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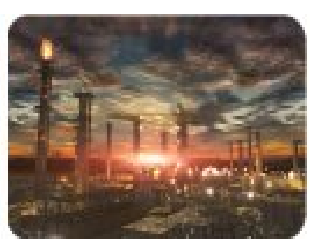
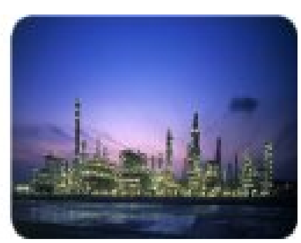
Critical Review of DIAL Emission Test Data for BP Petroleum Refinery in Texas City, Texas

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Critical Review of DIAL Emission Test Data for BP Petroleum Refinery in Texas City, Texas

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Executive Summary

In July and August 2007, the Texas Commission on Environmental Quality (TCEQ) and U.S. Environmental Protection Agency (EPA) sponsored testing of numerous "difficult to measure" emission sources at a BP petroleum refinery in Texas City, Texas, (crude capacity of 456,000 barrels per calendar day [bbl/cd]) using differential absorption LIDAR (DIAL). The testing, which was conducted by National Physical Laboratory (NPL), detected emissions of organic compounds with 3 or more carbon atoms. The units tested included numerous storage tanks storing a variety of materials, an activated sludge unit, an API separator, three flares, and a delayed coker. Throughout this report, the term "emissions" refers to C3+ compounds, unless otherwise noted. In addition, all DIAL test data presented in this report are from NPL's test report.[1]

The primary objective of the DIAL testing was to provide data for comparison with the results of emission estimation procedures that are the currently accepted means of determining emission levels for these types of sources. Units were selected for testing after considering the constraints of wind direction, unit operational status, and available scan paths at the time the test crew was onsite. Thus, the DIAL results may not be representative of all tanks and other types of tested units.

Table 1 presents the average hourly VOC emission rates calculated from the DIAL test data for each tested emission source. For storage tanks, the results are presented for groups of tanks rather than individual tanks because the DIAL testing generally could not isolate individual tanks. Table 1 also presents two sets of estimated emissions. The estimates in the first set were calculated using standard accepted estimating procedures along with actual conditions at the time of the DIAL testing. The second set of estimates presents the average hourly ozone season emission rates from BP's 2007 emission inventory report. The following key findings and conclusions can be drawn from the test results:

- For scans under similar conditions the DIAL results often varied widely, by as much as an order of magnitude for scans of the flares and some storage tanks.
- For storage tanks, the average DIAL results generally are higher than both sets of estimated emissions described above.
- The DIAL results cannot be used to assess the validity of default assumptions in the AP-42 procedures for storage tanks or how well the AP-42 procedures estimate short-term emission rates for storage tanks because it appears that the DIAL fluxes often included an unknown quantity of emissions from upwind sources, information on the composition and vapor pressure of stored material and the condition of seals and fittings is often uncertain or unavailable, and some of the scan ranges over which the DIAL fluxes were calculated are unclear.
- The DIAL results for the activated sludge unit are similar to modeled emissions when modeling is conducted using actual conditions at the time of the test.
- For two of the three flares, the DIAL results are consistent with expected control efficiencies, but the efficiency of one flare was considerably worse than expected.
- The lack of information on the steps in the coker cycle that were operating during the tests makes it difficult to assess how well the DIAL results for the coker represent total actual emissions.
- The refinery was operating at about 50 percent of capacity at the time of testing; this should not affect most of the emissions measured from a particular unit, but it complicates the comparison of measured volumes to those reported by BP in the annual inventory.

Table 1. Comparison of DIAL Results and Estimated Emissions

Source	Source Description	Compound	Average DIAL flux, lb/hr[a]	Estimated emissions using standard estimating procedures with actual conditions at the time of the DIAL test, lb/hr	2007 EIQ average ozone season emission rates, lb/hr[b]
Tanks 1020, 1021, 1024, and 1025	EFR[c] tanks storing crude oil	VOC	6.4[d]	1.3 – 1.9[e]	2.6 – 3.5[e]
Tanks 1052, 1053, and 1055	EFR tanks storing crude oil	VOC	16.3[d]	1.8 – 2.3[e]	2.4 – 2.9[e]
Tanks 501, 502, 503, and 504	EFR tanks storing light distillates	VOC	8.6[d]	3.0 – 3.9[e]	6.7 – 8.0[e]
Tank 43	VFR[f] tank storing fuel oil #6	VOC	2	1.3	0.2
			9.3	1.3	0.2
Tanks 60, 63, 11, 12, 18, 42, 61, and 65	VFR and EFR tanks storing various products	VOC	9	0.6 – 9.1[e]	4.6 – NA[e,g]
Tanks 54, 55, 56, and 98	VFR and EFR tanks storing various products	VOC	3.1[d]	0.3 – 9.7[e]	1.0 - NA[e,g]
Tanks 53 and 55	VFR tanks storing diesel fuel	VOC	23.8[d]	4.8 – 5.2[e]	1.0 – 2.0[e]
F-8 EBU	Activated sludge unit	VOC	30	22 – 55[h]	6.7
API separator	API separator	VOC	7	ND[i]	NA[g]
Wastewater vents	Vents from collection system	VOC	9	ND	NR[j]
Flare #6	Ground flare	VOC	13	17[k]	40
Temporary flare	Temporary flare	VOC	6	100 – 300[k]	196
ULC flare	Ultracracker flare	VOC	192	3 - 25[k]	28.3
Coker Unit C	Coker	VOC	18	ND	NR
Coker Unit C	Coker while cutting coke	Benzene	1.8	ND	NR

[a] The tabulated values typically represent the average of calculated fluxes for several scans.

[b] In their 2007 emissions inventory, BP reported average ozone season emissions in lb/d; these values were divided by 24 to estimate the tabulated average hourly emission rates.

[c] EFR means external fixed roof tank.

[d] The results for storage tanks typically are summarized for a group of tanks because the DIAL scans typically could not isolate individual tanks. All scans along the same path and covering the same range were grouped, and the calculated fluxes for the scans in a group were averaged. The averages for all groups of scans that apply to a group of tanks were then averaged to obtain the tabulated flux. Note that some groups of scans captured emissions from all of the listed tanks, while other groups of scans were downwind of only some of the listed tanks.

[e] Emissions were estimated for all tanks that appeared to be upwind of a group of scans, and the estimates for the individual tanks were summed. For each group of scans, the total emissions were estimated by summing the applicable individual tank emissions estimates. The upper end of the tabulated range represents the average of these sums. The lower end of the range represents the average emissions assuming only the tank(s) to which NPL attributed emissions were upwind of the scans.

[f] VFR means vertical fixed roof tank.

[g] The upper end of the range could not be determined because some of the tanks could not be found in the 2007 emissions inventory. The specific API separator of interest also could not be identified in the inventory.

[h] The low end of the range is based on pollutant properties used in modeling by BP, the measured benzene concentration, and annual average concentrations for other pollutants. The high end of the range is based on using the default pollutant properties in WATER9, the measured benzene concentration, and an assumption that all other pollutant concentrations at the time of DIAL testing were higher than average by the same percentage as benzene.

[I] ND means not determined.

[j] NR means not reported in the annual inventory.

[k] Estimated emission rates are based on assumed 98 percent destruction of C3+ hydrocarbons in flare gas at the time of DIAL testing. A range is presented for the temporary flare and ultracracker flare because the flow and composition of the flare gas varied significantly during the DIAL test period.

