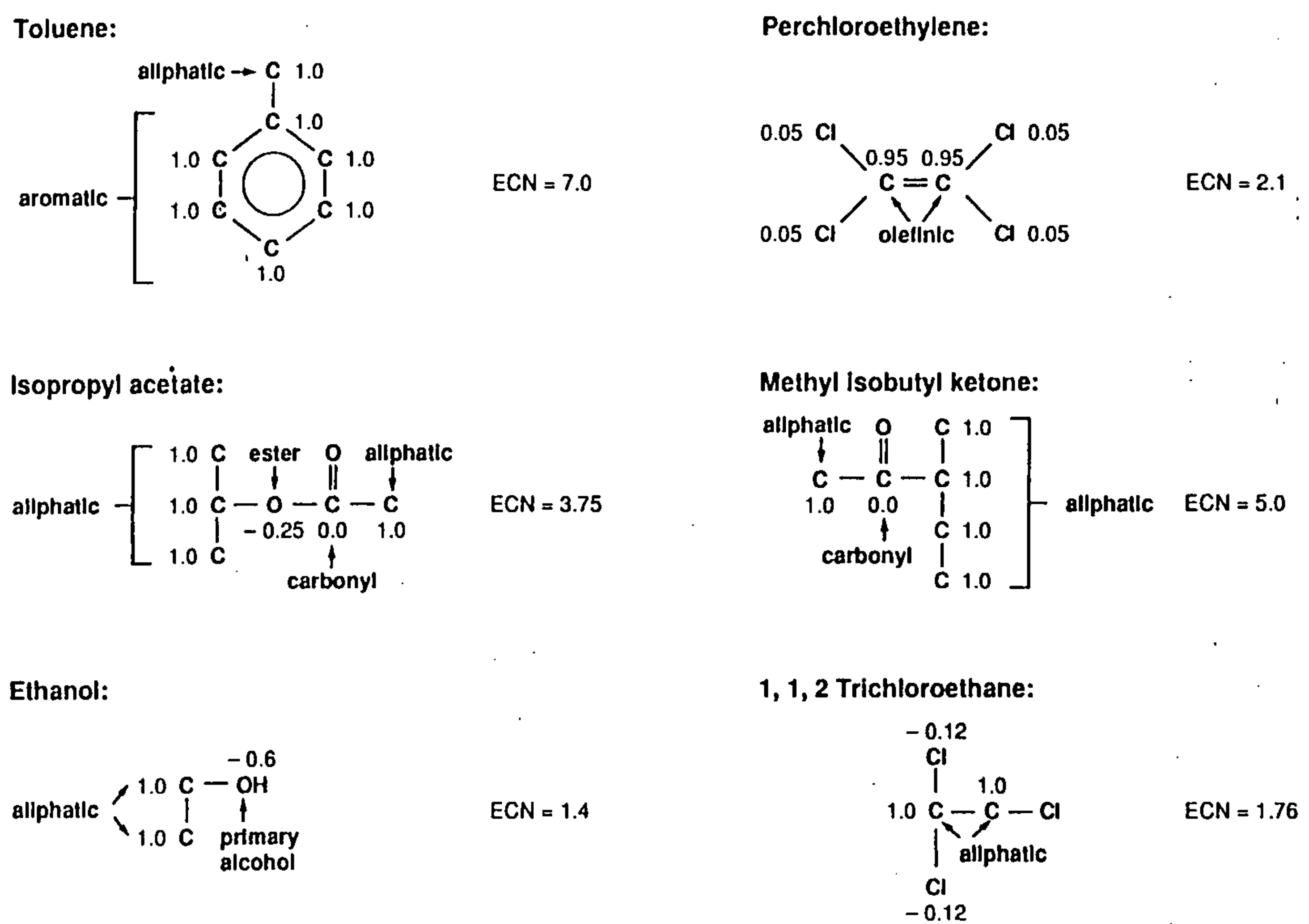

Figure C-2. Examples of ECN derivations.

Single VOC.. For a single VOC, monitoring considerations are relatively straightforward. The first step is to determine the relative response of the FIA to the VOC in terms of the FIA calibration gas (assumed to be propane) using the following equation:

$$RR_{VOC} = ECN_{VOC} \div 3.0 \qquad \text{(Equation 5)}$$

where:

RR_{VOC} = the relative response of the FIA to the VOC, ppmv propane per ppmv of the VOC (ppmv propane/ppmv VOC)

ECN_{VOC} = the effective carbon number of the compound, effective carbon atoms/molecule VOC

3.0 = the effective carbon number of propane, effective carbon atoms/molecule propane

Note: If a calibration gas other than propane is used, the ECN of the actual calibration gas is used in Equation 5.

Next, the maximum acceptable monitor reading is calculated by the equation below:

$$MR_{max} = RR_{VOC} \times C_{max} \qquad \text{(Equation 6)}$$

where:

MR_{max} = the maximum monitor reading that is considered acceptable, ppmv propane

RR_{VOC} = the relative response of the FIA to the VOC, ppmv propane/ppmv VOC

C_{max} = the maximum acceptable concentration of the VOC, ppmv VOC

As discussed previously, the maximum acceptable VOC concentration in the temporary exhaust stream is typically considered the PEL, while the maximum for points within the TTE may be somewhat higher, provided that the exposure of the workers over time does not exceed the PEL and that no STEL or ceiling level is violated.

EXAMPLE 5.

For the fabric coating operation presented in Example 2, what is the maximum acceptable monitor reading during CE testing?

Solution. The coating operation uses a single VOC, toluene. As illustrated in Figure C-2, the ECN for toluene is 7.0. The relative response for toluene, assuming that the calibration gas for the test instruments is propane, is found as follows:

$$\begin{aligned} RR &= 7.0 \div 3.0 \\ &\approx 2.3 \text{ ppmv propane/ppmv toluene} \end{aligned}$$

The maximum acceptable toluene concentration in the TTE's temporary exhaust stream is equal to the PEL, which is 100 ppmv. Using Equation 6, the maximum acceptable monitor reading is calculated below:

$$\begin{aligned} MR_{max} &= 2.3 \text{ ppmv propane/ppmv toluene} \times 100 \text{ ppmv toluene} \\ &= 230 \text{ ppmv propane} \end{aligned}$$

Thus, an FIA reading of 230 ppmv as propane in the temporary exhaust stream corresponds to a toluene concentration of 100 ppmv and indicates that the average concentration in the TTE is at the PEL.

An STEL of 150 ppmv also has been established for toluene by OSHA. The STEL is the maximum 15-min, time-weighted average concentration to which workers can be exposed. Thus, points in the breathing zone of the workers inside the TTE should not exceed this level. The monitor reading corresponding to the STEL can be calculated using Equation 6:

$$\begin{aligned} MR_{max} &= 2.3 \text{ ppmv propane/ppmv toluene} \times 150 \text{ ppmv toluene} \\ &= 345 \text{ ppmv propane} \end{aligned}$$

Mixture of VOC's. Where VOC mixtures are used, the process is analogous but more complicated. As with single-VOC systems, the first step is to calculate the relative response of the FIA to the VOC mixture in terms of the FIA calibration gas (again assumed to be propane). However, to calculate this composite relative response, three substeps are required:

1. First, calculate the relative response for each of the VOC compounds that make up the mixture using Equation 5 above.