DRAFT Review of Emissions Test Reports for Emissions Factors Development for Flares and Certain Refinery Operations

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Office of Air Quality Planning and Standards

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Section 1
Summary

The purpose of this report is to document the review and analysis of test reports and assess the use of test report data for developing emissions factors for flares and certain refinery operations. These emissions factors are being proposed as an update to the *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources,* AP-42 (EPA, 1995).

On May 1, 2013, Air Alliance Houston, Community In-Power and Development Association, Inc. (CIDA), Louisiana Bucket Brigade, and Texas Environmental Justice Advocacy Services (TEJAS), (collectively, "Plaintiffs") filed a lawsuit against the U.S. Environmental Protection Agency (EPA) alleging that the EPA had failed to review and, if necessary, revise emissions factors at least once every three years as required in Section 130 of the Clean Air Act (CAA). Air Alliance Houston, *et al.* v. McCarthy, No. 1:13-cv-00621-KBJ (D.D.C.). In the complaint, the Plaintiffs sought to compel the EPA to expeditiously complete a review of the volatile organic compounds (VOC) emissions factors for industrial flares ("flares"), liquid storage tanks ("tanks"), and wastewater collection, treatment and storage systems ("wastewater treatment systems"), and, if necessary, revise these factors. EPA entered into a consent decree with the Plaintiffs to settle the lawsuit. Under the terms of the consent decree, by August 19, 2014, EPA will review and either propose revisions to the VOC emission factors for flares, tanks and wastewater treatment systems under CAA section 130, or propose a determination under CAA section 130 that revision of these emission factors is not necessary. By December 19, 2014, EPA will issue final revisions to the VOC emission factors for flares, tanks and wastewater treatment systems, or issue a final determination that revision of these emission factors for flares is not necessary. EPA will post each proposed revision or determination (or combination thereof), and each final revision or determination (or combination thereof), on its AP-42 website on the dates indicated above.

As part of its efforts to comply with the consent decree, EPA reviewed emissions test data submitted by refineries for the 2011 Petroleum Refinery Information Collection Request (2011 Refinery ICR) and test data collected during the development of parameters for properly designed and operated flares and developed new emissions factors, as shown in Table S-1. The EPA proposes to add these emissions factors to AP-42 sections 5.1 Petroleum Refining, 8.13 Sulfur Recovery, and 13.5 Industrial Flares. Please submit your written comments on the proposed factors by October 19, 2014. Comments should be e-mailed to refineryfactor@epa.gov.

Table S-1. Summary of Proposed New and Revised Draft[a] Emissions Factors Developed

Emissions Unit and Pollutant	Emissions test data used: No. of test reports	Emissions test data used: No. of units [b]	Test methods	Draft AP-42 Emissions Factor	Representa-tiveness
Catalytic Reforming Unit (CRU), Total Hydrocarbon (THC)	4	4	EPA Method 25A	4.0 x 10^{-4} lb THC (as propane)/bbl feed	Poorly
Fluid Catalytic Cracking Unit (FCCU), Hydrogen Cyanide (HCN)	9	8	EPA Other Test Method-029	8.0 x 10^{-3} lb HCN/bbl feed	Moderately
Sulfur Recovery Unit (SRU), Carbon Monoxide (CO)	21	20	EPA Method 10	1.4 lb CO/ton sulfur	Moderately
Sulfur Recovery Unit, Oxides of Nitrogen (NOx)	22	23	EPA Method 7E	0.19 lb NOx/ton sulfur	Moderately
SRU, THC	5	6	EPA Method 25A	0.047 lb THC (as propane)/ ton sulfur	Poorly
Hydrogen Plant NOx	8	7	EPA Method 7E	0.081 lb NOx/MMbtu	Poorly
Flare CO	6	8	PFTIR [c]	0.34 lb CO/MMBtu	Moderately
Flare NOx	4	5	PFTIR [c]	2.9 lb NOx/MMBtu	Moderately
Flare Volatile Organic Compounds (VOC)	7	9	PFTIR; [c] DIAL [d]	0.55 lb VOC/MMBtu	Moderately

[a] Draft factors are factors that are being proposed. They are not final factors.

[b] Number of units used during emissions factor development process. This number includes outliers.

[c] PFTIR is passive Fourier Transform Infrared.

[d] DIAL is Differential infrared absorption LIDAR (light detection and ranging).

Section 2
Background

In April 2011, EPA sent an ICR under CAA section 114 authority to facilities in the Petroleum Refining industry (EPA, 2011) ("2011 Refinery ICR"). The 2011 Refinery ICR consisted of four components, and two of these components requested emissions testing data from refineries. Component 1 of the 2011 Refinery ICR requested all refineries to submit reports for emissions tests that had been conducted since 2005. Component 4 of the 2011 Refinery ICR requested that certain refineries conduct testing for specific pollutants at specific emissions sources in accordance with an EPA-approved protocol and submit the test reports to EPA. Emissions testing reports were collected for catalytic reforming units (CRUs), fluid catalytic cracking units (FCCUs), sulfur recovery units (SRUs), and hydrogen plants, along with several other emissions sources. Testing was conducted for a number of pollutants, including carbon monoxide (CO), hydrogen cyanide (HCN), oxides of nitrogen (NOx), and total hydrocarbons (THC). Emissions testing reports were analyzed for multiple emissions sources and pollutants, as shown in Table 1, for the purpose of updating or developing new emissions factors in AP-42. In general, this project focused on the pollutants required under section 130 of the CAA (CO, NOx, and VOC[1]), and those emissions units and pollutants for which there are no current AP-42 emissions factors (EPA 1995). For hazardous air pollutants (HAPs), we focused on HCN from catalytic cracking units because that emissions unit is often the largest emissions source at the refinery and HCN is a risk driver for the petroleum refinery source category (EPA 2014).

Test data for the operating parameters and emissions from flares at petroleum refineries and chemical plants are available as a result of various enforcement actions related to flare performance issues. The EPA collected additional flare data during development of an analysis of proper flare operating conditions (EPA 2012). Flare data are available for CO, NOx, and VOC, as shown in Table 2.

This report documents the review and analysis of the available source test reports from the 2011 Refinery ICR for the emissions sources/pollutants identified in Table 1 and from flare studies for the pollutants identified in Table 2.

The background files for the AP-42 sections being proposed for revision contain the information discussed in this document, including the data summary worksheets, the emissions factor creation worksheets, the Individual Test Rating (ITR) score sheets, and test reports that were reviewed but not used in the calculation of the draft[2] emissions factor. A link to the background files can be found under the section's heading on the AP-42 website (http://www.epa.gov/ttn/chief/ap42/index.html, see sections 5.1 Petroleum Refining, 8.13 Sulfur Recovery, and 13.5 Industrial Flares). The test reports that were used in the development of the

[1] We also focused on THC as a surrogate for VOC.

[2] Draft factors are factors that are being proposed. They are not final factors.

draft emissions factors are listed as references in the AP-42 sections being proposed for revision. These references can be accessed by clicking the reference's name in the draft AP-42 section.

Table 1. Emissions Sources and Pollutants with Emissions Test Report Data Reviewed [a]

Emissions source	Pollutant	No. Component 1 emissions test reports	No. Component 4 emissions test reports	Total number of emissions test reports
Catalytic Reforming Units (CRUs)	CO	5	3	8
	THC	13	1	14
Fluid Catalytic Cracking Units (FCCUs)	HCN	12	10	22
Sulfur Recovery Units (SRUs)	CO	45	5	50
	NOx	40	1	41
	THC	17	6	23
Hydrogen Plants	CO	5	3	8
	NOx	11	3	14
	THC	13	2	15
Total emissions test reports reviewed				195

[a] This table provides the total number of test reports (and not necessarily the number of emissions units). Each test report may have test data for 1 or more emissions unit(s), and in some instances, an emissions unit may have more than 1 test report.

Table 2. Flare Pollutants and Emissions Test Report Data Reviewed [a]

Emissions source	Pollutant	No. emissions test reports
Flares	CO	6
	NOx	4
	VOC	7
Total emissions test reports reviewed		7

[a] This table provides the total number of test reports (and not necessarily the number of emissions units). Each test report may have test data for 1 or more emissions unit(s).

2.1 Overview of Emissions Test Data Review

The facility and emissions information for each test report was compiled in a test data summary worksheet called "Test_Data_Sum_(pollutant)_(emissionssource)". The data fields included in the Test Data Summary file are provided in Appendix A. The Test Data Summary file includes the field "QA Notes" in column DA that summarizes what data are available in the test report and any potential issues with the data. The field "Looked at for EF?" identifies which emissions factor the test report was reviewed for and the field "Used for EF?" identifies whether the test report was included in emissions factor development.

To develop an emissions factor, two basic test data requirements need to be included in the report: (1) pounds per hour (lb/hr) emissions rate, or enough data to calculate the lb/hr emissions rate, and (2) process hourly production or process rate (process activity/hr), e.g., feed rate in barrels per hour (bbl/hr), coke burn rate in lb/hr, or production rate in tons per hour (ton/hr) or standard cubic feet per hour (scf/hr). Each test report was reviewed to confirm whether the critical fields were available, and the calculations in the test report were reviewed for accuracy.

For each emissions test report used in developing the emissions factor (i.e., "Yes" response for field "Use in EF?"), an individual test rating (ITR) score was given to the test report by completing the "Test Quality Rating Tool" tab in the EPA's WebFIRE Template and Test Quality Rating Tool (including instructions) spreadsheet (available on the ERT website at: http://www.epa.gov/ttnchie1/ert/). The "Test Quality Rating Tool" template for the ITR is provided in Appendix B. The ITR is a quantitative measure of the quality of the data contained within a test report. The ITR score may range from 0 to 100 and gives a general indication of the level and quality of documentation available in the test report and the level of conformance with the test method requirements. The "Test Quality Rating Tool" includes a series of questions related to "Supporting Documentation Provided" (columns A and B) and related to "Regulatory Agency Review" (columns G and H). Generally, the "Supporting Documentation Provided" columns are an indication of the completeness of the test report while the Regulatory Agency Review" columns provide an indication of whether the test was conducted according to the requirements of the test method. Columns A and B of the template worksheet were completed in this analysis. Columns G and H, which are specific to State/Local agency reviewers, were not completed.

Because only the "Supporting Documentation Provided" portion of the worksheet was completed, ITR scores for the test reports in the analysis range from approximately 31 to 65. For the "Supporting Documentation Provided" portion, the ITR includes 8 general questions, 8 questions for manual test methods, and 10 questions for instrumental test methods. Examples of the general questions include whether the testing firm described deviations from the test method or provided a statement that deviations were not required; whether a full description of the process and unit tested was provided; and whether an assessment of the validity, representativeness, achievement of data quality objectives and usability of the data was provided. For manual test methods, examples of questions include whether the Method 1 sample point evaluation was included in the test report; whether cyclonic flow checks were included in the report; and whether a complete laboratory report and flow diagram of sample analysis was included. For instrumental test methods, example questions include whether a complete description of the sampling system was provided; whether the response time tests were provided; whether the calibration error tests were included; and whether the drift tests were included. The ITR scores for the test reports reviewed are provided in a spreadsheet called "Webfire-template_(pollutant)_(emissionssource)".