Findings and conclusions specific to each type of tested emission unit are summarized below.

Crude oil storage tanks. On average, the DIAL results for external floating roof tanks storing crude oil were at least 3 to 7 times higher than estimates that used conditions at the time of the DIAL testing. One factor contributing to this difference is that emissions from upwind sources such as the activated sludge unit appear to have been included in the emissions measured in some of the DIAL tests. The estimates may also have been biased low due to uncertainties regarding the composition and vapor pressure of the stored crude oil. Using the actual temperatures and windspeed during the DIAL test instead of the annual averages used in the emissions inventory have minimal effect on the estimated emissions.

Gasoline and other light distillates storage tanks. The average DIAL results for the group of external floating roof storage tanks storing gasoline and other light distillates were about 2 to 3 times higher than estimates that are based on using AP-42 procedures and conditions at the time of the DIAL testing. No one factor is the clear cause of these differences. However, flare #6 is an upwind source that may have contributed to the emissions measured in some of the DIAL tests. The DIAL results are even closer to the average emission rates reported in the 2007 emissions inventory, but this similarity may be only a coincidence due to assumptions regarding the status of fittings in the inventory calculations that have been revised since 2007.

Diesel fuel, fuel oil #6, and other product storage tanks. The average DIAL results are less than estimated emission rates for some groups of product tanks and higher for others. Both the DIAL results and the estimates are subject to a number of uncertainties that make it difficult to determine which results are more representative of actual emissions. These uncertainties include: (1) types of stored materials and their vapor pressures for some tanks, (2) range of some DIAL scans, (3) structural integrity of the fixed roofs, (4) possible upwind contributions to some calculated DIAL fluxes, and (5) unexplained variability in DIAL results for some scans.

Activated sludge unit. The DIAL results for the activated sludge unit fall within a range of modeled emissions that are based on conditions at the time of the DIAL test and a range of pollutant property data. Both the DIAL results and modeled estimates are higher than the emission rate presented in the 2007 emission inventory primarily because one of two parallel units was shutdown so that the actual flow rate to the only operating unit when the DIAL testing was conducted was more than 3 times higher than the annual average flow rate. Another difference is that the benzene concentration during the DIAL test period was about 30 percent higher than the annual average value. The modeled emissions also vary by approximately a factor of two depending on whether WATER9 modeling uses default pollutant properties in WATER9 or different values reported by BP.

API separator. The DIAL results for an API separator were significantly less than the results for the activated sludge unit. Estimated emissions for this unit could not be developed because modeling inputs such as the wastewater flow, pollutant concentrations, and unit characteristics were unavailable. The DIAL results also could not be compared with emissions in the 2007 emission inventory report because the applicable separator in the inventory report has not been identified.

Flare #6. The DIAL results for flare #6 (13 lb/hr) were very similar to the projected emission rate based on the hourly flare inlet gas flow and composition measurements and assuming a 98 percent control efficiency (17 lb/hr). The average emission rate in the emission inventory report is slightly higher (40 lb/hr). The difference between these emissions estimates is likely the result of the flare flow rate and/or hydrocarbon concentration being lower than average during the days of the DIAL testing.

Temporary flare. The DIAL results for the temporary flare (7 lb/hr) were less than both the reported emissions in the 2007 emission inventory report (196 lb/hr) and an estimate of the emissions developed using the hourly flare inlet gas flow and composition measurements and assuming a 98 percent control efficiency (205 lb/hr). The good agreement between the two estimated values suggests that BP estimated emissions assuming an efficiency of 98 percent. The DIAL results, however, suggest the actual efficiency of the temporary flare was much higher than 98 percent (approximately 99.8 percent).

<u>Ultracracker flare</u>. The average emissions from DIAL testing of the ultracracker flare were 6 times higher than the average hourly emission rate in the 2007 emission inventory report (192 lb/hr versus 31 lb/hr). Estimated emissions are even lower (3 lb/hr to 25 lb/hr) when using the actual flow and composition data during the DIAL test period and assuming a control efficiency of 98 percent. Over the three days of DIAL testing it appears the ultracracker flare efficiency was highly variable between 50 and 90 percent. Possible reasons for the low efficiency include:

- Flare gas flow rate, velocity, and hydrocarbon content at the time of DIAL testing may have been much lower than usual, resulting in inadequate mixing for complete combustion. Testing occurred at a time when the high-hydrogen overheads stream from the ultracracker unit was being vented to the temporary flare because the compressor that normally compresses this stream for recycle to the process was off-line. It is not clear if this temporary operation had any effect on the gas flow to the ultracracker flare.
- The steam addition rate may have been too high, thus quenching combustion.

<u>Coker unit C</u>. Based on the DIAL test data, the VOC emissions from coker unit C were 18 lb/hr, and the benzene emissions during the coke cutting operation were 1.8 lb/hr. These results could not be compared with estimates in the 2007 emission inventory report because it is not clear which, if any, of the inventory estimates are for operations that correspond with the operations measured by the DIAL testing.

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1. Introduction

In July and August 2007, National Physical Laboratory (NPL) conducted emissions tests for numerous "difficult to measure" emission sources at a BP petroleum refinery in Texas City, Texas, using NPL's differential absorption LIDAR (DIAL) system.[1] The testing was sponsored by and conducted for the Texas Commission on Environmental Quality (TCEQ) with funding provided by both TCEQ and the U.S. Environmental Protection Agency. The purpose of this report is to summarize the DIAL results, compare the DIAL results with estimates developed using standard accepted procedures and conditions that existed when the DIAL tests were conducted, compare the DIAL results with average ozone-season emission rates reported in BP's 2007 emissions inventory,[2] and assess why DIAL results differ from estimates.

Section 2 of this report addresses emissions from external floating roof tanks and vertical fixed roof tanks storing a variety of materials. Sections 3, 4, and 5 address emissions from wastewater sources, flares, and delayed cokers, respectively. Recommendations for future testing and references are presented in sections 6 and 7, respectively. Appendix A provides the data used with AP-42 procedures to estimate emissions from storage tanks. Appendixes B, C, and D present details of the emission estimation calculations for different groups of storage tanks. Appendix E provides modeling inputs for estimating emissions from the activated sludge unit. Appendix F contains the hourly flare gas flow rate and composition data collected by BP's process monitoring instrumentation for the three tested flares, and it presents calculated emissions assuming different control efficiencies.

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2. Storage Tank Emissions

2.1 External Floating Roof Tanks for Crude Oil

NPL conducted DIAL testing downwind of seven external floating roof tanks that stored crude oil. Table 2 summarizes the results of the DIAL testing and compares these results to emission rates that were estimated using AP-42 procedures and to average ozone season emission rates presented in BP's 2007 emissions inventory. The comparisons generally apply to groups of tanks rather than individual tanks because the DIAL scans typically intercepted plumes from more than one tank, and only the total flux was calculated for each scan. These data show the DIAL results were nearly always higher than the other estimates (in 14 of the 18 groups of scans listed in Table 2), sometimes by an order of magnitude. For some scans, much of the difference appears to be due to influence from upwind sources. However, other factors also likely contributed to the differences. A discussion of the various factors and uncertainties that affect the DIAL results and estimated VOC emission levels is presented below.

