Interim VOC Measurement Protocol for the Wood Products Industry – July 2007

1.0 Background and Introduction

On July 12, 2006, Mr. William Wehrum, EPA Acting Assistant Administrator, sent a letter to Mr. Timothy G. Hunt, Senior Director, Air Quality Programs, at the American Forest and Paper Association outlining a path forward for the complex issue of measuring and reporting volatile organic compounds (VOCs) in the forest products industry. In this letter, EPA discussed their desire for the forest products industry to report VOCs as the total mass of the individual organic compounds comprising the VOCs to determine major source applicability of federal programs such as NSR and Title V. EPA recognized, however, that the existing test methods fall short of this goal, and that "…*it is impracticable to identify and quantify every compound*…" EPA recognized that it will take some time to develop practical methods to accurately characterize VOC mass in forest products industry emissions. Therefore, EPA endorsed the use of interim VOC measurement approaches to estimate the total mass of VOC emissions while more appropriate methods and additional information are being developed. EPA stated that a "…*reasonable approximation (of total mass) will be sufficient for assessing the applicability of several regulatory programs*." VOC measurements for existing SIP, NESHAPS, and NSPS requirements and permit limits should continue to use the specified methods.

This interim protocol establishes calculation procedures and emission measurement methods to approximate VOC emissions for determining applicability with federal programs (particularly for NSR and Title V) and to establish consistency across state programs for the forest products industry. For purposes of this protocol, "reasonable approximation" of total VOC mass means expressing VOC as propane and requiring individual measurements of methanol and formaldehyde at sources for which these compounds are significant, as listed in Appendix 1. Historically, the forest products industry has reported its VOC emissions in terms of the mass of carbon atoms in the VOC compounds because the analytical methods measured the VOCs in those terms. For many facilities, therefore, this interim protocol will substantially increase the reported total mass of VOCs to be used in applicability determinations.

2.0 Interim Protocol Overview

In general, VOC is to be calculated as Total Hydrocarbons (THC) expressed as propane plus methanol and formaldehyde expressed as compound, minus adjustments. In specific cases THC may be expressed as alpha-pinene and measurement of formaldehyde and methanol may be omitted. Further details are provided in subsequent sections of this protocol.

In an effort to reduce confusion, VOC as measured and calculated by this protocol is referred to as "WPP1 VOC" (Wood Products Protocol 1 VOC). It is suggested that the industry and sampling companies use this terminology to identify VOC measured by this protocol as differentiated from VOC measured by other protocols.

3.0 THC Measurement

EPA Method 25A shall be used for THC measurement with the following specifications or modifications:

- The THC portion of the VOCs shall be expressed as propane.
- For some facilities, in states where it is the current practice, it may be appropriate to report the THC portion of the VOCs as terpenes (as alpha-pinene) rather than propane.
- The reporting basis for VOC should be clearly identified.

4.0 Methanol and Formaldehyde Measurement

Methanol and formaldehyde may be measured by any of the approved methods listed in the Plywood and Composite Panel MACT (40 CFR 63 Subpart DDDD).

- Appendix 1 provides a list of sources for which formaldehyde and methanol testing <u>must be conducted</u> concurrently with VOC testing. For sources not listed, formaldehyde and methanol testing are not required and WPP1 VOC is the THC as propane measurement minus adjustments for non-VOCs.
- Separate measurement methods may be used for formaldehyde and methanol.

5.0 Response Factors

For the purposes of this document, response factor is defined as the Flame Ionization Analyzer (FIA) response divided by the actual compound concentration, both expressed on the same basis, and expressed as a percentage. For example, an EPA Protocol 1 methane gas with a tag value of 300 ppmvd is measured by a FIA as 315 ppmvd expressed as carbon (315 ppmvd expressed as methane or 105 ppmvd as expressed as propane). The response factor is 315/300 = 105%.

This protocol provides the following default response factors:

- Formaldehyde RF = 0%
- Methanol RF = 65%
- Alkanes, alkenes, and arenes RF = 100% (includes methane and ethane)
- Acetone RF = 65%

If desired, instrument specific response factors can be developed and used. Response factors must be developed according to procedures provided in Appendix 3.

Some compounds, such as methane, can have response factors exceeding 100%. For sources for which methane emissions are a significant fraction of the FIA measurement, the testing company may determine a response factor for methane. Similarly, if methanol represents a relatively large fraction of WPP1 VOC, response factor determination may be prudent.