2.2 Overview of Emissions Factor Analysis and Development

The emissions factor development approach followed EPA's *Recommended Procedures for Development of Emissions Factors and Use of the WebFIRE Database* (EPA, 2013). The emissions factor analysis for each draft emissions factor is provided in the spreadsheet "EF_Creation__(pollutant)_(emissionssource).xlsm". The recommended procedures in the 2013 guidelines were followed implicitly, including the handling of below detection limit (BDL) test data, assigning an ITR score for those test reports that are used in the emissions factor analysis, recommended statistical procedures for determining whether data sets are part of the same data population, statistical procedures for determining whether any data points are outliers (i.e., outlier checks), and determining whether data for a particular emissions unit should be included in the emissions factor. This last step, determining whether to include data from each unit, involves comparison of the Factor Quality Index (FQI) for different emissions units. The FQI is an indicator of the emissions factor's ability to estimate emissions for the entire national population, and it is related to both the ITR score and the number of units in the data set. Once the statistical procedures are complete, the data set is ranked by ITR score (high to low), and a FQI is developed for each unit in the candidate set. The FQI should decrease with each emissions unit. When the FQI increases, only average test values above the point where the FQI increases are considered in factor development.

EPA's Emissions Factor Creation spreadsheet combines the emissions data from multiple test reports conducted on a single emissions unit, so that each emissions unit is equally weighted with other units. Because the EPA's recommended emissions factor development procedures are based on the premise that more test data values are preferred over fewer test data values, the scope of this project was limited to data sets containing test averages from at least 3 different emissions units. Additionally, there are times when it is necessary to subcategorize the emissions factor data from particular units because the emissions are dissimilar. The recommended emissions factor development procedures include a statistical procedure for determining whether emissions data are from the same data population, to indicate whether emissions data should be subcategorized based on a characteristic of the emissions unit (e.g., type of APCD). This analysis requires 3 more emissions units from each potential subcategory.

Some of the data from instrumental test methods (e.g. Method 7E, Method 10, etc.) included test run averages reported as a negative value. The 2013 recommended procedures for emissions factor development do not specify how this data should be handled. Because the procedures are silent and it is not possible for emissions rates to be negative, this data has been excluded from emissions factor development in this project.

Section 3
Emissions Factor Development from Test Data Collected Under the 2011 Refinery ICR

EPA has reviewed emissions test data submitted by refineries for the 2011 Refinery ICR. The emissions data review and the draft emissions factor development for each emissions unit and pollutant are described below.

3.1 Catalytic Reforming Units - CO

The available emissions test data from the 2011 Refinery ICR included multiple test reports for CO from catalytic reforming units (CRU). Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score.

Based on the emissions test report review and analysis, 2 emissions test reports for 2 emissions units had useable data and were available for inclusion in development of an emissions factor; these units had reformer charge rate data as the available production data. These useable emissions test reports are provided in Table 3. In addition, another 2 emissions test reports for 2 emissions units had useable data, with coke burn rate data as the available production data. These useable test reports are also provided in Table 3. A complete list of the available test report information is provided in worksheet “Test_Data_Sum_CO_CRU_2014Aug.xlsm”. For more detail on the analysis and QA conducted, see the field “QA Notes” for each test report. The emissions data (lb CO/hr) in these test reports are based on measurements taken with EPA Method 10 (M10), and the test reports included production rate data for the CRU in bbl/hr feed rate or lb/hr coke burn rate.

Certain test reports were excluded from the emissions factor analysis because production rate data are not available.

Overall, 4 test reports have useable data. Two emissions test reports include data on a reformer charge rate basis while the other 2 emissions test reports include data on a coke burn rate basis. These production data bases are not in comparable units, and there is no way to calculate the production rate data on the same basis, so these test reports could not be combined for emissions factor development. Because the scope of this project is limited to data sets containing test averages from at least 3 emissions units and because there are only 2 emissions units with useable test reports in each of the different production rate categories, an emissions factor was not developed for CRU CO.

Table 3. Analysis of Emissions Test Reports for CO from CRUs

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test result	ITR
Production Data as Reformer Charge Rate, bbl/hr						
MS3C0740	Chevron Refinery, Pascagoula, Mississippi	EPN CH-004	Chlorsorb	M10	4.5×10^{-6} lb CO/bbl feed	46
OK2C0990	TPI Refining Company Ardmore Petroleum Refinery Ardmore, Oklahoma	CRU400B	Venturi Scrubber	M10	9.8×10^{-5} lb CO/bbl feed	48
Production Data as Coke Burn Rate, lb/hr						
OK2C0990	TPI Refining Company Ardmore Petroleum Refinery Ardmore, Oklahoma	CRU400B	Venturi Scrubber	M10	2.9×10^{-3} lb CO/lb Coke burn	48
TX3B1170	Exxonmobil Beaumont Refinery, Beaumont, Texas	PTR-4 Reactor Regenerator vent	Caustic Scrubber	M10	2.5×10^{-3} lb CO/lb Coke burn	38

3.2 Catalytic Reforming Units - THC

The available emissions test data from the 2011 Refinery ICR included multiple test reports for THC from CRU units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 4.

Based on the emissions test report review and analysis, 4 emissions test reports for 4 emissions units had useable data and were included in the development of the draft emissions factor. These emissions tests reports are provided in Table 5. A complete list of the available test report information is provided in worksheet “Test_Data_Sum_THC_CRU_2014Aug.xlsm”. For more detail on the analysis and QA conducted, see the field “QA Notes” for each test report. The ITR scores for these 4 test reports ranged from 33 to 41. The emissions data (lb THC, as propane/hr) in these test reports are based on measurements taken with EPA Method 25A (M25A), and the test reports included production rate data for the CRU in bbl/hr feed rate. In instances where both M25A and EPA Method 18 (M18) were conducted in the same test report, the THC data for M25A alone were extracted from the raw data in the test report appendices, so that the data from all tests was measured on the same basis.

Certain test reports were excluded from the draft emissions factor analysis for the following reasons: production rate data are not available, the test method was not compatible with THC (i.e, M18 test reports were excluded because M18 measures specific compounds where M25A counts total carbon) or the test method was not clearly identified.

EPA's recommended emissions factor development procedures were followed for the CRU THC data. All 4 emissions units were combined for the draft emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and no data were found to be outliers. The draft emissions factor is based on the emissions test data for 4 units and is characterized as Poorly Representative. The draft emissions factor analysis for CRU THC is provided in worksheet "EF Creation_THC_CRU_2014Aug.xlsm".

Table 4. Overview of the Draft Emissions Factor for THC from CRUs

Emissions test data used				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
4	4	EPA Method 25A	4.0×10^{-4} lb THC (as propane)/bbl feed	Poorly

Table 5. Analysis of Emissions Test Reports for THC from CRUs

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test result , lb THC, as propane/bbl feed	ITR
MS3C0740	Chevron Refinery, Pascagoula, Mississippi	CRU79	Chlorsorb	M25A	1.48×10^{-3}	41
OK2C0990	TPI Refining Company Ardmore Petroleum Refinery Ardmore, Oklahoma	CRU400B	Venturi Scrubber	M25A	1.4×10^{-5}	37
TX3B1250	The Premcor Refining Group, Inc., Port Arthur, Texas	CRU1344	Chlorsorb	M25A	9.0×10^{-5}	33
TX3B1310	Valero Refining – Texas, L.P., Corpus Christi, Texas	CRU	Scrubber	M25A	1.5×10^{-5}	34

3.3 Fluid Catalytic Cracking Units - HCN

The available emissions test data from the 2011 Refinery ICR included multiple test reports for HCN from FCCU units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 6.

Based on the emissions test report review and analysis, 9 emissions test reports for 8 emissions units had useable data and were included in the development of the draft emissions factor. These emissions tests reports are provided in Table 7. A complete list of the available test report information is provided in worksheet

"Test_Data_Sum_HCN_FCCU_2014Aug.xlsm". For more detail on the analysis and QA conducted, see the field "QA Notes" for each test report. The ITR scores for these 9 test reports ranged from 46 to 65. The emissions data (lb HCN/hr) in these test reports are based on measurements taken with EPA Other Test Method-029 (OTM-029) and in some instances with EPA Conditional Test Method-033 (CTM-033). Test data using CTM-033 were considered acceptable when the concentration of sodium hydroxide (NaOH) was high (6.0 N NaOH) and the pH was maintained above 12 for the duration of the test. One test report based on CTM-033 did not clearly indicate the NaOH concentration, and although the concentration used was unknown, this test was included in the analysis in order to not exclude potentially compatible data. The test reports included production rate data for the FCCU in bbl/hr feed rate.

Certain test reports were excluded from the emissions factor analysis for the following reasons: production rate data were not available or the test method was not compatible with OTM-029 (i.e., CARB Method 426 test reports and some CTM-033 test reports were excluded because the tests did not involve the use of the higher concentration NaOH solution required in OTM-029). Methods that use lower strength caustic solutions are not likely to measure the full HCN emissions.

EPA's recommended emissions factor development procedures were followed for the HCN FCCU data. For this draft emissions factor, there were two test reports with test runs that were detection level limited (DLL), meaning that the laboratory result for at least one fraction of the sample analysis was BDL. In the draft emissions factor calculations, the detection limit was substituted for sample fractions that were BDL. Although the complete burn and partial burn regenerators potentially emit different amounts of HCN, subcategories could not be formed for complete and partial burn regenerators because all of the useable data was for complete burn regenerators. Because 5 FCCUs are controlled with scrubbers and 3 FCCUs are controlled with electrostatic precipitators (ESPs) and it is uncertain what effect each type of control device has on the HCN emissions, a statistical analysis was performed to determine if these data belong to the same population. The statistical analysis showed that all of the data belong to the same data set. Also, while 2 of the FCCUs have CO boilers and 6 of the units do not have CO boilers, the purpose of the CO boiler is to convert CO to CO_2, not to control HCN. There is no data indicating that the CO_2 boiler has a significant impact on the HCN emissions. Therefore, all 8 FCCUs were combined for the draft emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and no outliers were found. The draft emissions factor is based on the emissions test data for the 8 units and is characterized as Moderately Representative. The draft emissions factor analysis for FCCU HCN is provided in worksheet "EF Creation_HCN_FCCU_2014Aug.xlsm".

