TECHNICAL SUPPLEMENT 1: SELECTED COMBUSTION SOURCES

Technical Disclaimer

This technical supplement is intended to help you accurately determine and correctly report emissions from combustion sources. It does not supersede or replace any state or federal law, regulation, or rule.

This guidance, which reflects our current understanding of how combustion sources work and how they generate emissions, how they are monitored or tested, and what data are available for emissions determination, may change over time as we continue our scientific studies and as new information becomes available. We welcome any data, information, or feedback that may improve our understanding of combustion emissions and thereby further improve emissions inventory emission determinations.

The represented calculation methods are intended as an emissions calculation aid; alternate calculation methods may be equally acceptable if they are based upon, and adequately demonstrate, sound engineering assumptions or data. If you have a question regarding the acceptability of a given emissions determination method, contact the Industrial Emissions Assessment Section at

Introduction

This technical supplement addresses common problems and concerns with internal combustion engines (turbines, reciprocating engines, and gasoline and diesel industrial engines); external combustion sources burning natural gas; and combined cycle turbines with heat recovery steam generators. For more information about these sources, or for information about combustion sources not covered in this appendix, consult the appropriate TCEQ new source review (NSR) guidance documents and EPA's Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources (AP-42), with Supplements A through E (continuously updated).

Internal Combustion Engines

Expected Contaminants

Reported engine emissions should include all of the following:

- TSP (contaminant code 10000)
- PM_{10} (contaminant code 20000)
- $PM_{2.5}$ (contaminant code 39999)
- VOCs (contaminant codes 50001 through 59998)
- NO_X (contaminant code 70400)
- SO_2 (contaminant code 70510)
- CO (contaminant code 90300)

Emissions Determination Methodologies

The appropriate emissions determination methodologies for internal combustion engines are, in order of preference:

- D (Continuous emissions monitoring system or CEMs)
- F (Predictive emissions monitoring system or PEMs)
- M (Measured - stack test data)
- V (Vendor-supplied emissions factors)
- A (AP-42 factors)
- S (Scientifically calculated)

Note that material balance (“B”) is not explicitly mentioned in the list because of its limited applicability in determining emissions from combustion sources. If you feel that none of these methodologies will accurately represent a source's emissions, contact the IEAS for further assistance.

SO_2 Emissions

If any sulfur is present in a source's inlet gas, then the source will emit sulfur dioxide as a product of combustion. When selecting an SO_2 emissions determination methodology, CEMS, PEMS, and stack test data are, in that order, the preferred emissions determination methods. However, material balance emissions determinations based upon the combusted fuel’s sulfur content are preferred to both vendor and AP-42 emissions determinations.

Particulate Emissions

Determining and reporting particulate emissions has caused some confusion in previous years. Please read the following information carefully.

Combustion sources emit particulate matter. Furthermore, particulate matter emitted from internal combustion engines has an aerodynamic diameter smaller than 2.5. Thus, all particulate emissions from these sources should be reported as $PM_{2.5}$, total suspended particulate matter (TSP) and PM_{10}. See Chapter 4, "Particulate Emissions" for more details.

In the past, some confusion has arisen from AP-42's representation of three particulate emission factors: PM_{10}(filterable), $PM_{2.5}$(filterable), and PM(condensable). Since the condensable and filterable fractions represent two different halves of cumulative particulate emissions, these factors must be used together to accurately represent cumulative particulate emissions.

However, the manner in which you sum these emission factors is not straightforward. Since all particulate matter emitted from internal combustion engines is $PM_{2.5}$ or smaller, the PM_{10} (filterable) and $PM_{2.5}$ (filterable) factors are equivalent; these two factors represent the same set of particulate emissions. In emissions calculations, then, you only need to use one of these factors when attempting to obtain the cumulative emissions factor.

To calculate particulate emissions, sum the $PM_{2.5}$(filterable) and one of the PM(condensable) factors to obtain the cumulative emissions factor. Use this cumulative emissions factor to determine all particulate emissions. Report the emission rate thus obtained as follows:

- total particulate (contaminant code 10000);
- PM_{10} (contaminant code 20000); and
- $PM_{2.5}$ (contaminant code 39999).