<u>Comparison of DIAL results and estimated emissions</u>. BP reported crude oil characteristics, tank characteristics, the number and type of rim seals and fittings, and the control status of fittings (see Appendix A).[3] These data were used with AP-42 procedures to estimate the hourly VOC emissions rate from each tank at the time it was subject to DIAL testing. The AP-42 procedures were modified slightly to account for actual conditions at the time of DIAL testing to the extent possible. Specifically, withdrawal losses were estimated from several of the tanks using actual withdrawal rates during the tests, actual wind speeds were used instead of monthly historical averages, and liquid bulk temperatures were calculated using historical monthly average ambient temperatures for either July or August (as applicable). Actual ambient temperatures during the test days were not available. Details of the calculations are presented in Appendix B.

Table 2 also presents the ozone season emission rates from BP's 2007 emissions inventory.[2] The emission rates reported in the inventory are in lb/d. To allow comparison with the DIAL results and the estimates based on modified AP-42 procedures as described above, these daily rates were divided by 24 to obtain average hourly emissions. As shown in Table 2, the average hourly emission rates are always higher than the hourly rates estimated using AP-42 procedures, but by only a small amount relative to large emission fluxes calculated for many of the DIAL scans. A difference between the average rates in the inventory and the rates estimated using the actual conditions during the DIAL test period is to be expected because the wind speeds used to develop the estimates described above were typically lower than the historical monthly averages, and most tanks have no withdrawal losses in the analysis described above. The difference, however, cannot be explained fully by these meteorological and operational variations. The same seal and withdrawal losses as in BP's 2007 inventory could be reproduced using the data obtained from BP and default parameters in the AP-42 procedures, but fittings losses estimated in this manner are much lower than BP's 2007 estimates. The most likely explanation for the difference is that there are unknown differences between the number, type, and/or control status of fittings used in the two analyses.

Table 2. Comparison of DIAL and Modeled VOC Emissions for External Floating Roof Tanks Storing Crude Oil[a]

Scan ID Nos.	Tanks upwind of scans according to DIAL report	Other tanks possibly upwind of scans	Wind characteristics during DIAL tests		Estimated emissions from DIAL testing, lb/hr		Estimated modeled emissions, lb/hr[b]	2007 EIQ ozone season emissions. lb/d (lb/hr)[c]	Comments
			Direction	Average speed, mph	Range	Average			
235, 236	1020	1021, 1024	ESE	8.0	<1 to 2	1.3	1.2 to 4.7	44 to 133 (1.8 to 5.5)	▪ Withdrawals from tanks 1020 and 1024. ▪ Testing conducted about 1:30 pm.
241, 242, 243	1020	1021, 1025	S and SSW	7.7	<1 to 3	1.3	1.2 to 3.2	44 to 134 (1.8 to 5.6)	▪ Withdrawals from tank 1020. ▪ Testing at about 2 pm.
182, 183, 184, 185, 187, 188	1020, 1021	None	SSE	8.7	10 to 20	15.5	2.7	89 (3.7)	▪ Not clear which scan path was used or if any other tanks or other sources may have been upwind. ▪ Testing conducted from about 5 to 6 pm.
179	1024	1025	SSE	7.4	5	5	0.9 to 1.6	44 to 89 (1.8 to 3.7)	▪ Testing conducted at about 4 pm.
178, 180, 181	1024, 1025	None	SE and SSE	8.2	14 to 15	14.7	1.7	89 (3.7)	▪ Testing conducted from 4 to 4:30 pm.
323, 324, 325	1024, 1025	None	SSE	8.7	4 to 11	6.3	1.8	89 (3.7)	▪ Testing conducted from 1 to 2 am.
338, 340	1024, 1025	None	S and SSW	5.7	1	1.0	1.3	89 (3.7)	▪ Testing conducted from 6 to 6:30 am.
138, 139, 140, 141, 148	1025	None	W, SW, and S	5.3	3 to 8	5.4	0.5	45 (1.9)	▪ Testing conducted from 12:30 to 2 pm. ▪ Tank 1053 may have been upwind for one scan.
173, 174, 175, 176	1025	None	SSE	8.6	8 to 13	10.5	0.7	45 (1.9)	▪ Testing conducted from 2:30 to 3:30 pm.
319, 320, 321, 322	1025	None	SSE	6.6	<1 to 5	2.9	0.6	45 (1.9)	▪ Testing conducted from 12 to 1 am.

Scan ID Nos.	Tanks upwind of scans according to DIAL report	Other tanks possibly upwind of scans	Wind characteristics during DIAL tests		Estimated emissions from DIAL testing, lb/hr		Estimated modeled emissions, lb/hr[b]	2007 EIQ ozone season emissions. lb/d (lb/hr)[c]	Comments
			Direction	Average speed, mph	Range	Average			
157, 158, 159	1052, 1053	None	SSE	9.1	13 to 31	22.3	2.3	70 (2.9)	▪ Activated sludge unit appears to be almost directly upwind of tank 1052. ▪ Withdrawal from tank 1053 at about 105,000 gal/hr
164	1052, 1053	None	SE	6.7	6	6	2.1	70 (2.9)	▪ Withdrawal from tank 1052 at about 84,000 gal/hr.
279, 280, 281, 282, 283	1052, 1053, 1055	None	SW	7.2	18 to 39	24.6	3.1	110 (4.6)	▪ Activated sludge unit likely upwind between the two tanks.
284, 285, 286, 287, 288	1052	None	SW to WSW	8.3	29 to 54	39.6	1.1	37 (1.5)	▪ Activated sludge unit likely upwind source for these scans. Plume in Figure 2.5 of the DIAL report for scan 285 appears to be directly downwind of the activated sludge unit.
328, 329, 330, 331	1052, 1053	None	SSE	7.8	12 to 44	24.3	2.1	70 (2.9)	▪ Activated sludge unit almost directly upwind of tank 1052.
156	1053	1052	S	10.3	7	7	1.6 to 2.9	33 to 70 (1.4 to 2.9)	▪ Withdrawal from tank 1053 at about 105,000 gal/hr.
163, 165, 166, 167, 168	1053	1052	ESE to SSE	8.6	3 to 7	5.2	1.1 to 2.3	33 to 70 (1.4 to 2.9)	▪ Withdrawal from tank 1052 during first scan, and filling during last four scans; average about 35,000 gal/hr withdrawal.
231, 232, 233	1053	1052	E to ESE	7.1	<1 to 3	1.5	1.0 to 2.2	33 to 70 (1.4 to 2.9)	

[a] Tanks 1052, 1053, and 1055 have a diameter of 345 ft, and the other four tanks have a diameter of 219 ft. The height of all seven tanks is between 47 and 48 ft.

[b] See Appendix B for calculations. Typically followed the AP-42 procedures, except that actual wind speeds at the time of each set of scans were used instead of historical monthly averages, and the liquid bulk temperature was calculated using the estimated daily average ambient temperatures during July and August. Withdrawal emissions were estimated for scans of tanks 1020 and 1024 during which material was removed from these two tanks. When a range is presented, the low end is for the tank to which emissions are assigned in the DIAL report, and the upper end includes emissions for both this tank and others that appear to have been upwind of the scans.

[c] The lb/hr estimates were obtained by dividing the reported lb/d estimates in the inventory by 24. A range is presented for the same situations described in footnote “b”.