Table 6. Overview of the Draft Emissions Factor HCN from Complete Burn FCCUs

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
9	8	EPA OTM-029; CTM-033	0.0080 lb HCN/bbl feed	Moderately

Table 7. Analysis of Emissions Test Reports for HCN from FCCUs

Facility ID No.	Facility name	Emissions unit [a]	APCD	Test method	Average test result, lb HCN/bbl feed	ITR
CA5A0190	ExxonMobil Torrance Refinery, in Torrance, CA	FCC [b]	ESP	EPA OTM-029	0.0031	65
LA3C0560	Citgo Petroleum Corporation, Lake Charles Manufacturing Complex, Lake Charles, LA	FCCU317	Scrubber	EPA OTM-029	0.015	60
MN2B0720	Flint Hills Resources Pine Bend, LLC Pine Bend Refinery in Rosemount, MN	FCCU228 [b]	ESP	EPA OTM-029	0.0010	56
MS3C0740 (2008 test)	Chevron Product Company Refinery, in Pascagoula, MS	FCCU1603	ESP	EPA CTM-033	0.00014	57
MS3C0740 (2007 test)	Chevron Product Company Refinery, in Pascagoula, MS	FCCU1603	ESP	EPA CTM-033	0.00011	35
NJ1A0820	Hess Corporation, Port Reading Refinery, in Port Reading, NJ	FCCU-PT1-A	Scrubber	EPA CTM-033	0.0047	57
NJ1A0860	Valero Refining Company, in Paulsboro, NJ	FCCU1	Scrubber	EPA CTM-033	0.0038	61
TX3B1250	Valero Port Arthur Refinery, in Port Arthur, TX	FCCU1241	Scrubber	EPA OTM-029	0.014	65
VI6A1530	Hovensa LLC, in Christiansted, US Virgin Islands	FCCU	Scrubber	EPA OTM-029	0.022	64

[a] All of the FCCUs with useable data are complete regeneration units.

[b] These FCCUs have CO boilers.

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3.4 Sulfur Recovery Units - CO

The available emissions test data from the 2011 Refinery ICR included multiple test reports for CO from SRU units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 8.

Based on the emissions test report review and analysis, 21 emissions test reports for 20 emissions units had useable data and were included in the development of the draft emissions factor. Several test reports provide emissions test data for SRU that share a common stack. When emissions testing is conducted on more than one SRU that share a common stack, the emissions units are counted as one "unit"; the total emissions rate is divided by the total production rate of all SRU venting to the stack when developing the units' average test results.

The emissions test reports used in the draft factor analysis are provided in Table 9. A complete list of the available test report information is provided in worksheet "Test_Data_Sum_CO_SRU_2014Aug.xlsm". For more detail on the analysis and QA conducted, see the field "QA Notes" for each test report. The ITR scores for these 21 test reports ranged from 38 to 53. The emissions data (lb CO/hr) in these test reports are based on measurements taken with EPA Method 10 (M10), and the test reports included production rate data for the SRU in ton/hr sulfur production.

Certain test reports were excluded from the draft emissions factor analysis because production rate data are not available, the concentration data for the test run average in the test report is a negative value, or the SRU did not have controls consistent with the other units (e.g., 2 SRU had no controls).

EPA's recommended emissions factor development procedures were followed for the SRU CO data. All 20 SRUs have either an incinerator or a thermal oxidizer as the control device. Both incinerators and thermal oxidizers work on the same principles of combustion, and these terms are often used interchangeably by field staff. As such, there is no reason to believe that these control devices would have differing levels of CO emissions. Therefore, all of these units were combined for emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and no data were found to be outliers. The draft emissions factor is based on the emissions test data for 20 units and is characterized as Moderately Representative. The draft emissions factor analysis for SRU CO is provided in spreadsheet "EF Creation_CO_SRU_2014Aug.xlsm".

Table 8. Overview of the Draft Emissions Factor for CO from SRUs

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
21	20	EPA Method 10	1.4 lb CO/ton sulfur	Moderately

Table 9. Analysis of Emissions Test Reports for CO from SRUs

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb CO/ton sulfur	ITR
LA3C0610	Marathon Petroleum Company LLC, Garyville, Louisiana	SRU220	Thermal oxidizer	M10	0.10	50
LA3C0610	Marathon Petroleum Company LLC, Garyville, Louisiana	SRU234	Thermal oxidizer	M10	0.21	50
LA3C0650	Valero Refining - New Orleans, LLC. St. Charles Refinery, Norco, Louisiana	SRU1600	Thermal oxidizer	M10	0.47	45
LA3C0650	Valero Refining - New Orleans, LLC. St. Charles Refinery, Norco, Louisiana	SRU30	Thermal oxidizer	M10	0.35	41
OK2C0990	Total Petroleum, Inc. Ardmore Refinery - Ardmore, Oklahoma	SRU1 (500A)	Incinerator	M10	0.038	46
OK2C0990	Total Petroleum, Inc. Ardmore Refinery - Ardmore, Oklahoma	SRU2 (560A)	Incinerator	M10	0.0061	44
TX3A1190	Delek Refining, LTD. Tyler Refinery, Tyler, Texas	SRU1/SRU2 TGI2	Incinerator	M10	0.36	38
TX3A1230	ConocoPhillips Borger Petroleum Refinery, Borger, Texas	SRU43	Incinerator	M10	0.38	46
TX3A1300 [a]	Valero McKee Refinery, Sunray, Texas	EPN V-16 [Unit 830]	Incinerator	M10	8.2	51
TX3A1300 [a]	Valero McKee Refinery, Sunray, Texas	EPN V-16 [Unit 830]	Incinerator	M10	7.1	51
TX3A1300	Valero McKee Refinery, Sunray, Texas	EPN V-5 [Unit 820]	Incinerator	M10	0.065	51
TX3B1090	Total Petrochemicals USA, Inc., Port Arthur, Texas	SRU1&2	Thermal Oxidizer	M10	2.0	46

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb CO/ton sulfur	ITR
TX3B1110	BP Products North America Inc., Texas City, Texas	SRU	Incinerator	M10	1.7	44
TX3B1140	Valero Refining - Texas, L.P. East Plant of Bill Greehey Refinery, Corpus Christi, Texas	SRU2	Incinerator	M10	0.061	49
TX3B1220	Motiva Enterprises, LLC, Port Arthur, Texas	SRU2&3 combined	Incinerator	M10	0.032	48
TX3B1240	ConocoPhillips Company, Sweeny Refinery, Old Ocean, Texas	EPN 28.2	Incinerator	M10	0.057	48
TX3B1250	Valero Port Arthur Refinery, Port Arthur, Texas	SRU543	Incinerator	M10	7.7	49
TX3B1250 (2009 test)	Valero Port Arthur Refinery, Port Arthur, Texas	SRU544	Incinerator	M10	1.4	49
TX3B1250	Valero Port Arthur Refinery, Port Arthur, Texas	SRU545	Incinerator	M10	0.42	49
TX3B1250 (2011 test)	Valero Port Arthur Refinery, Port Arthur, Texas	SRU544	Incinerator	M10	5.3	46
TX3B1310	Valero Refining, Bill Greehey Refinery - West Plant, Corpus Christi, Texas	SRU1&2Sulften	Incinerator	M10	2.6	41
TX3B1310	Valero Refining, Bill Greehey Refinery - West Plant, Corpus Christi, Texas	SRU3	Incinerator	M10	1.3	53

[a] Data is for same unit from same test report. Separate sets of test runs occurred on multiple days and were reported separately.

3.5 Sulfur Recovery Units - NOx

The available emissions test data from the 2011 Refinery ICR included multiple test reports for NOx from SRU units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 10.

Based on the emissions test report review and analysis, 22 emissions test reports for 23 emissions units had useable data and were included in the development of the draft emissions factor. Two test reports provide emissions test data for SRU that share a common stack. When emissions testing is conducted on more than one SRU that share a common stack, the emissions units are counted as one “unit”; the total emissions rate is divided by the total production rate of all SRU venting to the stack when developing the units’ average test results. The majority of the testing was conducted since 2005, although one test report is from 1996.

The emissions test reports used in the draft factor analysis are provided in Table 11. A complete list of the available test report information is provided in worksheet “Test_Data_Sum_NOx_SRU_2014Aug.xlsm”. For more detail on the analysis and QA conducted, see the field “QA Notes” for each test report. The ITR scores for these 22 test reports ranged from 38 to 56. The emissions data (lb NOx/hr) in these test reports are based on measurements taken with EPA Method 7E (M7E), and the test reports included production rate data for the SRU in ton/hr sulfur production.

Certain test reports were excluded from the draft emissions factor analysis because production rate data are not available or the SRU did not have controls consistent with the other units (e.g., 2 SRU had no controls).

EPA’s recommended emissions factor development procedures were followed for the SRU NOx data. All 23 SRU units have either an incinerator or a thermal oxidizer as the control device. Both incinerators and thermal oxidizers work on the same principles of combustion, and these terms are often used interchangeably by field staff. As such, there is no reason to believe that these control devices would have differing levels of NOx emissions. Therefore, all of these units were combined for emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and one data value was found to be an outlier and was removed from the analysis. The emissions test that was an outlier had the highest average test result in the data set. The outlier test conducted on the remaining data set showed no additional outliers. The draft emissions factor was based on the emissions test data for 22 units and is characterized as Moderately Representative. The draft emissions factor analysis for SRU NOx is provided in spreadsheet “EF Creation_NOx_SRU_2014Aug.xlsm”.

Table 10. Overview of the Draft Emissions Factor for NOx from SRUs

Emissions test data to use				
No. of test reports	No. of units	Test methods	Draft AP-42 Emissions Factor	Representativeness
22	23 [a]	EPA Method 7E	0.19 lb NOx/ton sulfur	Moderately

[a] One SRU was shown to be an outlier for the data set and was removed from the draft emissions factor analysis; the draft emissions factor is based on 22 SRUs.

Table 11. Analysis of Emissions Test Reports for NOx from SRUs

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb NOx/ton sulfur	ITR
LA3C0610	Marathon Petroleum Company LLC, Garyville, Louisiana	SRU220	Thermal Oxidizer	M7E	0.32	50
LA3C0610	Marathon Petroleum Company LLC, Garyville, Louisiana	SRU234	Thermal Oxidizer	M7E	0.24	50
LA3C0650[a]	Valero Refining - New Orleans, LLC, St. Charles Refinery, Norco, Louisiana	SRU1600	Thermal Oxidizer	M7E	0.86	48
LA3C0650	Valero Refining - New Orleans, LLC, St. Charles Refinery, Norco, Louisiana	SRU30	Thermal Oxidizer	M7E	0.13	44
OK2C0990	Total Petroleum, Inc. Ardmore Refinery - Ardmore, Oklahoma	SRU1 (500A)	Incinerator	M7E	0.13	49
OK2C0990	Total Petroleum, Inc. Ardmore Refinery - Ardmore, Oklahoma	SRU2 (560A)	Incinerator	M7E	0.30	48
TX3A1190	Delek Refining, LTD. Tyler Refinery, Tyler, Texas	SRU1/SRU2 TGI2	Incinerator	M7E	0.27	38
TX3A1230	ConocoPhillips Borger Petroleum Refinery, Borger, Hutchinson County, Texas	SRU34	Incinerator	M7E	0.32	50