Example: Suppose that AP-42 shows the following emission factors for particulate matter from a certain engine type:
PM_{10}(filterable) = 0.0095 lb/MMBtu
$PM_{2.5}$(filterable) = 0.0095 lb/MMBtu
PM(condensable) = 0.00991 lb/MMBtu

Then the correct particulate emission factor for this engine type would be the sum of the $PM_{2.5}$(filterable) and the PM(condensable) factors, or 0.01941 lb/MMBtu. If the engine consumed 35,000 MMBtu of fuel during the year, then its particulate emissions would be:

$$\frac{0.0194\ \text{lb}}{\text{MMBtu}} \times \frac{35{,}000\ \text{MMBtu}}{\text{year}} \times \frac{1\ \text{ton}}{2000\ \text{lb}} = 0.3395\ \text{tons}$$

The correct way to report these emissions is shown in the following table:

Table A-1. Particulate Emissions Reporting

Contaminant Code	Contaminant	Annual Emissions
10000	part - u	0.3395 tons
20000	PM_{10} - u	0.3395 tons
39999	total $PM_{2.5}$	0.3395 tons

VOC Emissions

Determining, speciating, and reporting VOC emissions has caused some confusion in previous years. Please read the information in this section carefully. VOC emissions may be determined using stack test data, vendor data, and/or AP-42 factors. Each methodology is discussed separately in the following sections; each section contains methology-specific speciation instructions.

Stack Test Data

When using stack test data to determine VOC emissions, verify that the test measured VOCs rather than total hydrocarbons. If it did measure VOCs, then use the test data to determine emissions; code the emissions with a determination methodology of "M."

If the test measured instead for total hydrocarbons, then you will need to adjust for this by multiplying the hydrocarbon factor by the following ratio: AP-42 VOC factor / AP-42 total organic carbon (TOC) factor. Code the emissions with a determination methodology of "S.”

Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the stack test total organic carbon (TOC) factor to obtain a VOC emission factor.

Vendor Data

When using vendor data to determine VOC emissions, verify that the factor refers to VOCs rather than total hydrocarbons. If it does, then use it to determine emissions; code the emissions with a determination methodology of "V.”

If the factor refers instead to total hydrocarbons, then you will need to adjust for this by multiplying the hydrocarbon factor by the following ratio: AP-42 VOC factor / AP-42 TOC factor. Code the emissions with a determination methodology of "S.”

Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the vendor's total organic carbon (TOC) factor to obtain a VOC emission factor.

AP-42 Factors

AP-42 provides both VOC and TOC factors. Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the AP-42 TOC factor to obtain a VOC emission factor.

When using an AP-42 factor to determine emissions, use the most recent VOC factor. Code emissions with a determination methodology of "A."

Speciation

To determine whether or not you need to speciate VOC emissions from an internal combustion engine, see *2005 Emissions Inventory Guidance*, Chapter 4.

If you have any source-specific information about the VOC emissions composition for a source, then you should use it to speciate the emissions. Supply the data and related information with your emissions inventory.

If you do not have any source-specific information about the VOC emissions composition, then you should speciate the emissions using the AP-42 Trace Organic Compounds factors that are graded C or better. Divide each trace organic factor by AP-42's VOC factor to obtain the contaminant's speciation ratio. Multiply the source's total VOC emissions by each ratio to obtain that compound's emission rate. You need only report speciated emissions of at least 0.1 tons; smaller rates may be reported under VOC-u (contaminant code 50001).

If you used stack test data or vendor data to determine total VOC emissions, then code the speciated emissions with a determination methodology of "S" for "scientifically calculated"; the VOC-u emissions will be coded as "M" or "V." If you used an AP-42 factor to determine total VOC emissions, then code all VOC emissions with a determination methodology of "A."

Example: Using a vendor-supplied VOC factor, you have determined VOC emissions from a four-cycle lean burn compressor at 11.2 tons. You have no information about the composition of the exhaust VOCs. You do have an inlet gas analysis, but because complex oxidation reactions in the combustion chamber alter the emissions composition significantly, you know that you cannot use these data to speciate the VOC emissions. You therefore turn to AP-42.

In AP-42, you find that one of the Trace Organic Compounds factors graded C or better is for formaldehyde: 0.0528 lb/MMBtu. The total VOC emission factor in AP-42 is 0.118 lb/MMBtu. To obtain formaldehyde's speciation ratio, you divide the formaldehyde factor by the total VOC factor:

0.0528 lb per MMBtu ÷ 0.118 lb per MMBtu = 0.44746

Now you multiply the engine's total VOC emissions by this ratio to determine the formaldehyde emissions:

11.2 tons VOC x 0.44746 = 5.0115 tons formaldehyde

If you perform a similar calculation for each Trace Organic Compound with a factor graded C or better, you will obtain 27 speciated emission rates. However, only eight of these exceed the 0.1 ton threshold. You should report the speciated emissions for these eight compounds and report the balance of VOC emissions under VOC-u, as shown in Table A-2.