Possible contribution from upwind sources in the DIAL emissions. The available data suggest that many of the calculated fluxes downwind of the crude oil storage tanks included emissions from upwind sources. As discussed in more detail below, the highest calculated fluxes for scans downwind of tanks 1052, 1053, and 1055 (22 to 40 lb/hr) occurred when the activated sludge unit was upwind. Conversely, when the activated sludge unit was not upwind, calculated fluxes were much lower (2 to 6 lb/hr). Similarly, unidentified offsite upwind sources may also have contributed to the highest calculated fluxes for tanks 1020 through 1025 (10 to 20 lb/hr) because these emissions were noted when wind was from one direction, but lower emissions (<1 to 8 lb/hr) were measured when wind was from other directions.

As discussed in section 3.1 of this report, average calculated fluxes downwind of the activated sludge unit on August 2nd were about 30 lb/hr. These emission levels are similar to the collective fluxes calculated downwind of tanks 1052, 1053, and 1055 later the same day while wind was still from approximately the same direction. Figure 2.5 in the DIAL final report presents an image of the plume location in one of these scans. Based on the wind direction at the time of this scan, the location of the plume is such that it could just as easily be from the activated sludge unit as from tank 1052. Table 2.4 in the DIAL final report identifies a few scans as upwind, but it does not appear that any of these scans were directed between the tanks and the activated sludge unit.

Scans on July 28th and August 6th were directed almost due west on the north side of tanks 1052 and 1053. The wind direction for these scans was from the south-southeast, which should cause the plume from the activated sludge unit to cross the plane of the scans a little to the west of tank 1052. If so, these emissions may not have been included in the calculated fluxes for the tanks. However, the DIAL report does not indicate the range over which the fluxes were determined, and it is possible that wind near the ground close to the tanks could have been disrupted such that some of the emissions from the activated sludge unit could be further east than would be predicted from the wind directions measured by the fixed mast located on the vehicle that housed the DIAL instrument.

The highest calculated fluxes for tanks 1020 through 1025 occurred for scans conducted in the afternoon while wind was from the southeast. Calculated fluxes were always lower when wind was from another direction. Even when wind was from the southeast, calculated fluxes were low when scans were conducted in the middle of the night. There should be no other onsite emission sources to the southeast of these tanks, but there may be one or more offsite sources. If so, this offsite source may not have operated at night. No scans were conducted upwind of these tanks when wind was from the southeast.

Uncertain characterization of the tank contents. Any differences between the actual and reported characteristics of the stored crude oil could cause estimated emissions to be biased either high or low. Actual emissions will be a function of the characteristics of the stored crude (primarily vapor pressure, but also the molecular weight and density). These characteristics will vary depending on the source of the crude, how it has been handled prior to storage, and the amount of time it has been in a storage tank. The modeled emissions shown in Table 2 were estimated using data for crude oil as reported by BP. However, it is not clear how these characteristics were developed or how well they represent the characteristics of the stored crude at the time of the DIAL testing.

Uncertainty in the condition of fittings and seals. Differences between the actual condition of seals and fittings versus norms assumed in estimating methodologies may account for some of the differences in DIAL results among the tanks or for differences between DIAL and modeled emissions. The AP-42 procedures estimate emissions from average-fitting seals and typical fittings. It is not clear whether the condition of the seals and fittings on BP's crude oil storage tanks would be considered better than average, average, or worse than average. TCEQ has documented that "strong VOC odors were present when the infrared (IR) camera team was on top of the crude tanks." TCEQ also noted that "hydrocarbon vapors were seen by the IR camera coming from the rim seals of some of the crude tanks."[4] However, the available documentation does not identify which tanks produced the IR-visible emissions, indicate the time of the observations, assess whether the results are comparable to results for a tank that has been inspected and is in compliance with NSPS/NESHAP seal gap requirements, or indicate if the cameras identified any evidence of leaks from deck fittings.

<u>Issue of non-detectable emissions in DIAL tests</u>. For 6 of the 18 groups of scans in Table 2, the DIAL report attributes emissions to only some of the tanks that appear to be upwind of the scans. This may be reasonable if either the scan path or the range over which fluxes were calculated were limited in some way, but the DIAL report does not indicate that the calculations were so limited. On the other hand, emissions may have been assigned to only certain tanks because no emissions were detected from other upwind tanks. If so, the modeling to estimate emissions for comparison to the DIAL results should include these additional tanks. Therefore, the estimated emissions for these scans are presented as a range in Table 2. The low end of the range estimates emissions for the tanks from which DIAL tests detected emissions, and the high end of the range estimates emissions for all tanks that appear to be upwind of the scan. Note that this issue introduces only minimal uncertainty to the analysis because both the low and high ends of the range are less than the DIAL results for three of the six groups of scans, and for the other three groups of scans both the low and high ends of the narrow ranges are close to the DIAL results (typically within 2 lb/hr).

<u>Potential issues regarding assumptions in AP-42 procedures</u>. The AP-42 procedures assume crude oil is weathered and stabilized. If these assumptions are incorrect, emissions estimates will be biased low. The degree of weathering or stabilization of BP's crude oil cannot be confirmed based on the results of DIAL testing and other available information. Analysis of the crude oil is needed to assess the validity of the stabilization assumption, and additional studies are needed to resolve the weathering issue.

The weathering assumption does not appear to be a significant factor in the difference between the DIAL results and the modeled estimates. The weathering assumption is incorporated in the AP-42 procedures for estimating losses from rim seals and fittings by using a "product factor" that accounts for the effect of different types of liquids on evaporative loss.[5] The product factor is 0.4 for crude oil and 1.0 for all other organic liquids. The product factor is lower for crude oil because in tests API found the losses from crude oil were consistently lower than the losses from other liquids, after normalizing for differences in vapor pressure and molecular weight.[6] This result for crude oil was attributed to effects such as weathering of the crude (i.e., loss of volatile components near the liquid surface) before testing. Assuming crude is weathered and using a product factor of 0.4 may underestimate emissions from a tank in which the liquid surface is disturbed, perhaps by mixing caused by adding material to the tank. Results from the testing at BP cannot confirm the appropriate product factor, or if weathering effects varied among the tanks. However, even if the product factor should be 1, the modeled emissions in Table 2 would increase by a factor of only 2.5 (or less for scans with withdrawal losses as well as rim seal and fittings losses). The resulting estimated emissions would still be less than the calculated DIAL fluxes for 14 of the 18 groups of scans listed in the table.

Unstabilized crude contains dissolved gasses that will volatilize under the atmospheric pressure conditions in a storage tank. If this situation exists, the AP-42 procedures will understate the emissions, and the highest DIAL results should be expected while the tank is being filled and for some unknown time afterward. The limited data suggest the crude was more likely stabilized than unstabilized. For example, calculated fluxes from tank 1025 (scans 138 to 148) and tank 1024 (scan 179) were at about the same relatively low levels, but the DIAL testing for tank 1025 were conducted after 8 hours in which material was added that raised the level in the tank from about 25 percent of capacity to more than 55 percent of capacity while no material had been added to or withdrawn from tank 1024 in more than 3 days preceding the tests. If the crude was unstabilized, the emissions from tank 1025 should have been higher than the emissions from tank 1024. Tank 1052 is the only other tank to which crude oil was added during the DIAL tests, but the results are inconclusive. Although the calculated fluxes from scans concurrent with or following the additions were high, which would be consistent with an assumption that the crude was unstabilized, these are also the scans most likely affected by upwind sources. Comparisons before and after filling the same tank would be more meaningful than these comparisons, but the DIAL testing at BP could not be conducted under such conditions. Alternatively, analysis of the crude at the time of the DIAL testing would also address the issue of whether the stored crude is stabilized.