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb NOx/ton sulfur	ITR
TX3A1230	ConocoPhillips Borger Petroleum Refinery, Borger, Hutchinson County, Texas	SRU43	Incinerator	M7E	0.12	50
TX3A1300	Valero McKee Refinery, Sunray, Texas	EPN V-5 [Unit 820]	Incinerator	M7E	0.27	54
TX3A1300	Valero McKee Refinery, Sunray, Texas	EPN V-16 [Unit 830]	Incinerator	M7E	0.21	54
TX3A1300[b]	Valero McKee Refinery, Sunray, Texas	EPN V-16 [Unit 830]	Incinerator	M7E	0.17	54
TX3B1090	Total Petrochemicals USA, Inc., Port Arthur, Texas	SRU1&2	Thermal Oxidizer	M7E	0.21	49
TX3B1110	BP Products North America Inc., Texas City, Texas	SRU	Incinerator	M7E	0.21	48
TX3B1140	Valero Refining - Texas, L.P. East Plant of Bill Greehey Refinery, Corpus Christi, Texas	SRU1	Incinerator	M7E	0.25	52
TX3B1140	Valero Refining - Texas, L.P. East Plant of Bill Greehey Refinery, Corpus Christi, Texas	SRU2	Incinerator	M7E	0.062	52
TX3B1220	Motiva Enterprises, LLC, Port Arthur, Texas	SRU2&3	Incinerator	M7E	0.13	52
TX3B1220	Motiva Enterprises, LLC, Port Arthur, Texas	SRU4	Incinerator	M7E	0.14	52
TX3B1240	ConocoPhillips Company, Sweeny Refinery, Old Ocean, Texas	EPN 28.2	Incinerator	M7E	0.20	45

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb NOx/ton sulfur	ITR
TX3B1250	Valero Port Arthur Refinery, Port Arthur, Texas	SRU543	Incinerator	M7E	0.085	52
TX3B1250	Valero Port Arthur Refinery, Port Arthur, Texas	SRU544	Incinerator	M7E	0.12	52
TX3B1250	Valero Port Arthur Refinery, Port Arthur, Texas	SRU545	Incinerator	M7E	0.086	52
TX3B1310	Valero Refining, Bill Greehey Refinery - West Plant, Corpus Christi, Texas	SRU1&2Sulften	Incinerator	M7E	0.093	44
TX3B1310	Valero Refining, Bill Greehey Refinery - West Plant, Corpus Christi, Texas	SRU3	Incinerator	M7E	0.22	56

[a] This emissions unit was shown to be an outlier for the data set and was removed from the draft emissions factor analysis.

[b] Data is for same unit from same test report. Separate sets of test runs occurred on multiple days and were reported separately.

3.6 Sulfur Recovery Units - THC

The available emissions test data from the 2011 Refinery ICR included multiple test reports for THC from SRU units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 12.

Based on the emissions test report review and analysis, 5 emissions test reports for 6 emissions units had useable data and were included in the development of the draft emissions factor. Two test reports provide emissions test data for SRU that share a common stack. When emissions testing is conducted on more than one SRU that share a common stack, the emissions units are counted as one “unit”; the total emissions rate is divided by the total production rate of all SRU venting to the stack when developing the units’ average test results. The majority of the testing was conducted since 2005, although one test report is from 1996.

The emissions test reports used in the draft factor analysis are provided in Table 13. A complete list of the available test report information is provided in worksheet “Test_Data_Sum_THC_SRU_2014Aug.xlsm”. For more detail on the analysis and QA conducted, see the field “QA Notes” for each test report. The ITR scores for these 5 test reports ranged from 33 to 44. The emissions data (lb THC [as propane]/hr) in these test reports are based on measurements taken with EPA Method 25A (M25A), and the test reports included production rate data for the SRU in ton/hr sulfur production.

Certain test reports were excluded from the draft emissions factor analysis because production rate data are not available or the concentration data for the test run average in the test report is a negative value.

EPA’s recommended emissions factor development procedures were followed for the SRU THC data. All 6 SRU units have either an incinerator or a thermal oxidizer as the control device. Both incinerators and thermal oxidizers work on the same principles of combustion, and these terms are often used interchangeably by field staff. As such, there is no reason to believe that these control devices would have differing levels of THC emissions. Therefore, all of these units were combined for emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and no data were found to be outliers. The draft emissions factor is based on the emissions test data for 6 units and is characterized as Poorly Representative. The draft emissions factor analysis for SRU THC is provided in spreadsheet “EF Creation_THC_SRU_2014Aug.xlsm”.

Table 12. Overview of the Draft Emissions Factor for THC from SRUs

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
5	6	EPA Method 25A	0.047 lb THC [as propane]/ton sulfur	Poorly

Table 13. Analysis of Emissions Test Reports for THC from SRUs

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb THC [as propane]/ton sulfur	ITR
LA3C0650	Valero Refining - New Orleans, LLC at St. Charles Refinery in Norco, LA	SRU1600	Thermal Oxidizer	M25A	5.9×10^{-3}	34
OK2C0990	Total Petroleum, Inc. Ardmore Refinery - Ardmore, Oklahoma	SRU500A	Incinerator	M25A	1.8×10^{-3}	37
TX3B1090	Total Petrochemicals USA, Inc. in Port Arthur, TX	SRU1&2	Thermal Oxidizer	M25A	8.2×10^{-2}	39
TX3B1110	BP Products North America Inc. in Texas City, TX	SRU	Incinerator	M25A	1.8×10^{-1}	33
TX3B1220	Motiva Enterprises, LLC in Port Arthur, TX	SRU4	Incinerator	M25A	1.2×10^{-3}	44
TX3B1250	Valero Port Arthur Refinery in Port Arthur, TX	SRU544	Incinerator	M25A	7.4×10^{-3}	37

3.7 Hydrogen Plants - CO

The available emissions test data from the 2011 Refinery ICR included multiple test reports for CO from Hydrogen Plants. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score.

Based on the emissions test report review and analysis, 3 emissions test reports for 3 emissions units had useable data and were available for inclusion in development of an emissions factor. The emissions units for which emissions data are available include 2 condensate stripper vents (prior to returning water to the site feed water system) and 1 reformer furnace. The production data for each of these emissions units are not on the same basis. Hydrogen production data in scf/hr is available for 1 of the condensate stripper vents, and production data in the form of Methane Feed Rate in scf/hr are available for the other condensate striper vent. For the reformer furnace, heat input rate is available as the process activity rate. Because these production data are not in comparable units and there is no way to calculate the production rate data on the same basis, these test reports could not be combined for emissions factor development. These useable emissions test reports are provided in Table 14. A complete list of the available test report information is provided in worksheet

"Test_Data_Sum_CO_H2P_2014Aug.xlsm". For more detail on the analysis and QA conducted, see the field "QA Notes" for each test report. The emissions data (lb CO/hr) in these test reports are based on measurements taken with EPA Method 10 (M10).

Certain test reports were excluded from the draft emissions factor analysis because production rate data are not available or the concentration data for the test run average in the test report is a negative value.

Because the scope of this project is limited to data sets containing test averages from at least 3 emissions units and there are 2 emissions units with useable test reports for the condensate stripper vent and 1 reformer furnace with useable test data, but none of these units have production rate data on the same basis, an emissions factor was not developed for CO for Hydrogen Plants.

Table 14. Analysis of Emissions Test Reports for CO from H_2 Plants

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results	ITR
Condensate stripper vent						
AR3D0110	Lion Oil Company in El Dorado, AR	Condensate stripper vent (prior to boiler water feed system)	None	M10	0.48 lb CO/MMscf H2 Production	22
NJ1A0850	ConocoPhillips Company Bayway Refinery, ConocoPhillips Company in Linden, NJ	Condensate stripper vent (prior to boiler water feed system)	None	M10	0.0011 lb CO/scf methane process feed	36
Reformer						
CO4A0340		Plant 1 Hydrogen Furnace stack	None	M10	0.00077 lb CO/MMBtu	31

3.8 Hydrogen Plants - NOx

The available emissions test data from the 2011 Refinery ICR included multiple test reports for NOx from Hydrogen Plant units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score. An overview of the draft emissions factor is provided in Table 15.

Based on the emissions test report review and analysis, 8 emissions test reports for 7 emissions units had useable data and were included in the development of the draft emissions factor. The emissions test reports used in the draft factor analysis are provided in Table 16. A complete list of the available test report information is provided in worksheet

"Test_Data_Sum_NOx_H2P_2014Aug.xlsm". For more detail on the analysis and QA conducted, see the field "QA Notes" for each test report. The ITR scores for these 8 test reports ranged from 23 to 52. The emissions data (lb NOx/hr) in these test reports are based on measurements taken with EPA Method 7E (M7E), and the test reports included activity rate data for the Hydrogen Plant in MMBtu/hr heat input.

Certain test reports were excluded from the draft emissions factor analysis because heat input data are not available or the emissions unit did not have controls consistent with the other units (e.g. 1 emissions units had ultra-low NOx burners, and 1 emissions unit had selective catalytic reductions controls).

EPA's recommended emissions factor development procedures were followed for the Hydrogen Plant NOx data. None of the 7 units have controls for NOx, and all were combined for emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and no data were found to be outliers.

One of the last steps in developing an emissions factor is a comparison of the Factor Quality Index (FQI) for different units. The FQI is an indicator of the emissions factor's ability to estimate emissions for the entire national population, and it is related to both the ITR score and the number of units in the data set. Once the statistical procedures are complete, the data set is ranked by ITR score (high to low), and a FQI is developed for each unit in the candidate set. The FQI should decrease with each emissions unit. When the FQI increases, only average test values above the point where the FQI increases should be considered in the factor development. In the development of the draft emissions factor for NOx from Hydrogen Plants, the FQI evaluation excluded one unit from the data set, so the draft emissions factor is based on the emissions test data for 6 units and is characterized as Moderately Representative. The draft emissions factor analysis for NOx from Hydrogen Plants is provided in spreadsheet "EF Creation_NOx_H2P_2014Aug.xlsm".

Table 15. Overview of the Draft Emissions Factor for NOx from Hydrogen Plants

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
8	7 [a]	EPA Method 7E	0.081 lb NOx/MMBtu	Moderately

[a] One Hydrogen Plant was excluded from the data set during the emissions factor calculation due to a low ITR score and was removed from the draft emissions factor analysis; the draft emissions factor is based on 6 Hydrogen Plants.

Table 16. Analysis of Emissions Test Reports for NOx from Hydrogen Plants

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results, lb NOx/MMBtu	ITR
AL3D0020 (2007 test) [a]	Hunt Refining, Tuscaloosa, Alabama	Reformers A, B, and C	None	M7E	0.016	23
AL3D0020 (2010 test)	Hunt Refining, Tuscaloosa, Alabama	No. 2 Hydrogen Plant Reformer - indirect heaters	None	M7E	0.016	38
IL2A0430	ConocoPhillips Company , Wood River Refinery Hydrogen Plant in Roxana, Illinois	Hydrogen Plant 1	None	M7E	0.041	45
MT4A0790	ExxonMobil Billings Refinery, Billings, Montana	F-551 Hydrogen Plant Process Heater/Furnace	None	M7E	0.17	45
OH2A0910	BP Husky Refining LLC, Toledo, OH	Hydrogen Furnace	None	M7E	0.090	52
MT4A0800 (2008 test)	Montana Refining Company, Great Falls, Montana	Hydrogen Plant Reformer Heater H1810	None	M7E	0.11	51
CO4A0340	Suncor Energy Inc. Commerce City Refinery, Commerce City, Colorado	H-2101	None	M7E	0.052	31

[a] This facility was excluded from the data set during the draft emissions factor analysis.