6.0 Treatment of Values Below Detection Limits (Non-Detects)

This section applies to individual compounds required for measurement by this protocol (e.g., methanol) as well as compounds that may be measured as an option. Emissions of these individual compounds may be treated as zero if all of the test runs result in a non-detect measurement and the detection limit is less than or equal to one part per million by volume. Otherwise, non-detect sample runs should be treated as one-half of the detection limit. Compounds measured at concentrations between the detection limit and the practical limit of quantitation should be flagged, but used in calculations as a fully detected value.

7.0 WPP1 VOC Adjustments

This protocol allows users to make adjustments for methanol and non-VOC compounds measured by the FIA. Adjustments are discussed in the following sub-sections. Equations and examples are provided in later sections.

7.1 Adjustments for Methanol

The flame ionization analyzer (FIA) used to measure THC partially measures methanol, resulting in partial “double counting” since methanol is also measured individually according to this protocol. To avoid double-counting, a percentage of the methanol measured independently is subtracted from the THC measurement. The percentage subtracted is either 65% (based on the default response factor provided in Section 5) or a percentage based on an instrument specific response factor. Methanol must be converted to the same basis as THC before subtraction, as shown in Equation 1. This approximately corrects double-counting. The 65% response factor (or instrument specific response factor) represents the amount of methanol measured by the FIA divided by the amount present in the gas stream (both on a carbon basis or common basis).

7.2 Exempt VOCs or non-VOCs

This protocol does not require separate or individual measurement of exempt VOCs or non-VOCs but allows measurement and adjustment for non-VOCs, if desired. Any listed non-VOC compound may be measured independently and the value subtracted from the THC measurement, with appropriate adjustments (proper basis and response factor). An equation and example calculations are provided in later sections of this protocol. Methane, ethane, and acetone are the non-VOCs most commonly sampled in the wood products industry. Methane emissions can sometimes be significant from natural gas fired sources such as direct-natural-gas-fired dryers and RTOs. Typically, acetone and ethane emissions are relatively small, but may vary by source. EPA provides a list of non-VOCs in 40 CFR 51.100(s).

8.0 Calculation of Total VOC Emissions

Total VOC emissions may be calculated by using Equation 1 or by using the "VOC Worksheet." A spreadsheet for conducting the calculations is also available at www.ncasi.org.

WPP1 VOC emissions are calculated by subtracting (b) from (a) where (a) equals the sum of THC expressed as propane, methanol expressed as methanol (if applicable), and formaldehyde expressed as formaldehyde (if applicable) and (b) equals the sum of methanol and all measured non-VOC compounds, all expressed as propane with each compound multiplied by the appropriate response factor. Units for the calculations should be mass basis (lb/hr or other mass emission rate unit such as lb/ODT or grams/second). Concentration units (e.g., ppm) cannot be used. If, according to Section 3, VOCs are expressed as terpenes, then the term "alpha-pinene" may be substituted for "propane" in Equation 1.

Equation 1

$$\mathrm{VOC} = \begin{bmatrix} \begin{pmatrix} \text{Method 25A VOC} \\ \textit{expressed as propane} \end{pmatrix} \\ \\ + \begin{pmatrix} \text{Methanol} \\ \textit{expressed as methanol} \end{pmatrix} \\ \\ + \begin{pmatrix} \text{Formaldehyde} \\ \textit{expressed as formaldehyde} \end{pmatrix} \end{bmatrix} - \begin{pmatrix} \sum_{i=1}^{n} \left(\mathrm{RF}_i \text{ x } \mathrm{Compound}_i \right) \\ \textit{expressed as propane} \end{pmatrix}$$

Where: RF_i = response factor of $_i$th compound (expressed as a decimal)

$Compound_i$ includes methanol and any individually measured, listed, non-VOC compound but does not include formaldehyde.

Units for all expressions are lb/hr or other mass emission rate unit. Units cannot be concentration units.

Methanol and formaldehyde measurements are required only for sources listed in Appendix 1.

Appendix 1

Dryers
Presses
Board Coolers
Blenders
Formers
Pressurized refiners
Fiber washers

(Includes control devices for the above listed process units. For example, a RTO controlling a dryer would be a listed source.)