<u>Effect of default ambient temperatures in AP-42 procedures</u>. The AP-42 procedures use default historical average ambient temperatures in the calculation of the liquid surface temperatures which in turn are used to estimate the vapor pressure of the stored material. Since actual ambient temperatures during the DIAL test were not available, the modeled emissions in Table 2 were calculated using the default ambient temperatures for Galveston. A sensitivity analysis shows that even if the actual temperatures were 10ºF higher than the ambient average (highly unlikely that the actual temperatures were this much higher than the defaults), the estimated emissions would increase by only 25 to 30 percent, on average, which is far less than the difference between the DIAL results and the estimates shown in Table 2. Thus, the lack of actual ambient temperature data causes only a small fraction of the difference between the DIAL results and the estimated emissions.

2.2 External Floating Roof Tanks for Gasoline and Other Light Distillates

NPL measured emissions from four external floating roof tanks that stored light distillates. Tank 501 stored regular gasoline, tank 502 stored heavy virgin naphtha, tank 503 stored heavy raffinate, and tank 504 stored alkylate. Table 3 presents the results of the DIAL testing and modeling calculations for six sets of scans of these tanks. A discussion of the various factors and uncertainties that affect the DIAL results and estimated VOC emission levels is presented below.

<u>Comparison of DIAL results and estimated emissions</u>. Of the six groups of scans summarized in Table 3, only the first four are considered to be valid. The DIAL results for all four groups are higher than the estimated emissions, although the difference is less than 5 lb/hr for three of the four groups of scans. The scans in the final two groups summarized in Table 3 were conducted when the wind was nearly parallel to the scan path, which makes it likely that the scans did not capture all of the emissions from the targeted tanks. Thus the results of these scans should not be evaluated with the first four groups of scans and are not considered further in this analysis. The estimated emissions were calculated using slightly modified AP-42 procedures that accounted for conditions during the DIAL testing to the extent possible. Specifically, withdrawal losses were estimated using actual withdrawal rates during the testing, actual wind speeds were used instead of monthly historical averages, and liquid bulk temperatures were calculated using historical daily average ambient temperatures during either July or August (actual ambient temperatures were unavailable). Details of the calculations are presented in Appendix C.

Although most scans were directed downwind of more than one tank, it is not clear from the DIAL final report why collective emissions were reported for so many of the scans; it seems likely that in some scans the plumes from each tank would have been spatially separated, and separate range-resolved fluxes could have been calculated for each tank.

Table 3. Comparison of DIAL and Modeled VOC Emissions for External Floating Roof Tanks Storing Light Distillates[a]

Scan ID Nos.	Tanks upwind of scans according to DIAL report	Other tanks possibly upwind of scans	Wind characteristics during DIAL tests		Estimated emissions from DIAL testing, lb/hr		Estimated modeled emissions, lb/hr[b]	2007 EIQ ozone season emissions. lb/d (lb/hr)[c]	Comments
			Direction	Average speed, mph	Range	Average			
196, 198	501, 502, 503, 504	None	SW and WSW	5.3	2 to 5	3.5	2.9	206 (8.6)	▪ Scans unlikely to be affected by flare #6 due to wind direction.
205, 207, 208	501, 504	502	SSE, S, and SSW	10.4	2 to 13	8.7	3.5 to 4.3	169 to 188 (7.0 to 7.8)	▪ Flare #6 was directly upwind for the two scans with the highest DIAL emissions. ▪ The range of modeled and EIQ emissions reflects the estimates with and without emissions from tank 502.
218, 221	504	501, 502	S and SSW	9.6	5	5	1.5 to 4.2	84 to 188 (3.5 to 7.8)	▪ Flare #6 emissions was nearly directly upwind for at least one of the two scans. ▪ The range of modeled and EIQ emissions reflects the estimates with and without emissions from tanks 501 and 502.
220, 224	501, 502, 504	None	SW	9.5	16 to 18	17	4.1	188 (7.8)	▪ Flare #6 was nearly directly upwind for tank 504 during these scans
347, 353, 354, 355	501, 502, 504	None	SE	6.3	<1 to 8	2.5	3.0	188 (7.8)	▪ NPL cautioned that the wind direction was not good for flux determination, and scans may not have captured all emissions from tank 502.
356	503	None	SE	6.0	1	1	0.3	18 (0.8)	▪ NPL cautioned that the wind direction was not good for flux determination.

[a] According to BP, tank 501 stored gasoline, tank 502 stored heavy virgin naphtha, tank 503 stored heavy raffinate, and tank 504 stored alkylate. The diameter of each tank is 144 ft, and the height is slightly over 40 ft.

[b] See Appendix C for calculations. Typically followed the AP-42 procedures, except that the actual wind speeds at the time of each set of scans were used instead of historical monthly averages, and the liquid bulk temperature was calculated using the estimated daily average ambient temperatures during July and August. Withdrawal emissions were estimated for scans 220 and 224 (and the upper end of the range for scans 218 and 221) based on the actual withdrawal rate of about 58,800 gal/hr from tank 502 during these scans..

[c] The lb/hr estimates were obtained by dividing the reported lb/d estimates in the inventory by 24.

Table 3 also shows BP's ozone season estimates from their 2007 emissions inventory report. The ozone season emissions were reported in pounds per day; these values were divided by 24 to estimate the average hourly emissions. The resulting averages are comparable to the DIAL results (higher for some scans and lower for others). The estimates in the inventory also are always higher than the estimates that were based on the AP-42 procedures. This trend is expected because the wind speed during the DIAL testing was similar to or lower than the historical averages for June through August in Galveston, and most of the estimates for the DIAL test period do not include withdrawal losses because the tanks were not being emptied during the test period. The magnitude of the differences between the two sets of estimates, however, appears larger than should be expected based on the differences in meteorological and operational conditions. Details of the inventory calculations are unavailable; however, as for the crude oil storage tanks, the most likely explanation for the differences is that there are unknown differences in the number, type, and/or control status of fittings in the two analyses.

Without additional information it is not possible to conclude that actual emissions are more accurately represented by either the DIAL results or estimated values or that there are any shortcomings in the AP-42 estimation procedures. Factors and uncertainties that may affect the results are discussed below.

<u>Possibility that measured emissions include contribution from upwind source</u>. In the DIAL final report, NPL acknowledged flare #6 as a potential upwind source, but they concluded that the flare emissions were spatially separated from the tank emissions and thus were not included in the flux calculations for the tanks. This may be true, but the DIAL report does not include figures with images of the plumes for any of the scans for these tanks, and it does not identify the ranges over which the fluxes were calculated. Furthermore, DIAL emissions were relatively high for all but one of the scans when flare #6 was upwind of the tanks, while the lowest DIAL emissions were obtained for scans with wind from directions where the flare should not have influenced the results

<u>Uncertainty in characteristics of stored materials</u>. If there are differences between the actual and reported vapor pressures and other characteristics of the stored materials, the estimated emissions may be biased either high or low. BP reported vapor pressure data for each of the materials stored in these four tanks (see Appendix A).[3] However, the characteristics can vary with fluctuations in the composition of a particular distillate. It is unclear how well the reported data represent the characteristics of the stored materials during the test period because samples of the stored materials at that time were not collected and analyzed.