3.9 Hydrogen Plants - THC

The available emissions test data from the 2011 Refinery ICR included multiple test reports for THC from Hydrogen Plant units. Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports included in the draft emissions factor analysis, given an ITR score.

Based on the emissions test report review and analysis, 3 emissions test reports for 3 emissions units had useable data and were available for inclusion in development of an emissions factor. The emissions units for which emissions data are available include 2 condensate stripper vents (prior to returning water to the site feed water system) and 1 reformer furnace. The production data for each of these emissions units are not on the same basis. Hydrogen production data in scf/hr is available for 1 of the condensate stripper vents, and production data in the form of Methane Feed Rate in scf/hr are available for the other condensate striper vent. For the reformer furnace, heat input rate is available as the process activity rate. Because these production data are not in comparable units and there is no way to calculate the production rate data on the same basis, these test reports could not be combined for emissions factor development. These useable emissions test reports are provided in Table 17. A complete list of the available test report information is provided in worksheet "Test_Data_Sum_THC_H2Plants_2014Aug.xlsm". For more detail on the analysis and QA conducted, see the field "QA Notes" for each test report. The emissions data (lb THC [as propane]/hr) in these test reports are based on measurements taken with EPA Method 25A (M25A).

Certain test reports were excluded from the emissions factor analysis for the following reasons: production rate data were not available or the test method was not compatible with THC measurements taken with M25A (i.e., M18 test reports and SCAQMD M25.3 test reports were excluded because these methods measure specific compounds where M25A counts total carbon).

Because the scope of this project is limited to data sets containing test averages from at least 3 emissions units and because there are 2 emissions units with useable test reports for the condensate stripper vent and 1 reformer furnace with useable test data, but none of these units have production rate data on the same basis, **a**n emissions factor was not developed for THC from Hydrogen Plants.

Table 17. Analysis of Emissions Test Reports for THC from Hydrogen Plants

Facility ID No.	Facility name	Emissions unit	APCD	Test method	Average test results	ITR
Condensate stripper vent						
AR3D0110	Lion Oil Company, El Dorado, AR	Condensate stripper vent (prior to boiler water feed system)	None	M25A	1.1 lb THC [as propane]/MMscf H_2 product	13
NJ1A0850	ConocoPhillips Company Bayway Refinery, ConocoPhillips Company, Linden, NJ	Condensate stripper vent (prior to boiler water feed system)	None	M25A	0.0035 lb THC [as propane]/scf methane process feed	36
Reformer						
AL3D0020	Hunt Refining in Tuscaloosa, AL	Reformer	None	M25A	0.00046 lb THC/MMBtu	15

Section 4
Discussion of Proposed Revisions to SO_2 Emissions Factors in AP-42 Section 8.13, Sulfur Recovery

In addition to adding new emissions factors for sulfur recovery plants, as described in sections 3.4, 3.5, and 3.6 for CO, NOx, and THC, respectively, revisions are being proposed to the SO_2 emissions factors presented in the 1993 version of Table 8.13-1 in Section 8.13 of AP-42. The current emissions factors were based on assumed average sulfur recovery efficiencies instead of on a statistical evaluation of measured emissions data. While this approach is technically sound, the current emissions factors do not appear to be consistent with current sulfur recovery plant performance data because mid-range values were used rather than developing a more statistically-based approach. The background document for AP-42 section 8.13[3] presents test data for 16 sulfur recovery plants. Nine of the 16 plants had SO_2 emissions of approximately 2 kg/Mg sulfur produced, but the smallest emissions factor in the 1993 version of Table 8.13-1 was 29 kg/Mg. The footnotes to Table 8.13-1 indicated that test data for 2-staged "controlled" units showed 98.3 to 98.8 percent sulfur recovery and that 3-staged "controlled" units showed 95 to 99.9 percent sulfur recovery; using the mid-range value, the 2-staged controlled units have the lowest emissions factor (29 kg/Mg versus 65 kg/Mg). From review of the background document, it is unclear how these ranges were determined unless incineration was considered an SO_2 control (in which case all units tested had "controls"). The data presented in the background document show that the highest average run data for a sulfur recovery plant with a tailgas cleanup units was 7.8 kg/Mg, so that the lowest "controlled" emissions factor in Table 8.13-1 is roughly 4 times the highest emissions results from a Claus unit with tailgas cleanup. Thus, the "controlled" emissions factors in Table 8.13-1 do not appear to be representative of the Claus sulfur recovery plants with tail gas clean-up.

Due to the issues identified with the current version of Table 8.13-1, revisions are being proposed to the table to more accurately present emissions factors for different types of sulfur recovery plants based on specific SCC codes, which include the expected sulfur recovery efficiencies for those sulfur recovery plants. Revisions are also being proposed for the discussion of tailgas "controls" to more clearly distinguish between tailgas cleanup units, which enhance sulfur recovery efficiencies, and incineration, which merely converts reduced sulfur compounds to SO_2.

The proposed revisions to the emissions factors in Table 8.13-1 are still based on a mass balance approach assuming that all sulfur not recovered is emitted as SO_2. The emissions factors in Table 8.13-1 are applicable to sulfur recovery plants that are followed by a thermal oxidizer, incinerator, or other oxidative control system in which hydrogen sulfide or other reduced sulfur compounds in the tailgas can be converted to SO_2 prior to atmospheric release. Revisions are being proposed to the Title of Table 8.13-1 to clarify this applicability. The proposed title for

[3] The 1993 background document for sulfur recovery is entitled "Background Report, AP-42 Section 5.18, Sulfur Recovery." With the publication of the Fifth Edition of AP-42, the Chapter and Section number for Sulfur Recovery changed to 8.13.

Table 8.13-1 is "SO_2 EMISSION FACTORS FOR CLAUS SULFUR RECOVERY PLANTS WITH OXIDATIVE CONTROL SYSTEMS."

Additionally, Table 8.13-1 does not currently provide applicable SCC codes for the sulfur recovery plants described in the table, and the footnote showing the calculation of the emissions factor is incorrectly presented. Therefore, the proposed version of Section 8.13 is updated to specify applicable SCC codes and to correct the footnote equations in Table 8.13-1.

DRAFT

Section 5
Emissions Factor Development from Test Data Collected During the Development of Parameters for Properly Designed and Operated Flares

EPA has reviewed the emissions test data in multiple recent flare studies. Several of these test reports are based on studies that resulted from various enforcement actions related to flare performance issues. The EPA collected additional flare data during development of an analysis of proper flare operating conditions (EPA 2012). The emissions data review and the draft emissions factor development for each pollutant is described below.

5.1 Flares - CO

The available emissions test data included multiple test reports for CO from flares. [Additional discussion of these test reports is included in EPA's Review of Available Documents Report (EPA, 2014b).] Each of the available test reports was reviewed, analyzed, and summarized, and given an ITR score. An overview of the draft emissions factor is provided in Table 18.

Based on the emissions test report review and analysis, 6 emissions test reports for 8 flares had useable data and were included in the development of the draft emissions factor. The flares tested include 7 steam-assisted flares and one air-assisted flare. The test data are based on the measurement principle of passive Fourier Transform infrared (PFTIR). The emissions data for flares consisted of 1-minute CO concentration-pathlength data for approximately 10 to 15 test runs for each flare. Each test run was approximately 15 to 20 minutes in duration.

The mass emissions of CO were calculated using a carbon balance as follows:

$$E_{CO} = C\_inlet \times \frac{[CO]}{[CO_2]} \times CE \times \frac{28}{12}$$

Where:

E_{CO} = emissions rate of carbon monoxide (lbs/hr).

C_inlet= mass flow of carbon in the flare vent gas sent to the flare (lb/hr).

[CO] = PFTIR measured CO concentration (ppm-m).

$[CO_2]$ = PFTIR measured CO_2 concentration (ppm-m).

CE = Measured flare combustion efficiency

28 = molecular weight of carbon monoxide (lb/lb-mole).

12 = molecular weight of carbon (lb/lb-mole).

C_inlet was determined based on the standard flow rate of the vent gas and the carbon constituents of the vent gas. C_inlet was calculated as follows:

$$\text{C\_inlet} = Q_{fg} \times \frac{12}{MVC} \times \sum_{x=1}^{y} \left(MF_x \times CMN_x \right)$$

Where:

C_inlet = mass flow of carbon in the flare vent gas sent to the flare (lb/hr).

Q_{fg} = volumetric flow rate of flare gas (standard cubic feet per hour; scf/hr).

12 = molecular weight of carbon (lb/lb-mole).

MVC = molar volume correction factor (scf/lb-mole) = 385.5 scf/lb-mole.

MF_x = mole fraction of compound "x" in the flare vent gas (unitless)

CMN_x = Carbon mole number of compound "x" in the flare vent gas (mole carbon atoms per mole compound). E.g., CMN for ethane (C_2H_6) is 2; CMN for propane (C_3H_8) is 3.

12 = molecular weight of carbon (lb/lb-mole).

Because the flare testing was conducted to help identify conditions where flare performance deteriorates, there were many test runs conducted at operating conditions that resulted in poor flare combustion efficiencies. These operating conditions are not representative of normal flare performance. Properly operated flares achieve at least 98 percent destruction efficiency in the flare plume. The one-minute data were reviewed to determine if the combustion efficiency was less than 96.5 percent (considered to be equivalent to a destruction efficiency of 98 percent) (EPA, 2014b). Any data that did not meet this combustion efficiency was excluded from the analysis. Additionally, any data from one-minute periods where the CO_2 concentration could not be measured or the CO_2 concentration was reported as zero were excluded from the analysis because the CO mass emissions could not be calculated for that minute. For steam-assisted flares, periods of time when there was no steam flow to the flare were eliminated because this would not be representative of normal operations. All data for a given flare with measurable one-minute CO_2 concentrations, steam flow (for steam-assisted flares) and acceptable combustion efficiencies were used to calculate an average emissions value (in CO mass per heat input of vent gas) for the flare.

Some test reports included multiple values for CO_2 measurements. These measurements represent the CO_2 values determined by the PFTIR operator at up to three different wavelengths. Conversations with the PFTIR operator indicated that one of the CO_2 wavelength measurements (generally labeled 1k) is not as reliable as the other two wavelength measurements (generally labeled 765 and 2k). If data were available for either 765 or 2k, the 1k CO_2 measurements were discarded from consideration. If data were not available for either 765 or 2k, the 1k CO_2 measurements were used in the emissions calculations. Because the 765 and 2k measurement values should be fairly close to each other, if data were available for both 765 and 2k these two measurements were generally averaged. But at times, the measurement for either 765 or 2k (but not always the same one) would drop to zero or near to zero. To remove these readings in order not to artificially decrease the value of CO_2 used in the emissions calculations, the CO_2 measured value at 765 was compared to the FTIR's calculated CO_2 error at 765 and the CO_2 measured value at 2k was compared to the FTIR's calculated CO_2 error at 2k. If the measured value for 765 or 2k dropped below the corresponding instrument error, the value at that wavelength was removed from the average CO_2 value for that minute of data and only the value that remained above the FTIR's calculated CO_2 error was used in the emissions calculations.