Appendix 2

VOC Worksheet

	Run 1	Run 2	Run 3
Measurements – VOC, formaldehyde, and methanol			
lb/hr VOC expressed as propane	1a ________	1a ________	1a ________
lb/hr Formaldehyde expressed as formaldehyde	2b ________	2b ________	2b ________
lb/hr Methanol expressed as methanol	3c ________	3c ________	3c ________
(1a + 2b + 3c) lb/hr	4________	4________	4________
Adjustments - methane, ethane, and methanol			
Methanol expressed as methanol, lb/hr	5a ________	5a ________	5a ________
(5a x 0.458 x RF) lb/hr	6________	6________	6________
Methane expressed as methane, lb/hr	7a ________	7a ________	7a ________
(7a x 0.917 x RF) lb/hr	8________	8________	8________
Ethane expressed as ethane, lb/hr	9a ________	9a ________	9a ________
(9a x 0.976 x RF) lb/hr	10________	10________	10________
Non-VOC compounds other than methane and ethane			
Response factor for non-VOC Compound 1	11a ________	11a ________	11a ________
Molecular weight of non-VOC Compound 1	12b ________	12b ________	12b ________
Number of carbon atoms in non-VOC Compound 1	13c ________	13c ________	13c ________
Mass ER non-VOC Compound 1	14d ________	14d ________	14d ________
[(14d x 13c x 11a x 14.667) ÷ (12b)] =	15________	15________	15________
Response factor for non-VOC Compound 2	16a ________	16a ________	16a ________
Molecular weight of non-VOC Compound 2	17b ________	17b ________	17b ________
Number of carbon atoms in non-VOC Compound 2	18c ________	18c ________	18c ________
Mass ER non-VOC Compound 2	19d ________	19d ________	19d ________
[(19d x 18c x 16a x 14.667) ÷ (17b)] =	20________	20________	20________
Final Calculations			
Enter value from line 4	21________	21________	21________
Enter sum of lines 6, 8, 10, 15 and 20	22________	22________	22________
Subtract line 22 from line 21	23________	23________	23________

Sample Calculation
This example follows the VOC worksheet but provides equations and additional detail. Calculations are provided and discussed, corresponding with the line number on the VOC Worksheet.

Example - A sampling company provides the following results from concurrent sampling at a wood products source:

Compound	Value	Units
VOC as propane (from FIA)	50	lb/hr
Methanol as methanol	10	lb/hr
Formaldehyde as formaldehyde	5	lb/hr
Methane as methane	2	lb/hr
Ethane as ethane	2	lb/hr
Acetone as acetone	2	lb/hr

Acetone, methane, and ethane are listed non-VOCs. The sampling company does not conduct response factor work but uses the default response factors provided in Section 5. Calculate the WPP1 VOC value for this example problem?

Line 4 – This is simply a sum of the mass emission rates of formaldehyde, methanol, and VOCs. 50 lb/hr VOCs as propane + 10 lb/hr methanol as methanol + 5 lb/hr formaldehyde as formaldehyde = 65 lb/hr.

Line 6 – In order for the methanol to be subtracted from the FIA THC measurement, methanol must first be converted to a propane basis. This can be done by using Equation 2 as shown below:

Equation 2

$$\text{Mass}_{\text{VOC expressed as X}} = \text{Mass}_{\text{VOC expressed as Y}} \text{ x} \left(\frac{\text{molecular weight of X}}{\text{molecular weight of Y}}\right) \text{x} \left(\frac{\begin{array}{c}\text{number of carbon atoms}\\ \text{in compound Y}\end{array}}{\begin{array}{c}\text{number of carbon atoms}\\ \text{in compound X}\end{array}}\right)$$

For this example converting 10 lb/hr of methanol, measured as methanol, to a mass rate of methanol expressed as propane yields 4.89 lb/hr of methanol expressed as propane as shown below.

$$\text{methanol}_{\text{expressed as propane}} = 10 \text{ lb/hr methanol}_{\text{expressed as methanol}} \text{ x} \left(\frac{44}{32}\right) \text{x} \left(\frac{1}{3}\right)$$

$$= 4.89 \text{ lb/hr methanol}_{\text{expressed as propane}}$$

This value requires a second adjustment since less than 100% of the methanol responds in a FIA. The response factor set by this protocol is 65%.