Table A-2. Internal Combustion VOC Emissions Reporting

Contaminant Code	Contaminant	Annual Emissions	Determination Methodology
50001	VOC - u	0.2240 tons	V
51620	acetaldehyde	0.7935 tons	S
51640	acrolein	0.4879 tons	S
51680	formaldehyde	5.0115 tons	S
51530	methanol	0.2373 tons	S
56150	methylcyclohexane	0.1167 tons	S
56600	n-hexane	0.1054 tons	S
56750	n-pentane	0.2468 tons	S
56775	propane	3.9769 tons	S

External Combustion Sources Burning Natural Gas

Expected Contaminants

Reported boiler emissions should include all of the following:

- TSP (contaminant code 10000)
- PM_{10} (contaminant code 20000)
- $PM_{2.5}$ (contaminant code 39999)
- VOCs (contaminant codes 50001 through 59998)
- NO_X (contaminant code 70400)
- SO_2 (contaminant code 70510)
- CO (contaminant code 90300)

Emissions Determination Methodologies

The appropriate emission determination methodologies for boilers are, in order of preference:

- D (Continuous monitoring system or CEMs)
- F (Predictive monitoring system or PEMs)
- M (Measured—stack test data)
- V (Vendor-supplied emissions factors)
- A (AP-42 factors)
- S (Scientifically calculated)

If you feel that none of these methodologies will accurately represent a source's emissions, contact the IEAS for further assistance.

SO_2 Emissions

Note that if any sulfur is present in a source's inlet gas, then the source will emit sulfur dioxide as a product of combustion.

Particulate Emissions

Determining and reporting particulate emissions has caused some confusion in previous years. Please read the following information carefully.

Combustion sources emit particulate matter. Furthermore, all of the particulate matter emitted from boilers as a result of combustion has an aerodynamic diameter smaller than 2.5. Hence, all particulate emissions from these sources should be reported as TSP, PM_{10} and $PM_{2.5}$.

Note that AP-42 provides three particulate emission factors: PM (total), PM (condensable), and PM (filterable). Use the PM (total) factor (which can also be obtained by summing the PM (condensable) and PM (filterable) factors) to determine boiler particulate emissions. Report these emissions as TSP (contaminant code 10000), as PM_{10} (contaminant code 20000), and as $PM_{2.5}$ (contaminant code 39999).

VOC Emissions

The practice of determining, speciating and reporting VOC emissions has caused some confusion in previous years. Please read the information in this section carefully. Emissions may be determined using stack test data and/or AP-42 factors. Each methodology is discussed separately in the following sections, and is followed by speciation instructions.

Stack Test Data

When using stack test data to determine VOC emissions, verify that the test measured VOCs rather than total hydrocarbons. If it did measure for VOCs, then use the test data to determine emissions; code the emissions with a determination methodology of "M."

If the test measured instead for total hydrocarbons, then you will need to adjust for this by multiplying the hydrocarbon factor by the following ratio: AP-42 VOC factor / AP-42 TOC factor. Code the emissions with a determination methodology of "S." Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the stack test TOC factor to obtain a VOC emission factor.

Vendor Data

When using vendor data to determine VOC emissions, verify that the factor refers to VOCs rather than total hydrocarbons. If it does, then use it to determine emissions; code the emissions with a determination methodology of "V.”

If the factor refers instead to total hydrocarbons, then you will need to adjust for this by multiplying the hydrocarbon factor by the following ratio: AP-42 VOC factor / AP-42 TOC factor. Code the emissions with a determination methodology of "S.”

Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the vendor’s total organic carbon (TOC) factor to obtain a VOC emission factor.

AP-42 Factor

AP-42 provides both VOC and TOC factors. Because complex oxidation reactions in the combustion chamber significantly alter the emissions composition, it is unacceptable to apply the inlet gas stream's VOC percentage to the AP-42 TOC factor to obtain a VOC emission factor.

When using an AP-42 factor to determine emissions, use the most recent factor. Code all emissions with a determination methodology of "A."

Speciation

To determine whether or not you need to speciate VOC emissions from a source, consult *2005 Emissions Inventory Guidance*, Chapter 4.

If you have any source-specific information about the VOC emissions composition for a source, then you should use it to speciate the emissions. Supply the data and related information with your emissions inventory.

If you do not have any source-specific information about the VOC emissions composition, then you should speciate the emissions using the AP-42 speciated organic compounds factors for formaldehyde, toluene, and benzene. Divide each of these factors by the AP-42 VOC factor to obtain the contaminant's speciation ratio. Then multiply the source's VOC emissions total by each contaminant's ratio to obtain that contaminant's emission rate. Report the emissions balance as VOC-u (contaminant code 50001).