The emissions test reports used in the factor analysis are provided in Table 19. The available data from each test report included in the draft emissions factor analysis is provided in worksheet "Flare Calculation.xlsx". The ITR scores for these 7 test reports ranged from 38 to 52. The emissions data (ppm-m CO) in these test reports are based on measurements taken with passive FTIR and the activity rate data in the test reports included flare vent gas flow rates and compositions, from which C_inlet (lb C/hr) and the net heat input (MMBtu/hr) to the flare could be calculated.

EPA's recommended emissions factor development procedures include guidelines for the inclusion of previous emissions data when existing emissions factors are revised. The existing data should be included alongside the new data prior to running any statistical tests. The ITR score for the existing data is based on the letter-rating of the data. There is a current AP-42 emissions factor for CO emissions from flares (see AP-42 section 13.5), and so the draft emissions factor analysis includes the existing CO emissions data. Per the EPA's recommended emissions factor development procedures, since the current factor is B-rated, an ITR score of 80 was assigned to the existing data.

EPA's recommended emissions factor development procedures were followed for the flare CO data. Potential subcategories were considered for the flare emissions data based on the type of flare and based on the heat input value to the flare. With respect to flare type, because there are 7 steam-assisted flares and only 1 air-assisted flare and the statistical analysis for determining whether the data are part of the same population requires at least 3 emissions units in each category, the statistical analysis for subcategorization could not be performed. However, since the current AP-42 emissions factors are based on emissions from both air-assisted and steam-assisted flares, it is appropriate to combine the emissions from both types of flares for this draft analysis as well. Subcategorization based on heat input was considered because some states recommend separate emissions factors for flares with net heat input values above 1,000 Btu/scf. However, there were less than 3 flares with test data that included heat input values above 1,000 Btu/scf, so the analysis could not be performed. Furthermore, because the current AP-42 emissions factors do not distinguish between flares with different heat input values, the data from all available flares was combined, regardless of vent gas heating value, for this draft analysis. All 8 units from flare test reports under the current analysis were combined for emissions factor development, along with the existing flare emissions data in AP-42. The statistical analysis for determining outliers in the data set was conducted, and one emissions unit was shown to be an outlier. The CO emissions were significantly higher for the outlier, by two orders of magnitude, than the other test values in the data set. After removing the outlier emissions unit from the data set, the outlier statistical analysis conducted on the remaining data showed no additional outliers. The draft emissions factor is based on the current flare CO emissions factor in AP-42 and the emissions test data for 7 additional units and is characterized as Moderately Representative. The spreadsheet "EF Creation_CO_flare_2014Aug.xlsm" provides the analysis for the draft emissions factor for CO emissions from flares.

Table 18. Overview of the Draft Emissions Factor for CO from Flares

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Draft AP-42 Emissions Factor**	**Representativeness**
6	8 [a]	(Measurement technique is Passive FTIR)	0.34 lb CO/MMBtu	Moderately

[a] One flare was an outlier for the data set and was removed from the draft emissions factor analysis. The draft flare CO emissions factor is based on 7 emissions units plus the current flare CO emissions factor in AP-42.

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Table 19. Analysis of Emissions Test Reports for CO from Flares

Facility ID No.	Facility name	Emissions unit	Test method	Average test results, lb CO/MMBtu	ITR
FHR	FHRAU Flint Hills Resources Port Arthur, LLC in Port Arthur, TX	Flare AU (steam-assisted)	PFTIR	0.23	38
FHR	FHRLOU Flint Hills Resources Port Arthur, LLC in Port Arthur, TX	Flare LOU (steam-assisted)	PFTIR	0.15	38
MI2A0710	MPCDET Marathon Petroleum Company, LLC, Detroit, MI	Flare CP (steam-assisted)	PFTIR	0.27	51
TX3B1210 [a]	MPCTX Marathon Petroleum Company, LLC, Texas Refining Division in Texas City, TX	Flare Main (steam-assisted)	PFTIR	88	51
INEOS	INEOS INEOS ABS Corporation in Addyston, OH	Flare P001 (steam-assisted)	PFTIR	0.28	38
TX3B1260	SHELL Shell Deer Park Refinery in Deer Park, TX	Flare EP (steam-assisted)	PFTIR	0.58	41
NA	TCEQ testing conducted at John Zink facility	Flare (steam-assisted)	PFTIR	0.31	52
NA	TCEQ testing conducted at John Zink facility	Flare (air-assisted)	PFTIR	0.37	52
NA	Existing AP-42 CO emissions factor for flares (OLD)	Flare	PFTIR	0.37	80

[a] This Flare unit was shown to be an outlier for the data set and was removed from the emissions factor analysis.

5.2 Flares - NOx

The available emissions test data included multiple test reports for NOx from flares. [Additional discussion of these test reports is included in EPA's Review of Available Documents Report (EPA, 2014b).] Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports that are to be included in the emissions factor analysis, given an ITR score. An overview of the emissions factor is provided in Table 20.

Based on the emissions test report review and analysis, 4 emissions test reports for 5 flares had useable data and were included in the development of the emissions factor. The flares tested include 4 steam-assisted flares and one air-assisted flare. The emissions data for flares consisted of 1-minute NOx concentration-pathlength data for approximately 10 to 15 test runs for each flare. Each test run was approximately 15 to 20 minutes in duration.

The mass emissions of NOx were calculated as follows:

$$E_{NOx} = C\_inlet \times \frac{[NO] \times 30 + [NO_2] \times 46}{[CO_2] \times 12} \times CE$$

Where:

E_{NOx}	=	emissions rate of nitrogen oxides (lbs/hr).
C_inlet	=	mass flow of carbon in the flare vent gas sent to the flare (lb/hr).
[NO]	=	PFTIR measured NO concentration (ppm-m).
$[NO_2]$	=	PFTIR measured NO_2 concentration (ppm-m).
30	=	molecular weight of NO (lb/lb-mole).
46	=	molecular weight of NO_2 (lb/lb-mole).
$[CO_2]$	=	FTIR measured CO_2 concentration (ppm-m).
12	=	molecular weight of carbon (lb/lb-mole).
CE	=	Measured flare combustion efficiency

C_inlet was determined based on the standard flow rate of the vent gas and the carbon constituents of the vent gas. C_inlet was calculated as follows:

$$C\_inlet = Q_{fg} \times \frac{12}{MVC} \times \sum_{x=1}^{y} \left(MF_x \times CMN_x \right)$$

Where:

C_inlet	=	mass flow of carbon in the flare vent gas sent to the flare (lb/hr).
Q_{fg}	=	volumetric flow rate of flare gas (standard cubic feet per hour; scf/hr).
12	=	molecular weight of carbon (lb/lb-mole).
MVC	=	molar volume correction factor (scf/lb-mole) = 385.5 scf/lb-mole.
MF_x	=	mole fraction of compound “x” in the flare vent gas (unitless)
CMN_x	=	Carbon mole number of compound “x” in the flare vent gas (mole carbon atoms per mole compound). E.g., CMN for ethane (C_2H_6) is 2; CMN for propane (C_3H_8) is 3.

12 = molecular weight of carbon (lb/lb-mole).

Because the flare testing was conducted to help identify conditions where flare performance deteriorated, many of the test runs were conducted at operating conditions that resulted in poor flare combustion efficiencies. These operating conditions are not representative of normal flare performance. Properly operated flares achieve at least 98 percent destruction efficiency in the flare plume. The one-minute data were reviewed to determine if the combustion efficiency was less than of 96.5 percent (considered to be equivalent to a destruction efficiency of 98 percent). Any data that did not meet this combustion efficiency was excluded from the analysis. Additionally, any data from one-minute periods where CO_2 concentration could not be measured or the CO_2 concentration was reported as zero were excluded from the analysis because the NOx mass emissions could not be calculated for that minute. For steam-assisted flares, periods of time when there was no steam flow to the flare was eliminated because this would not be representative of normal operations. All data for a given flare with measurable one-minute CO_2 concentrations, steam flow (for steam-assisted flares) and acceptable combustion efficiencies were used to calculate an average emissions value (in NOx mass per heat input of vent gas) for the flare.

Some test reports included multiple values for CO_2 measurements. These measurements represent the CO_2 values determined by the PFTIR operator at up to three different wavelengths. Conversations with the PFTIR operator indicated that one of the CO_2 wavelength measurements (generally labeled 1k) is not as reliable as the other two wavelength measurements (generally labeled 765 and 2k). If data were available for either 765 or 2k, the 1k CO_2 measurements were discarded from consideration. If data were not available for either 765 or 2k, the 1k CO_2 measurements were used in the emissions calculations. Because the 765 and 2k measurement values should be fairly close to each other, if data were available for both 765 and 2k these two measurements were generally averaged. But at times, the measurement for either 765 or 2k (but not always the same one) would drop to zero or near to zero. To remove these readings in order not to artificially decrease the value of CO_2 used in the emissions calculations, the CO_2 measured value at 765 was compared to the FTIR's calculated CO_2 error at 765 and the CO_2 measured value at 2k was compared to the FTIR's calculated CO_2 error at 2k. If the measured value for 765 or 2k dropped below the corresponding instrument error, the value at that wavelength was removed from the average CO_2 value for that minute of data and only the value that remained above the FTIR's calculated CO_2 error was used in the emissions calculations.

The emissions test reports used in the factor analysis are provided in Table 21. The available data from each test report included in the draft emissions factor analysis is provided in worksheet "Flare Calculation.xlsx". The ITR ratings for these 4 test reports ranged from 38 to 52. The emissions data (ppm-m NOx) in these test reports are based on measurements taken with passive FTIR, and the activity rate data in the test reports included flare vent gas flow rates and compositions, from which C_inlet (lb C/hr) and the net heat input (MMBtu/hr) to the flare could be calculated.

EPA's recommended emissions factor development procedures include guidelines for the inclusion of previous emissions data when existing emissions factors are revised. The existing data should be included alongside the new data prior to running any statistical tests. The ITR score for the existing data is based on the letter-rating of the data. There is a current AP-42 emissions factor for NOx emissions from flares (see AP-42 section 13.5), and so the draft emissions factor analysis includes the existing CO emissions data. Per the EPA's recommended emissions factor development procedures, since the current factor is B-rated, an ITR score of 80 was assigned to the existing data.

EPA's recommended emissions factor development procedures were followed for the flare NOx data. Potential subcategories were considered for the flare emissions data based on the type of flare and based on the heat input value to the flare. With respect to flare type, because there are 4 steam-assisted flares and only 1 air-assisted flare and the statistical analysis for determining whether the data are part of the same population requires at least 3 emissions units in each category, the statistical analysis for subcategorization could not be performed. However, since the current AP-42 emissions factors are based on emissions from both air-assisted and steam-assisted flares, it is appropriate to combine the emissions from both types of flares for this draft analysis as well. Subcategorization based on heat input was considered because some states recommend separate emissions factors for flares with net heat input values above 1,000 Btu/scf. However, there were less than 3 flares with test data that included heat input values above 1,000 Btu/scf, so the analysis could not be performed. Furthermore, because the current AP-42 emissions factors do not distinguish between flares with different heat input values, the data from all available flares was combined, regardless of vent gas heating value, for this draft analysis. All 5 units from flare test reports under the current analysis were combined for emissions factor development, along with the existing flare emissions data in AP-42. The statistical analysis for determining outliers in the data set determined that no outliers existed. The draft emissions factor is based on the current flare NOx emissions factor in AP-42 and the emissions test data for 5 additional units and is characterized as Moderately Representative. The spreadsheet "EF Creation_NOx_flare_2014Aug.xlsm" provides the analysis for the draft emissions factor for NOx emissions from flares.