0.65 x 4.89 = 2.98 lb/hr methanol expressed as propane

Line 8 – Methane must be converted to a propane basis prior to adjustment. Equation 2 may be used as shown below. A response factor adjustment is not needed for methane.

$$\text{methane}_{\text{expressed as propane}} = 2\ \text{lb/hr methane}_{\text{expressed as methane}}\ \text{x}\left(\frac{44}{16}\right)\text{x}\left(\frac{1}{3}\right)$$

$$= 1.83\ \text{lb/hr methane}_{\text{expressed as propane}}$$

Line 10 – Ethane must be converted to a propane basis prior to adjustment. Equation 2 may be used as shown below. A response factor adjustment is not needed for ethane.

$$\text{ethane}_{\text{expressed as propane}} = 2\ \text{lb/hr ethane}_{\text{expressed as ethane}}\ \text{x}\left(\frac{44}{30}\right)\text{x}\left(\frac{2}{3}\right)$$

$$= 1.95\ \text{lb/hr ethane}_{\text{expressed as propane}}$$

Lines 15 and 20 - For this example, two non-VOC compounds were included – acetone and methyl acetate. The example assumes the sampling company developed response factors of 65% for both compounds. Equation 2 is used, followed by a response factor correction, as shown below.

Line 15 -

$$\text{acetone}_{\text{expressed as propane}} = 2\ \text{lb/hr acetone}_{\text{expressed as acetone}}\ \text{x}\left(\frac{44}{58.1}\right)\text{x}\left(\frac{3}{3}\right)$$

$$= 1.52\ \text{lb/hr acetone}_{\text{expressed as propane}}$$

This value requires a second adjustment since the example response factor for acetone is 65%.

0.65 x 1.52 = 0.98 lb/hr acetone expressed as propane

Line 20 – Not required for this example problem.

Line 21 – This is the sum of VOCs as propane, formaldehyde, and methanol and is copied from Line 4. For this example the value is 65 lb/hr.

Line 22 – The sum of lines 6, 8,10, 15 and 20 is the sum of the adjustments. 2.98 + 1.83 + 1.95 + 0.98 = 7.75 lb/hr of VOCs that may be adjusted or subtracted from the total from Line 4.

Line 23 – The adjustments are subtracted from Line 21 to provide the adjusted Total VOC value. 65 – 7.75 **= 57.3 lb/hr of VOCs.**

Example VOC Worksheet

	Run 1	Run 2	Run 3
Measurements – VOC, formaldehyde, and methanol			
lb/hr VOC expressed as propane	1a 50	1a	1a
lb/hr Formaldehyde expressed as formaldehyde	2b 5	2b	2b
lb/hr Methanol expressed as methanol	3c 10	3c	3c
(1a + 2b + 3c) lb/hr	4 65	4	4
Adjustments - methane, ethane, and methanol			
Methanol expressed as methanol, lb/hr	5a 10	5a	5a
(5a x .458 x 0.65) lb/hr	6 2.98	6	6
Methane expressed as methane, lb/hr	7a 2	7a	7a
(7a x 0.917 x 1.0) lb/hr	8 1.83	8	8
Ethane expressed as ethane, lb/hr	9a 2	9a	9a
(9a x 0.976 x 1.0) lb/hr	10 1.95	10	10
Non-VOC compounds other than methane and ethane			
Response factor for non-VOC Compound 1	11a 65%	11a	11a
Molecular weight of non-VOC Compound 1	12b 58.1	12b	12b
Number of carbon atoms in non-VOC Compound 1	13c 3	13c	13c
Mass ER non-VOC Compound 1	14d 2	14d	14d
[(14d x 13c x 11a x 14.667) ÷ (12b)] =	15 0.98	15	15
Response factor for non-VOC Compound 2	16a	16a	16a
Molecular weight of non-VOC Compound 2	17b	17b	17b
Number of carbon atoms in non-VOC Compound 2	18c	18c	18c
Mass ER non-VOC Compound 2	19d	19d	19d
[(19d x 18c x 16a x 14.667) ÷ (17b)] =	20	20	20
Final Calculations			
Enter value from line 4	21 65	21	21
Enter sum of lines 6, 8, 10, 15 and 20	22 7.75	22	22
Subtract line 22 from line 21	23 57.3	23	23

Appendix 3

Procedure for Response Factor Determination for the Interim VOC Measurement Protocol for the Wood Products Industry

<u>Introduction and Definitions</u> -

The Interim VOC Measurement Protocol for the Wood Products Industry (referred to herein as the Protocol) provides the following default response factors (RFs):

- Formaldehyde RF = 0%
- Methanol RF = 65%
- Alkanes, alkenes, and arenes RF = 100% (includes methane and ethane)
- Acetone RF = 65%