<u>Issue of non-detectable emissions in DIAL tests</u>. The DIAL report attributes emissions to only some of the tanks that appear to be upwind of the second and third groups of scans in Table 3. This may be reasonable if either the scan path or the range over which fluxes were calculated were limited in some way, but the DIAL report does not indicate that the calculations were so limited. On the other hand, emissions may have been assigned to only certain tanks because no emissions were detected from other upwind tanks. If so, the modeling to estimate emissions for comparison to the DIAL results should include these additional tanks. Therefore, the estimated emissions for these scans are presented as a range in Table 3. The low end of the range estimates emissions for the tanks from which DIAL tests detected emissions, and the high end of the range estimates emissions for all tanks that appear to be upwind of the scan. Note that both the low and high estimates are less than the DIAL results.

<u>Uncertainty in DIAL estimates of emissions from flare #6</u>. It is possible that on July 30th, when flare #6 was upwind of the tanks, that the DIAL results for scans between the tanks and the flare understated the actual emissions from the flare. On July 30th DIAL emissions downwind of all of the tanks except the raffinate tank were 11 to 18 lb/hr. Over approximately the same time period, DIAL data resulted in estimated emissions upwind of the tanks (and downwind of flare #6) that were generally about 3 lb/hr, which suggests the flare did not contribute significantly to the measured emissions from the tanks.

However, on August 7th DIAL results downwind of the flare were 18 lb/hr, which is similar to the DIAL results downwind of the tanks on July 30th. As discussed in section 4.1 of this report, the flow and composition of gas burned in flare #6 were similar on July 30th and August 7th. If the flare operation was similar on both July 30th and August 7th, then the DIAL results downwind of the flare should have been similar as well. If the DIAL results on August 7th more closely represent the actual emissions from the flare on both days, then the DIAL results downwind of the tanks may be due more to emissions from the flare than is suggested by the July 30th data alone.

Uncertainty in the condition of fittings and seals. The actual condition of seals and fittings relative to norms assumed in estimating methodology may account for some of the differences between the DIAL results and estimated emissions. The AP-42 rim seal loss factors are for average-fitting seals, and the AP-42 deck fitting loss factors are for typical fittings. It is not clear whether the condition of the seals and fittings on BP's storage tanks for gasoline and light distillates would be considered better than average, average, or worse than average. TCEQ has documented that when using an IR camera they saw only "very small amounts of hydrocarbon vapor coming from the rim seals of the gasoline tanks".[4] However, the documentation does not provide the time of the observations, indicate if there were any differences in the observations among the four tanks, assess whether the results are comparable to results for a tank that has been inspected and is in compliance with NSPS/NESHAP seal gap requirements, or indicate if there was any evidence of leaks from deck fittings.

2.3 Product Storage Tanks

NPL conducted scans downwind of numerous tanks that were storing products such as diesel fuel, fuel oil # 6, kerosene, and light naphtha. Most of these products were stored in vertical fixed roof tanks; naphtha was stored in tanks with external floating roofs. NPL attributed calculated fluxes to only five of the tanks that appear to have been upwind of the scans (tanks 43, 53, 55, 60, and 63). Several of the diesel and oil storage tanks were nominally heated during the DIAL test period (typically between 90ºF and 106ºF). Only tank 43 was storing material at a temperature significantly above ambient levels (148ºF).[7]

Table 4 summarizes the results of DIAL testing and two sets of modeling results for the scans downwind of product storage tanks. One modeling approach estimated emissions using AP-42 procedures and conditions at the time of DIAL testing. For example, working losses from tanks 43 and 53 were estimated based on the actual filling rates during the DIAL testing, assuming the saturation factor is 1. See Appendix D for details of the calculations. The second set of modeled emissions consists of the average ozone season emission rates presented in BP's 2007 emissions inventory. The inventory data are incomplete because information for some of the tanks could not be found in the inventory. For most groups of scans in Table 4 the DIAL results are comparable to or greater than the modeled emission rates. However, there is considerable uncertainty in both the DIAL and modeling results, as discussed below.

Uncertainty in the range over which DIAL fluxes were calculated. Except for the scans of tank 43, it was not possible to direct scans in such a way as to isolate individual storage tanks. In addition, although the DIAL report documents the path of most scans, it does not identify the range over which concentrations were measured or the range over which fluxes were calculated. Without this information, it is not clear if the calculated fluxes actually represent emissions from tanks other than the five to which NPL attributed emissions, if the emissions from some tanks should be considered to be below the DIAL detection limit, or if emissions from some tanks were beyond the range of the scans. Therefore, as in the analyses for crude oil and light distillate storage tanks, the modeled emissions estimates are presented as a range in Table 4 to reflect the uncertainty regarding the range of the scans and the range over which the DIAL fluxes were calculated. For example, Table 2.1 in the DIAL report shows the path of scans from location 1. All calculated fluxes for these scans are attributed to tank 55 in the DIAL report. However, based on the wind direction and the length of the arrow representing the scan paths, it appears that the scans should also have captured any emissions from tanks 54, 56, and 98, and possibly even from tanks 80 and 97 as well. For the purposes of this review, it has been assumed that the scans may have captured emissions from tanks 54, 56, and 98 in addition to emissions from tank 55. Similarly, Figure 2.8 in the DIAL report shows the scan path from location 7 passes downwind of at least 8 tanks (another 4 were out of service during the DIAL test period). The DIAL report attributes the bulk of the calculated emissions to only 1 of these 8 tanks. For the purposes of this analysis, the upper bound on the modeled emissions assumes that the fluxes were calculated over the full range of the scans, thus capturing emissions from all 8 upwind tanks.

<u>Uncertain characterization of the tank contents</u>. Uncertainty regarding the types of material being stored and their vapor pressures and molecular weights could have resulted in either over- or under-estimation of the actual emissions. It is not clear what material was stored in some of the product tanks because the listed material varied from one document to another. For example, in response to an EPA request, BP indicated that tank 43 was storing fuel oil #6, but BP's 2007 emissions inventory report identified the tank as a diesel emission point and that one of the pollutants was fuel oil.[2,3] TCEQ indicated the tank was storing light cycle oil.[8]

Characteristics for diesel fuel, furnace oil, kerosene, and light naphtha were provided by BP[3] and TCEQ,[8] but it is not clear how well the reported characteristics reflect the actual characteristics of the stored materials because samples of the stored materials were not collected and analyzed at the time of the DIAL test. Furthermore, none of the available data are clearly for fuel oil #6. In calculations of emissions from tanks 43 and 60 in Appendix D, it was assumed that characteristics for furnace oil represent the characteristics of fuel oil #6. If this assumption is incorrect, the estimated emissions are likely low.

<u>Possible contribution from upwind sources in the measured DIAL emissions</u>. Although subject to considerable uncertainty, it appears likely that some of the emissions measured downwind of tank 55 are due to contributions from an upwind source. Two scans upwind of tank 55 were conducted on July 26th. One of the scans was conducted at the end of a period of varying wind direction and low wind speeds. This scan resulted in an estimated flux less than detection. However, because scans downwind of tank 55 under similar wind conditions were discounted as being unreliable, this scan also should be discounted. The other scan was conducted 9 minutes later when the wind shifted to the east-southeast and picked up to nearly 5 m/s. This wind pattern continued for the next 2 hours when scans downwind of tank 55 were conducted. The estimated flux for this upwind scan was 7 lb/hr, which is comparable to the average of the measured emissions from all subsequent scans downwind of tank 55. It is not clear how well only one scan represents the average upwind flux, or whether the actual emissions fluctuate over time. Some point in the hydrogen plant appears to be the source of this flux, but the specific source cannot be identified because information about operation of the hydrogen plant during the DIAL measurements is unavailable, and the range in the scan path over which the flux was determined is not described in the final DIAL report.