Table 20. Overview of the Draft Emissions Factor for NOx from Flares

Emissions test data to use				
No. of test reports	No. of units	Test methods	Draft AP-42 Emissions Factor	Representativeness
4	5	(Measurement technique is Passive FTIR)	2.9 lb NOx/MMBtu	Moderately

Table 21. Analysis of Emissions Test Reports for NOx from Flares

Facility ID No.	Facility name	Emissions unit	Test method	Average test results, lb NOx/MMBtu	ITR
FHR	FHRAU Flint Hills Resources Port Arthur, LLC in Port Arthur, TX	Flare AU (steam-assisted)	PFTIR	16	38
MI2A0710	MPCDET Marathon Petroleum Company, LLC, Detroit, MI	Flare CP (steam-assisted)	PFTIR	0.011	51
INEOS	INEOS INEOS ABS Corporation in Addyston, OH	Flare P001 (steam-assisted)	PFTIR	0.47	38
NA	TCEQ tests conducted at John Zink facility	Flare (steam-assisted)	PFTIR	0.13	52
NA	TCEQ tests conducted at John Zink facility	Flare (air-assisted)	PFTIR	0.58	52
NA	Existing AP-42 NOx emissions factor for lares (OLD)	Flare	PFTIR	0.068	80

5.3 Flares – VOC

The available emissions test data included multiple test reports for VOC related data from flares. [Additional discussion of these test reports is included in EPA's Review of Available Documents Report (EPA, 2014b).] Each of the available test reports was reviewed, analyzed, and summarized, and for those test reports that are to be included in the emissions factor analysis, given an ITR score. An overview of the emissions factor is provided in Table 22.

Based on the emissions test report review and analysis, 7 emissions test reports for 9 flares had useable data and were included in the development of the emissions factor. The flares tested include 8 steam-assisted flares and one air-assisted flare. The PFTIR emissions data for flares consisted of 1-minute THC and individual hydrocarbon concentration-pathlength data for approximately 10 to 15 test runs for each flare. Each test run was approximately 15 to 20 minutes in duration. The DIAL data for flares consisted of multiple scans directly measuring the mass emissions of C3+ hydrocarbons. As the mass emissions of "C3+ hydrocarbons" was directly reported in the DIAL study, only the heat input to the flare had to be calculated. Data on vent gas composition and flow rate were available to perform this calculation.

The mass emissions of VOC from the PFTIR tests were calculated as follows. Any measurement data for methane and ethane were excluded from the VOC calculation:

$$E_{VOC} = C\_inlet \times \frac{\sum_{x}[HCx] \times MW_{HCx}}{[CO_2] \times 12} \times CE$$

Where:

E_{VOC} = emissions rate of volatile organic compounds (lbs/hr).

C_inlet = mass flow of carbon in the flare vent gas sent to the flare (lb/hr).

[HCx] = PFTIR measured hydrocarbon constituent "x" concentration (other than methane or ethane) (ppm-m).

MW_{HCx} = molecular weight of hydrocarbon constituent "x" (lb/lb-mole).

$[CO_2]$ = PFTIR measured CO_2 concentration (ppm-m).

12 = molecular weight of carbon (lb/lb-mole).

CE = Measured flare combustion efficiency

C_inlet was determined based on the standard flow rate of the vent gas and the carbon constituents of the vent gas. C_inlet was calculated as follows:

$$C\_inlet = Q_{fg} \times \frac{12}{MVC} \times \sum_{x=1}^{y}(MF_x \times CMN_x)$$

Where:

C_inlet= mass flow of carbon in the flare vent gas sent to the flare (lb/hr).

Q_{fg} = volumetric flow rate of flare gas (standard cubic feet per hour; scf/hr).

12 = molecular weight of carbon (lb/lb-mole).

MVC = molar volume correction factor (scf/lb-mole) = 385.5 scf/lb-mole.

MF_x = mole fraction of compound "x" in the flare vent gas (unitless)

CMN_x = Carbon mole number of compound "x" in the flare vent gas (mole carbon atoms per mole compound). E.g., CMN for ethane (C_2H_6) is 2; CMN for propane (C_3H_8) is 3.

12 = molecular weight of carbon (lb/lb-mole).

Because the flare testing was conducted to help identify conditions where flare performance deteriorated, there were many test runs conducted at operating conditions that resulted in poor flare combustion efficiencies. These operating conditions are not representative of normal flare performance. Properly operated flares achieve at least 98 percent destruction efficiency in the flare plume. The one minute data were reviewed to determine if the combustion efficiency was less than of 96.5 percent (considered to be equivalent to a destruction efficiency of 98 percent). Any data that did not meet this combustion efficiency was excluded from the analysis. Additionally, any data from one-minute periods where CO_2 concentration could not be measured or the CO_2 concentration was reported as zero were excluded from the analysis because the VOC mass emissions could not be calculated for that minute. For steam-assisted flares, periods of time when there was no steam flow to the flare were eliminated because this would not be representative of normal operations. All data for a given flare with measurable one-minute CO_2 concentrations, steam flow (for steam-assisted flares) and acceptable combustion efficiencies were used to calculate an average emissions value (in VOC mass per heat input of vent gas) for the flare.

Some test reports included multiple values for CO_2 measurements. These measurements represent the CO_2 values determined by the PFTIR operator at up to three different wavelengths. Conversations with the PFTIR operator indicated that one of the CO_2 wavelength measurements (generally labeled 1k) is not as reliable as the other two wavelength measurements (generally labeled 765 and 2k). If data were available for either 765 or 2k, the 1k CO_2 measurements were discarded from consideration. If data were not available for either 765 or 2k, the 1k CO_2 measurements were used in the emissions calculations. Because the 765 and 2k measurement values should be fairly close to each other, if data were available for both 765 and 2k these two measurements were generally averaged. But at times, the measurement for either 765 or 2k (but not always the same one) would drop to zero or near to zero. To remove these readings in order not to artificially decrease the value of CO_2 used in the emissions calculations, the CO_2 measured value at 765 was compared to the FTIR's calculated CO_2 error at 765 and the CO_2 measured value at 2k was compared to the FTIR's calculated CO_2 error at 2k. If the measured value for 765 or 2k dropped below the corresponding instrument error, the value at that wavelength was removed from the average CO_2 value for that minute of data and only the value that remained above the FTIR's calculated CO_2 error was used in the emissions calculations.

The emissions test reports used in the factor analysis are provided in Table 23. The available data from each test report included in the draft emissions factor analysis is provided in worksheet "Flare Calculation.xlsx". The ITR scores for these 7 test reports ranged from 38 to 52. The emissions data (ppm-m or lb/hr) in these test reports were based on measurements taken with passive FTIR and DIAL, and the activity rate data in the test reports which included flare vent gas flow rates and compositions, from which C_inlet (lb C/hr) and the net heat input (MMBtu/hr) to the flare could be calculated.

In the existing AP-42 section for Industrial Flares, there is an emissions factor for THC (measured as methane equivalent), but there is no current emissions factor for VOC. Even though THC is often used as a surrogate for VOC, the measurement methods for the two compounds vary. In this case, the measurements for THC and VOC are not directly comparable.

As such, there is no existing emissions factor from AP-42 included in the current emissions factor analysis.

EPA's recommended emissions factor development procedures were followed for the flare VOC data. Potential subcategories were considered for the flare emissions data based on the type of flare and based on the heat input value to the flare. With respect to flare type, because there are 8 steam-assisted flares and only 1 air-assisted flare and the statistical analysis for determining whether the data are part of the same population requires at least 3 emissions units in each category, the statistical analysis for subcategorization could not be performed. However, since the current AP-42 emissions factors are based on emissions from both air-assisted and steam-assisted flares, it is appropriate to combine the emissions from both types of flares for this draft analysis as well. Subcategorization based on heat input was considered because some states recommend separate emissions factors for flares with net heat input values above 1,000 Btu/scf. However, there were less than 3 flares with test data that included heat input values above 1,000 Btu/scf, so the analysis could not be performed. Furthermore, because the current AP-42 emissions factors do not distinguish between flares with different heat input values, the data from all available flares was combined, regardless of vent gas heating value, for this draft analysis. All 9 units from flare test reports under the current analysis were combined for emissions factor development. The statistical analysis for determining outliers in the data set was conducted, and one emissions unit was shown to be an outlier. The VOC emissions were significantly lower for the outlier, by one order of magnitude, than the other test values in the data set. After removing the outlier emissions unit for the data set, the outlier statistical analysis conducted on the remaining data showed no additional outliers. The draft emissions factor is based on the emissions test data for 8 units and is characterized as Moderately Representative. The spreadsheet "EF Creation_VOC_flare_2014Aug.xlsm." provides the analysis for the draft emissions factor for VOC emissions from flares.

Table 22. Overview of the Draft Emissions Factor for VOC from Flares

Emissions test data to use				
No. of test reports	**No. of units**	**Test methods**	**Proposed AP-42 Emissions Factor**	**Representativeness**
7	9 [a]	(Measurement technique is Passive FTIR and DIAL)	0.55 lb VOC/MMBtu	Moderately

[a] One flare was an outlier for the data set and was removed from the draft emissions factor analysis.

Table 23. Analysis of Emissions Test Reports for VOC from Flares

Facility ID No.	Facility name	Emissions unit	Test method	Average test results, lb VOC/MMBtu	ITR
FHR	FHRAU Flint Hills Resources Port Arthur, LLC in Port Arthur, TX	Flare AU (steam-assisted)	PFTIR	0.50	38
FHR	FHRLOU Flint Hills Resources Port Arthur, LLC in Port Arthur, TX	Flare LOU (steam-assisted)	PFTIR	0.95	38
MI2A0710	MPCDET Marathon Petroleum Company, LLC, Detroit, MI	Flare CP (steam-assisted)	PFTIR	0.42	51
TX3B1210 [a]	MPCTX Marathon Petroleum Company, LLC, Texas Refining Division in Texas City, TX	Flare Main (steam-assisted)	PFTIR	0.016	51
INEOS	INEOS INEOS ABS Corporation in Addyston, OH	Flare P001 (steam-assisted)	PFTIR	0.70	38
TX3B1260	SHELL Shell Deer Park Refinery in Deer Park, TX	Flare EP (steam-assisted)	PFTIR	0.53	41
NA	TCEQ testing conducted at John Zink facility	Flare (steam-assisted)	PFTIR	0.59	52
NA	TCEQ testing conducted at John Zink facility	Flare (air-assisted)	PFTIR	0.47	52
TX3B1110	BP Texas City, TX	Flare No. 6 (steam-assisted)	DIAL	0.25	40

[a] This flare was an outlier for the data set and was removed from the draft emissions factor analysis.