If you used stack test data to determine total VOC emissions, then code the speciated emissions with a determination methodology of "S" for "scientifically calculated"; the VOC-u emissions will be coded as "M." If you used an AP-42 factor to determine total VOC emissions, then code all VOC emissions with a determination methodology of "A."

Example: Using stack test data, you have determined VOC emissions from a boiler at 43 tons. You have no information about the composition of the exhaust VOCs. You do have an inlet gas analysis, but because complex oxidation reactions in the combustion chamber alter the emissions composition significantly, you know that you cannot use these data to speciate the VOC emissions. You therefore turn to AP-42.

In AP-42, you find that one of the speciated organic compounds factors graded C or better is for formaldehyde: 0.075 lb/MMscf. The total VOC emission factor in AP-42 is 5.5 lb/MMscf. To obtain formaldehyde's speciation ratio, you divide the formaldehyde factor by the total VOC factor:

$$0.075 \text{ lb per MMscf} \div 5.5 \text{ lb per MMscf} = 0.0136$$

Now you multiply the boiler's total VOC emissions by this ratio to determine the formaldehyde emissions:

43 tons VOC * 0.0136 = 0.5864 tons formaldehyde

Perform similar calculations for benzene and toluene. Report the boiler's VOC emissions as shown in Table A-3.

Table A-3. External Combustion VOC Emissions Reporting

Contaminant Code	Contaminant	Annual Emissions	Determination Methodology
50001	VOC - u	42.3706 tons	M
51680	formaldehyde	0.5864 tons	S
52420	benzene	0.0164 tons	S
52490	toluene	0.0266 tons	S

Combined Cycle Turbines with Heat Recovery Steam Generators

Structure

Structural representation of cogeneration turbines with an associated duct burner, heat recovery steam generator (HRSG), or boiler will vary, depending upon the operation of the units in question.

If the unit associated with the cogeneration turbine cannot operate independently from the turbine, represent the units as one FIN/EPN path, noting in the path or facility comments that a duct burner or HRSG operates in conjunction with the turbine.

If the unit associated with the cogeneration turbine can operate independently from the turbine, as is the case for most boilers, then represent the turbine as one FIN and the associated unit as a separate FIN. If both the turbine and the associated unit vent to the same EPN, create a common EPN for both FINs.

If the turbine can vent to a separate EPN (that is **not** the EPN shared with the associated unit) when it operates independently, this EPN also needs to be represented in the EI. Create two paths for the turbine, using one FIN and two EPNs: one for the separate turbine stack, and one for the stack shared with the associated unit. Remember also to include the path for the associated unit that vents to the shared stack in the EI. Figure A-1 is an illustration of how to represent these paths in the EI, using the FIN designation TURBINE for the turbine, and the FIN designation BOILER for the associated unit:

Figure A-1. Structural Representation of a Cogeneration Turbine and Associated HRSG

FIN		EPN
TURBINE	⇨	SEP_STK (Separate Stack)
TURBINE	⇨	SHARED_STK (Shared Stack)
BOILER	⇨	SHARED_STK (Shared Stack)

Expected Contaminants

These facilities' reported emissions should include all of the following:

- TSP (contaminant code 10000)
- PM_{10} (contaminant code 20000)
- $PM_{2.5}$ (contaminant code 39999) (continued on next page)
- VOCs (contaminant codes 50001 through 59998)
- NO_X (contaminant code 70400)
- SO_2 (contaminant code 70510)
- CO (contaminant code 90300)
- NH_3 (contaminant code 70050)

Emissions Determination Methodologies

The appropriate emission determination methodologies for combined cycle turbines are, in order of preference:

- D (Continuous monitoring system or CEMs)
- F (Predictive monitoring system or PEMs)
- M (Measured—stack test data)
- V (Vendor-supplied emissions factors)
- A (AP-42 factors)
- S (Scientifically calculated)

If you feel that none of these methodologies will accurately represent a source's emissions, contact the IEAS for further assistance.

NO_X and CO Emissions

NO_X and CO emissions from these sources are typically continuously monitored. In this case, emissions reporting is straightforward.

If, however, you use stack test data to determine emissions from a combined cycle turbine equipped with a duct burner, you should have and use two data sets: one representing emissions with the duct burner on, the other representing emissions with the duct burner off. If you do not have two separate data sets, or if you are using another method to determine emissions, then contact the IEAS for guidance.

Particulate, VOC, and SO_2 Emissions

For guidance on determining and speciating these emissions, see the “Internal Combustion Engines” section of this supplement.