<u>Potential limitation of AP-42 procedures</u>. One potential limitation of the AP-42 procedures is that they do not estimate emissions from leaks or from vents on freely vented tanks. For example, leaks may occur from a fixed roof tank of bolted or riveted construction in which the roof or shell plates are not vapor tight. In such cases, there could be emissions from diffusion, and the emissions could be exacerbated in windy conditions. The potential for leaks from the tested tanks cannot be assessed because information regarding the construction and integrity of the tanks is unavailable. Whether or not emissions from the tested tanks were occurring from leaks (or vents) could have been resolved by conducting a scan of the roof surface with an optical gas imaging camera.

Table 4. Summary of DIAL Results and Estimated Emissions from Fuel Oil and Other Product Tanks

Scan ID Nos.	Tanks upwind of scans according to DIAL report	Other tanks possibly upwind of scans	Wind direction during DIAL tests	Estimated emissions from DIAL testing, lb/hr		Estimated modeled emissions, lb/hr[a]	2007 EIQ ozone season emissions. lb/d (lb/hr)[b]	Comments
				Range	Average			
382, 383, 384	43	None	SSW and SW	1 to 3	2	1.3	3.7 (0.2)	▪ Tank 43 stored fuel oil #6. Assumed characteristics for furnace oil are similar to those for fuel oil #6. Possibly underestimates vapor pressure. ▪ Tank 43 filled at about 40,000 gal/hr during the DIAL tests.
388, 389, 390	43	None	SSW and SW	7 to 13	9.3	1.3	3.7 (0.2)	▪ Same as above.
399, 400, 401, 402, 403, 404	60, 63	11, 12, 18, 42, 61, 65[c]	S and SSW	4 to 15	9	0.6 to 9.1	110 to ?? (4.6 to ??)	▪ Could not find tanks 11, 12, 61, and 65 in the inventory.
79, 80, 82, 84	55	54, 56, 98[d]	SE and SSE	<1 to 3	1.9	0.3 to 8.4	0.2 to ?? (0.01[e] to ??)	▪ Could not find tank 98 in the inventory.
96, 97, 98, 99, 100, 101, 102, 106, 107, 108	55	54, 56, 98[d]	ESE and SSE	<1 to 14	4.3	0.2 to 11.1	0.2 to ?? (0.01[e] to ??)	▪ Could not find tank 98 in the inventory.
377, 378, 379, 380	53	55	S and SSW	13 to 32	23.8	4.8 to 5.2	23.4 (1.0)	▪ Tank 53 being filled at about 58,800 gal/hr during the DIAL tests.
369, 373, 374	55, 66		S	4 to 8	6			▪ Not clear where the scans were directed because there is no tank 66 near tank 55. Did not evaluate data further.

[a] See Appendix D for calculations. Followed the AP-42 procedures, except modified the standing loss and working loss equations to calculate emissions in lb/hr instead of lb/yr. When a range is presented, the low end is for the tank(s) to which emissions were attributed in the DIAL report, and the high end includes emissions for all tanks that appear to have been upwind of the scan.

[b] The lb/hr estimates were obtained by dividing the reported lb/d estimates in the inventory by 24. A range is presented for the same situations described in footnote “a”.

[c] Other tanks upwind of the scans were out of service (tanks 17, 44, 59, and 64).

[d] The DIAL report does not indicate the range of the scans. It is possible that additional tanks could have been upwind if the range extended farther than assumed.

[e] Likely too low because emissions were estimated using a vapor pressure based on a temperature of 0^{o}F. Average emissions are about 1.0 lb/hr, or 24 lb/d, when a temperature of 100^{o}F is used.

Uncertainty in DIAL measurements. There are some unusual patterns in measurement results for tank 43 (and possibly tank 53) that cannot be explained without additional information from the test crew. As shown in Table 5, tank 43 was tested over a period of 1.5 hours on August 8th. Three scans were conducted downwind, followed by three scans upwind, and then another three scans downwind. Average calculated DIAL fluxes during the first three scans were 2 lb/hr, which as shown in Table 4 is close to the estimated emissions if the stored material is accurately represented by the characteristics for furnace oil. The average measured emission rate in the second set of downwind scans was over 9 lb/hr. In addition, the individual scan results spanned more than an order of magnitude (from 1 lb/hr in the first set of scans to 13 lb/hr in the second set of scans). The wind speed and direction during both sets of downwind scans were essentially the same, the temperature of the stored material was essentially constant, and the tank level rose by no more than 1 foot. Thus, it is not clear why the measured emissions are significantly different in the two sets of downwind scans. The issue of whether something in the operation of the DIAL instrument itself could have changed as a result of moving the instrument to conduct upwind scans and then back to the original position to conduct additional downwind scans, and an assessment of which group of scans is likely more accurate than the other, should be addressed in the final DIAL report.

Inventory may have underestimated emissions for heated tanks. Information from BP indicates that emissions in the 2007 inventory for tanks 53 and 55 were calculated assuming no breathing losses.[9] As noted above, however, these tanks were only nominally heated, and the liquid temperature fluctuated. The tanks also were not insulated, so the vapor would still expand with solar input. Thus, the inventory likely underestimates emissions from these tanks. The procedures and input data for inventory calculations of other heated tanks (e.g., tanks 43 and 60) are not available.

3. Wastewater System Emissions

3.1 Activated Sludge Unit

Three scans were conducted downwind of an activated sludge unit on August 2nd. The measured fluxes ranged from 15 to 42 lb/hr with an average of 31 lb/hr. In the 2007 emission inventory report, the estimated emissions from this activated sludge unit were 6.7 lb/hr. This estimate was reproduced as part of this analysis by using WATER9 modeling with inputs provided by BP (see Appendix E).[10] The reported inputs show BP used property values for some compounds that differed from the defaults in WATER9. The most significant were a much higher biodegradation rate constant for benzene (120 l/g-hr versus 1.4 l/g-hr) and small (rather than no) hydrolysis rates for xylenes.

Although the measured emissions are significantly higher than the annual average in the inventory, Table 5 shows the measured emissions fall within a range of modeled emissions that are based on the actual wastewater flow rate and a range of possible pollutant concentrations at the time of DIAL testing. Table 6 also shows the estimated emissions approximately double when using the default pollutant properties in WATER9 instead of the property values reported by BP. The actual flow was more than 3 times the average value (because an adjacent unit was drained and temporarily out of service at the time of the DIAL test), and the average benzene concentration from several wastewater samples in early August was about 30 percent higher than the annual average concentration. Actual concentrations for other pollutants are unavailable. Using the actual flow rate and assuming all of the other compounds in the wastewater on August 2nd were also 30 percent higher than their annual average values results in estimated emissions of either 29 or 55 lb/hr, depending on whether the modeling uses BP's reported property values or the default values in WATER9. Table 5 also shows the lower estimates obtained when assuming benzene was the only pollutant at a concentration above its annual average and if all pollutants are at their annual average concentrations.