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Section 6
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Appendix A

EMISSIONS TEST REPORT DATA FIELDS INCLUDED IN TEST DATA SUMMARY FILES

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Appendix A. Data Fields in the Test Data Summary Files

Table column	Field name
A	Column
B	Facility ID Number
C	Unit ID Number
D	APCD ID(s)
E	Combustion controls used to reduce air pollution (from combustion sources)
F	General Description
G	Code for Process Unit Type
H	Test Report ID
I	Test Date (mm/dd/yyyy)
J	Pollutant Name
K	Pollutant CAS No.
L	Pollutant Class
M	Test Method
N	Run 1 Hourly Production Rate (value)
O	Run 2 Hourly Production Rate (value)
P	Run 3 Hourly Production Rate (value)
Q	Average Hourly Production Rate (value)
R	Hourly Production Rate (units)
S	Production comment
T	Run 1 Hourly Production Rate (value)
U	Run 2 Hourly Production Rate (value)
V	Run 3 Hourly Production Rate (value)
W	Average Hourly Production Rate (value)
X	Hourly Production Rate (units)
Y	Production comment
Z	Run 1 Airflow Rate Outlet (acfm)
AA	Run 1 Airflow Rate Outlet (scfm)
AB	Run 1 Airflow Rate Outlet (dscfm)
AC	Run 1 Gas Moisture Outlet (%)
AD	Run 1 Gas Temp Outlet (F)
AE	Run 1 Gas Pressure Outlet (in. Hg)
AF	Run 1 Gas Oxygen Outlet (%)
AG	Run 1 Gas CO2 Outlet (%)
AH	Run 2 Airflow Rate Outlet (acfm)
AI	Run 2 Airflow Rate Outlet (scfm)
AJ	Run 2 Airflow Rate Outlet (dscfm)
AK	Run 2 Gas Moisture Outlet (%)
AL	Run 2 Gas Temp Outlet (F)
AM	Run 2 Gas Pressure Outlet (in. Hg)
AN	Run 2 Gas Oxygen Outlet (%)

Table column	Field name
AO	Run 2 Gas CO2 Outlet (%)
AP	Run 3 Airflow Rate Outlet (acfm)
AQ	Run 3 Airflow Rate Outlet (scfm)
AR	Run 3 Airflow Rate Outlet (dscfm)
AS	Run 3 Gas Moisture Outlet (%)
AT	Run 3 Gas Temp Outlet (F)
AU	Run 3 Gas Pressure Outlet (in. Hg)
AV	Run 3 Gas Oxygen Outlet (%)
AW	Run 3 Gas CO2 Outlet (%)
AX	Average Airflow Rate Outlet (acfm)
AY	Average Airflow Rate Outlet (scfm)
AZ	Average Airflow Rate Outlet (dscfm)
BA	Average Gas Moisture Outlet (%)
BB	Average Gas Temp Outlet (F)
BC	Average Gas Pressure Outlet (in. Hg)
BD	Average Gas Oxygen Outlet (%)
BE	Average Gas CO2 Outlet (%)
BF	Run 1 Outlet concentration
BG	Run 1 Outlet concentration units
BH	Run 1 Outlet Detect Flag
BI	Run 1 Outlet (lb/hr)
BJ	Run 2 Outlet concentration
BK	Run 2 Outlet concentration units
BL	Run 2 Outlet Detect Flag
BM	Run 2 Outlet (lb/hr)
BN	Run 3 Outlet concentration
BO	Run 3 Outlet concentration units
BP	Run 3 Outlet Detect Flag
BQ	Run 3 Outlet (lb/hr)
BR	Average Outlet concentration
BS	Average Outlet concentration units
BT	Count Outlet Non-Detect Runs
BU	Average Outlet (lb/hr)
BV	Sampling comments
BW	Analytical comments
BX	QA Comments
BY	Other comments
DA	QA Notes
DB	RTI Reviewer initials
DC	Looked at for EF?
DD	Used in EF?
DE	SCC

Table column	Field name
DF	NEI_POLLUTANT_CODE
DG	PROCESS_DESCRIPTION
DH	CONTROL_CODE1
DI	CONTROL_CODE2
DJ	MDL
DK	FACTOR
DL	UNIT
DM	MEASURE
DN	MATERIAL
DO	ACTION
DP	FLAG
DQ	TEST_REPORT_RATING
DR	REF_ID
DS	REFERENCE_TEXT
DT	No. pages

Appendix B

EPA'S "TEST QUALITY RATING TOOL" TEMPLATE (ITR TEMPLATE)

August 2013

DRAFT

	A	B	G	H	N
1	Name of Facility where the test was performed				
2	Name of Company performing stationary source test				
3	SCC of tested unit or units				
4	Name of assessor and name of employer.				
5	Name of regulatory assessor and regulatory agency name.	NA			
6					
7	**Emissions Factor Development Quality Indicator Value Rating** 0				
8					
9					
10	**Supporting Documentation Provided**	**Response**	**Regulatory Agency Review**	**Response**	**Justification**
11	**General**				
12	As described in ASTM D7036-12 Standard Practice for Competence of Air Emission Testing Bodies, does the testing firm meet the criteria as an AETB or is the person in charge of the field team a QI for the type of testing conducted? A certificate from an independent organization (e.g., Stack Testing Accreditation Council (STAC), California Air Resources Board (CARB), National Environmental Laboratory Accreditation Program (NELAP)) or self declaration provides documentation of competence as an AETB.		As described in ASTM D7036-12 Standard Practice for Competence of Air Emission Testing Bodies, does the testing firm meet the criteria as an AETB or is the person in charge of the field team a QI for the type of testing conducted? A certificate from an independent organization (e.g., STAC, CARB, NELAP) or self declaration provides documentation of competence as an AETB.		
13			Was a representative of the regulatory agency on site during the test?		
14	Is a description and drawing of test location provided?		Is a description and drawing of test location provided?		
15	Has a description of deviations from published test methods been provided, or is there a statement that deviations were not required to obtain data representative of typical facility operation?		Is there documentation that the source or the test company sought and obtained approval for deviations from the published test method prior to conducting the test or that the tester's assertion that deviations were not required to obtain data representative of operations that are typical for the facility?		
16			Were all test method deviations acceptable?		
17	Is a full description of the process and the unit being tested (including installed controls) provided?		Is a full description of the process and the unit being tested (including installed controls) provided?		
18	Has a detailed discussion of source operating conditions, air pollution control device operations and the representativeness of measurements made during the test been provided?		Has a detailed discussion of source operating conditions, air pollution control device operations and the representativeness of measurements made during the test been provided?		
19	Were the operating parameters for the tested process unit and associated controls described and reported?		Is there documentation that the required process monitors have been calibrated and that the calibration is acceptable?		
20			Was the process capacity documented?		
21			Was the process operating within an appropriate range for the test program objectives?		
22			Were process data concurrent with testing?		
23			Were data included in the report for all parameters for which limits will be set?		
24	Is there an assessment of the validity, representativeness, achievement of DQO's and usability of the data?		Did the report discuss the representativeness of the facility operations, control device operation, and the measurements of the target pollutants, and were any changes from published test methods or process and control device monitoring protocols identified?		
25	Have field notes addressing issues that may influence data quality been provided?		Were all sampling issues handled such that data quality was not adversely affected?		
26	**Manual Test Methods**				
27	**Have the following been included in the report:**				
28	Dry gas meter (DGM) calibrations, pitot tube and nozzle inspections?		Was the DGM pre-test calibration within the criteria specified by the test method?		
29			Was the DGM post-test calibration within the criteria specified by the test method?		
30			Were thermocouple calibrations within method criteria?		
31			Was the pitot tube inspection acceptable?		
32			Were nozzle inspections acceptable?		
33			Were flow meter calibrations acceptable?		
34	Was the Method 1 sample point evaluation included in the report?		Were the appropriate number and location of sampling points used?		
35	Were the cyclonic flow checks included in the report?		Did the cyclonic flow evaluation show the presence of an acceptable average gas flow angle?		
36	Were the raw sampling data and test sheets included in the report?		Were all data required by the method recorded?		
37			Were required leak checks performed and did the checks meet method requirements?		
38			Was the required minimum sample volume collected?		
39			Did probe, filter, and impinger exit temperatures meet method criteria (as applicable)?		

	A	B	G	H	N
40			Did isokinetic sampling rates meet method criteria?		
41			Was the sampling time at each point greater than 2 minutes and the same for each point?		
42	Did the report include a description and flow diagram of the recovery procedures?		Was the recovery process consistent with the method?		
43			Were all required blanks collected in the field?		
44			Where performed, were blank corrections handled per method requirements?		
45			Were sample volumes clearly marked on the jar or measured and recorded?		
46	Was the laboratory certified/accredited to perform these analyses?		Was the laboratory certified/accredited to perform these analyses?		
47	Did the report include a complete laboratory report and flow diagram of sample analysis?		Did the laboratory note the sample volume upon receipt?		
48			If sample loss occurred, was the compensation method used documented and approved for the method?		
49			Were the physical characteristics of the samples (e.g., color, volume, integrity, pH, temperature) recorded and consistent with the method?		
50			Were sample hold times within method requirements?		
51			Does the laboratory report document the analytical procedures and techniques?		
52			Were all laboratory QA requirements documented?		
53			Were analytical standards required by the method documented?		
54			Were required laboratory duplicates within acceptable limits?		
55			Were required spike recoveries within method requirements?		
56			Were method-specified analytical blanks analyzed?		
57			If problems occurred during analysis, is there sufficient documentation to conclude that the problems did not adversely affect the sample results?		
58			Was the analytical detection limit specified in the test report?		
59			Is the reported detection limit adequate for the purposes of the test program?		
60	Were the chain-of-custody forms included in the report?		Do the chain-of-custody forms indicate acceptable management of collected samples between collection and analysis?		
61	**Instrumental Test Methods**				
62	**Have the following been included in the report:**				
63	Did the report include a complete description of the instrumental method sampling system?		Was a complete description of the sampling system provided?		
64	Did the report include calibration gas certifications?		Were calibration standards used prior to the end of the expiration date?		
65			Did calibration standards meet method criteria?		
66	Did report include interference tests?		Did interference checks meet method requirements?		
67	Were the response time tests included in the report?		Was a response time test performed?		
68	Were the calibration error tests included in the report?		Did calibration error tests meet method requirements?		
69	Did the report include drift tests?		Were drift tests performed after each run and did they meet method requirements?		
70	Did the report include system bias tests?		Did system bias checks meet method requirements?		
71	Were the converter efficiency tests included in the report?		Was the NOX converter test acceptable?		
72	Did the report include stratification checks?		Was a stratification assessment performed?		
73	Did the report include the raw data for the instrumental method?		Was the duration of each sample run within method criteria?		
74			Was an appropriate traverse performed during sample collection, or was the probe placed at an appropriate center point (if allowed by the method)?		
75			Were sample times at each point uniform and did they meet the method requirements?		
76			Were sample lines heated sufficiently to prevent potential adverse data quality issues?		
77			Was all data required by the method recorded?		
88					
89					
90					
91				Total	
92			Manual Test	0	
93			Instrumental Test	0	