These default response factors may be used in Protocol calculations or, if desired, response factors can be determined for methane, ethane, methanol, and acetone by following the measurement procedures established in this Appendix. EPA Protocol 1 gases with air as a diluent must be used for response factor determination for methane and ethane. If methanol and acetone EPA Protocol 1 gases can be obtained with air as a diluent, they may also be used. Otherwise, methanol and acetone standard gases must be prepared in Tedlar or Teflon sampling bags using air as a diluent. Flame ionization analyzers (FIAs) used to determine response factors must be calibrated with propane in an air diluent. If response factors are determined, then the WPP1 VOC testing must be conducted with the same Flame Ionization Analyzer (FIA) calibrated with the same type hydrocarbon gas used during response factor determination and the gas must be in an air diluent. (If response factors are determined, VOC calibration gases with nitrogen diluents cannot be used either during RF determination or during testing.)

Procedures for preparing challenge gases and determining response factors, other than those provided in this Appendix (e.g. permeation tubes or syringe pumps), may be used if approved by the administrator or regulatory authority.

For the purposes of this document:

<u>Response factor</u> is defined as the flame ionization analyzer (FIA) response divided by the "actual compound concentration", both expressed on the same basis, and expressed as a percentage. Examples are provided near the end of this Appendix.

<u>Actual compound concentration</u> is defined as the tag or bottle value of the EPA Protocol 1 gas or as the concentration of gas in a Tedlar or Teflon sampling bag. The concentration in the bag is determined by dividing the mass of compound by the volume of total dry gas in the bag and using appropriate conversion factors. Examples are provided near the end of this Appendix.

<u>Challenge gas</u> is defined as the gas used to determine a response factor. Challenge gases must be purchased or prepared as specified in this Appendix.

Determining Response Factors Using EPA Protocol 1 Gases – Prior to introduction of the Protocol 1 challenge gas, the VOC analyzer (Flame Ionization Analyzer or FIA) must be successfully calibrated according to EPA Method 25A procedures with EPA Protocol 1 gases in an air diluent. Once calibrated, the instrument may be challenged with the challenge gas to determine the response factor of the compound in the gas. The challenge-compound concentration should be near the mid range of the FIA span and may not be less than 30% of span or more than 70% of span. For example, a 150 ppmvd methane gas (expressed as methane or as carbon and equivalent to 50 ppmvd expressed as propane) would be an appropriate challenge gas for use on an instrument calibrated with propane with a 0 to 100 ppmvd span (expressed as propane).

The EPA Protocol 1 challenge gas must be introduced to the analyzer in the same manner as the calibration gases were introduced. The gas must be introduced until the response stabilizes and remains stable for at least a five-minute period. One-minute averages or less must be recorded during the five-minute period. Any single one-minute average within the five-minute period must not differ from the overall five-minute-average by more than 10%. The five-minute average concentration of the challenge gas is used to determine the response factor as defined in the Introduction and Definitions section of this document. Documentation of challenge gas introduction and measurement as well as the FIA calibration must be included in the VOC test report.

Determining Response Factors Using Standard Gases Prepared in Tedlar or Teflon Sampling Bags – Methanol and acetone standard gases may be prepared in Tedlar or Teflon sampling bags using the procedures specified in EPA Method 18. Three or more separate bag samples must be prepared. Air must be used as the diluent gas. The mass of methanol or acetone and the volume of gas in the bag must be measured and recorded in the VOC report. Measurements of the compound mass and gas volume must be made by devices traceable to a primary standard and the sampling company must describe how the volume of gas and the mass of compound was measured or determined. The means of introducing the compound into the bag must also be described in the test report.

If the compound is introduced as an aqueous solution the amount of water introduced may not exceed water vapor saturation in the air at 50°F (a moisture content of about 1.2%). The testing company must report the concentration of compound in the water, the amount of solution introduced into the bag, measures taken to assure that all water was converted into water vapor within the bag, the amount of dry air in the bag, and the moisture content of the final gas in the bag. (Because the bag will contain water vapor, the FIA reading will be on a wet basis. The actual compound concentration should also be calculated on a wet basis or both values should be converted to a dry basis before calculation of the response factor. See “Actual Compound Concentration – Example 2” below.)

Prior to introduction of the Teflon or Tedlar bag challenge gas, the VOC analyzer (Flame Ionization Analyzer or FIA) must be successfully calibrated according to EPA Method 25A procedures with EPA Protocol 1 gases in an air diluent. Propane in nitrogen gases cannot be used. Once calibrated, the instrument may be challenged with the bag challenge gas to determine the response factor of the compound in the gas. The challenge-compound concentration should be near the mid range of the FIA span and may not be less than 30% of span or more than 70% of span (measured on an equivalent basis). For example, a 230 ppmvd methanol gas would be appropriate for use on an instrument calibrated with propane with a 0 to 100 ppmvd span (expressed as propane). (The example assumes a 65% response factor for methanol.)

The Tedlar or Teflon sampling bag challenge gas must be introduced to the analyzer in the same manner as the calibration gases. The gas must be introduced until the response stabilizes. Three or more separate bag samples must be introduced. A single bag sample may not be introduced three times. The results from the three or more samples must be averaged and the average used to determine the response factor as defined in the Introduction and Definitions section of this Appendix. The results from any one of the bag samples may not vary from the average by more than 10%. Documentation must be provided to show that the FIA reading stabilized on each of the three bag samples. Additionally, the VOC test report must contain a discussion of the means by which bag challenge gases and FIA calibration gases were introduced to the FIA. Evidence of a successful FIA calibration must also be provided.

Applicability – The response factors developed via the above described procedures may be used in conjunction with the Interim VOC Measurement Protocol for the Wood Products Industry only for the instrument on which the response factors were determined. The response factors determined via these procedures are not valid for the instrument if (1) adjustments have been made that would affect the fuel or air flow rates to the instrument, (2) the instrument has undergone repair, or (3) adjustments to the instrument other than those required for calibrations have been made. Further, the determined response factors may only be used within 30 days of the date on which they were determined. Response factors may be, but are not required to be, determined in the field during the testing event. Response factors determined in the laboratory may be determined under better controlled conditions but response factors determined in the field may be determined under conditions more representative of the testing.

Response factors determined via these procedures are not applicable to FIAs calibrated with nitrogen diluent gases.

Example Calculations Intended to Illustrate the Definitions of "Response Factor" and "Actual Compound Concentration"

Actual Compound Concentration – Example 1

Fifteen milligrams of methanol is introduced into a Tedlar bag containing 45.0 liters of dry air (corrected to 68°F and one atmosphere). The 15 mg of methanol occupies 0.01 liters at standard conditions. The total Tedlar bag volume is 45.01 liters. The actual compound concentration is

$$\left(\frac{15\ \text{mg methanol}}{45.0113\ \text{liters}}\right) \text{x} \left(\frac{24.05\ \text{liters}}{\text{gram-mole}}\right) \text{x} \left(\frac{\text{gram-mole}}{32.04\ \text{grams methanol}}\right) \text{x} \left(\frac{\text{gram}}{1000\ \text{mg}}\right) = 0.00025 = 250\ \text{ppmvd methanol}$$

Actual Compound Concentration – Example 2

Four milliliters of a 5,000 mg/L solution of methanol in water is introduced into a Tedlar bag containing 50 liters of dry air (corrected to 68°F and one atmosphere). The water and 20 mg of methanol introduced occupy 0.53 and 0.015 liters, respectively. The total Tedlar bag volume is 50.55 liters. The moisture content of the bag is 1.05%. The actual compound concentration is

$$\left(\frac{20\ \text{mg methanol}}{50.545\ \text{liters}}\right) \text{x} \left(\frac{24.05\ \text{liters}}{\text{gram-mole}}\right) \text{x} \left(\frac{\text{gram-mole}}{32.04\ \text{grams methanol}}\right) \text{x} \left(\frac{\text{gram}}{1000\ \text{mg}}\right) = 297\ \text{ppmvw methanol}$$

Note that the methanol concentration is expressed on a wet basis.

Response Factor – Example 3

A FIA calibrated with propane in air measures an EPA Protocol 1 methane in air cylinder gas with a tag value of 150 ppmvd, as methane. The FIA measures the gas as 57 ppmvd, expressed as propane, or 171 ppmvd expressed as methane. The response factor is the measured concentration divided by the actual compound concentration or 171/150 = 114%.

Response Factor – Example 4

A FIA calibrated with propane in air measures the Tedlar bag in Example 2 above. The actual compound concentration is 297 ppmvw, expressed as methanol or expressed as carbon. The FIA measures the bag gas as 59 ppmvw, expressed as propane, or 177 ppmvw expressed as carbon. The response factor is the measured compound concentration divided by the actual compound concentration or 177/297 = 59.6%.