Table 5. Estimated VOC Emissions from Activated Sludge Unit during DIAL Testing

Condition	Emissions, lb/hr[a]	
	Using default compound properties in WATER9	Using compound properties reported by BP
1. All compounds in the wastewater are at the average hourly concentration BP used to develop the estimated emissions for the 2007 emissions inventory report	43	21
2. Benzene concentration is 30% higher than in BP's 2007 analysis[b]	46	22
3. Concentrations of all compounds are 30% higher than in BP's 2007 analysis	55	29

[a] Average flow to the activated sludge unit was about 16,800 gal/min on August 2nd. Reported characteristics of the activated sludge unit and compound properties used by BP are presented in Appendix E. Composition of the wastewater is claimed confidential.[9]

[b] According to BP, the benzene concentration in wastewater to the activated sludge unit in several samples in early August was about 30% higher than the concentration used in the estimate for the 2007 emission inventory report. Data for the other compounds are unavailable.

The default benzene biodegradation constant in WATER9 is based primarily on data for treatment units at sites other than petroleum refineries.[11] The benzene content in the wastewater in these units may have been lower than in refinery wastewater because the microorganisms in these systems are not as acclimated to benzene, and thus this average biodegradation rate is lower than it would be when considering only treatment units at a refinery. The biodegradation rate constant reported by BP is from biorate tests specifically for this unit using wastewater with a mixture of pollutants. Thus, the most appropriate biodegradation rate constant for benzene in refinery wastewater treatment units is likely much closer to the value reported by BP than the default value in WATER9. Using the actual wastewater conditions at the time of the DIAL testing, the benzene biodegradation rate reported by BP, and defaults in WATER9 for other parameters, would narrow the range of estimates relative to that shown in Table 5. The narrowed range, however, still includes 30 lb/hr, suggesting that the estimation procedures and DIAL testing are in good agreement.

3.2 API Separator

Two scans were conducted downwind of the API separator that is located in the northeast corner of surge basin number 2 (south of all of the crude oil storage tanks and east of the activated sludge unit). Calculated fluxes were 5 and 8 lb/hr. An estimate of emissions from this unit using WATER9 has not been developed because information on the flow rate and composition of the wastewater to this unit and characteristics of the unit itself are unavailable. In addition, it is not clear how the DIAL results compare to the estimated average emissions in the 2007 emission inventory report because the EPN for this unit has not been provided.

3.3 Wastewater Collection System Vents

In two scans downwind of the coker unit, VOC fluxes of 9 lb/hr were calculated from some unit at a considerable distance south of the coker (closer to the DIAL instrument). These emissions were traced to wastewater vent pipes. No information about the characteristics of the vent operation or the wastewater is available. Therefore, estimates of the emissions for comparison to the DIAL results cannot be performed.

4. Flare Emissions

4.1 Flare No. 6 (Ground flare)

DIAL testing of Flare No. 6 (a ground flare) was conducted on July 30th and August 7th, 2007. On July 30th, hydrocarbon emissions (C3 hydrocarbons and heavier) calculated from the test data were consistent at approximately 3 to 4 lb/hr. Emissions calculated using test data from just after midnight on August 7th were approximately 37 lb/hr, but the rate dropped rather quickly to an average of approximately 18 lb/hr. The flow rate and composition of the gases combusted in the flare were measured hourly by BP.[12] These data were used to determine the mass rate of C3+ hydrocarbons sent to the flare. Emissions from the flare were then projected assuming the flare had a control efficiency of 98 percent (i.e., the emissions from the flare were assumed to be 2% of the total mass rate of C3+ hydrocarbons fed to the flare). Figures 1 and 2 provide a comparison of the DIAL results and estimated emissions for July 30th and August 7th, respectively. As seen by these figures, the DIAL results and estimated emissions agree reasonably well. The flare control efficiency appears to exceed 99 percent on July 30th, but marginally achieved the assumed 98 percent control efficiency on August 7th. See Appendix F for the measured flare gas flow and composition data and estimated controlled emissions.

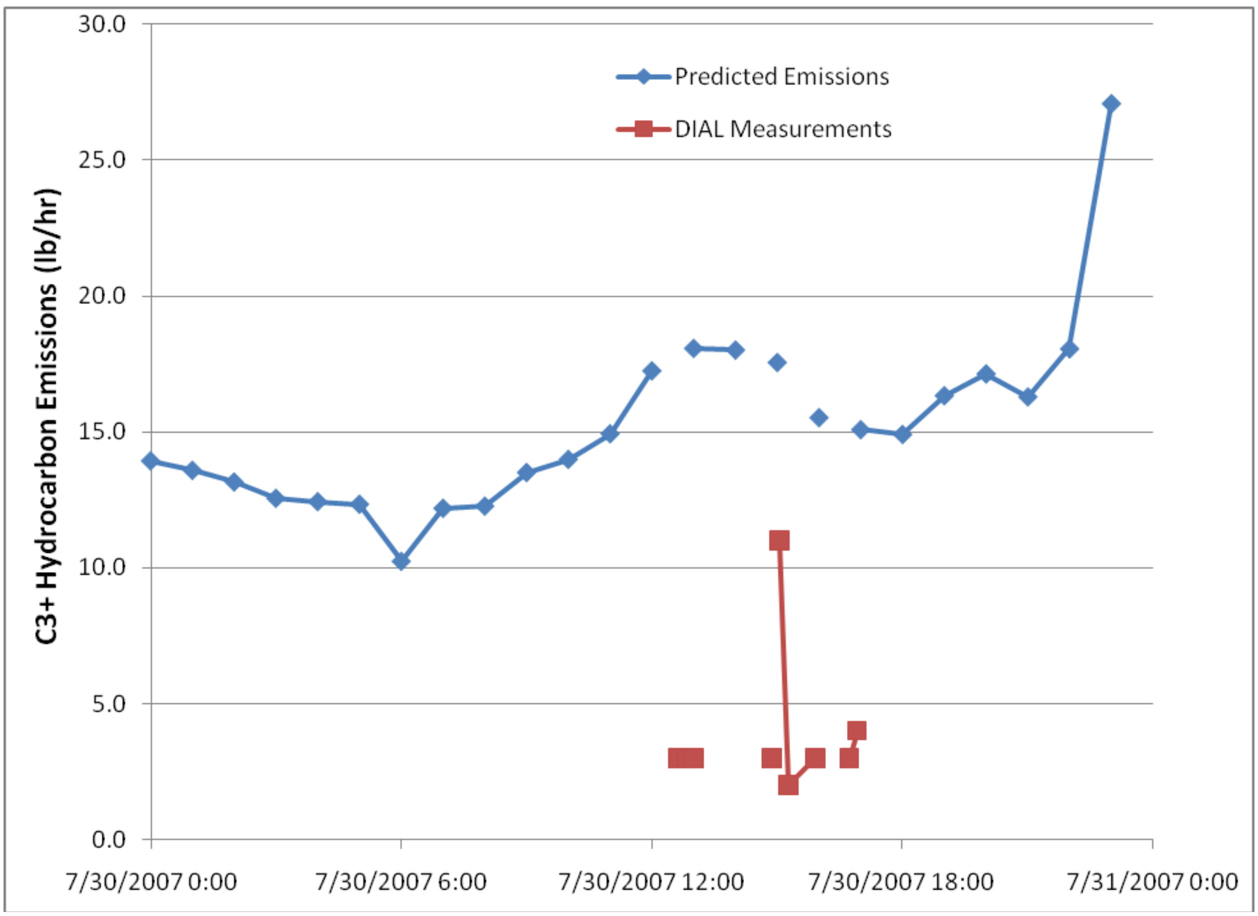

Figure 1. Comparison of the DIAL results and estimated C3+ emissions for Flare No. 6 on July 30, 2007.

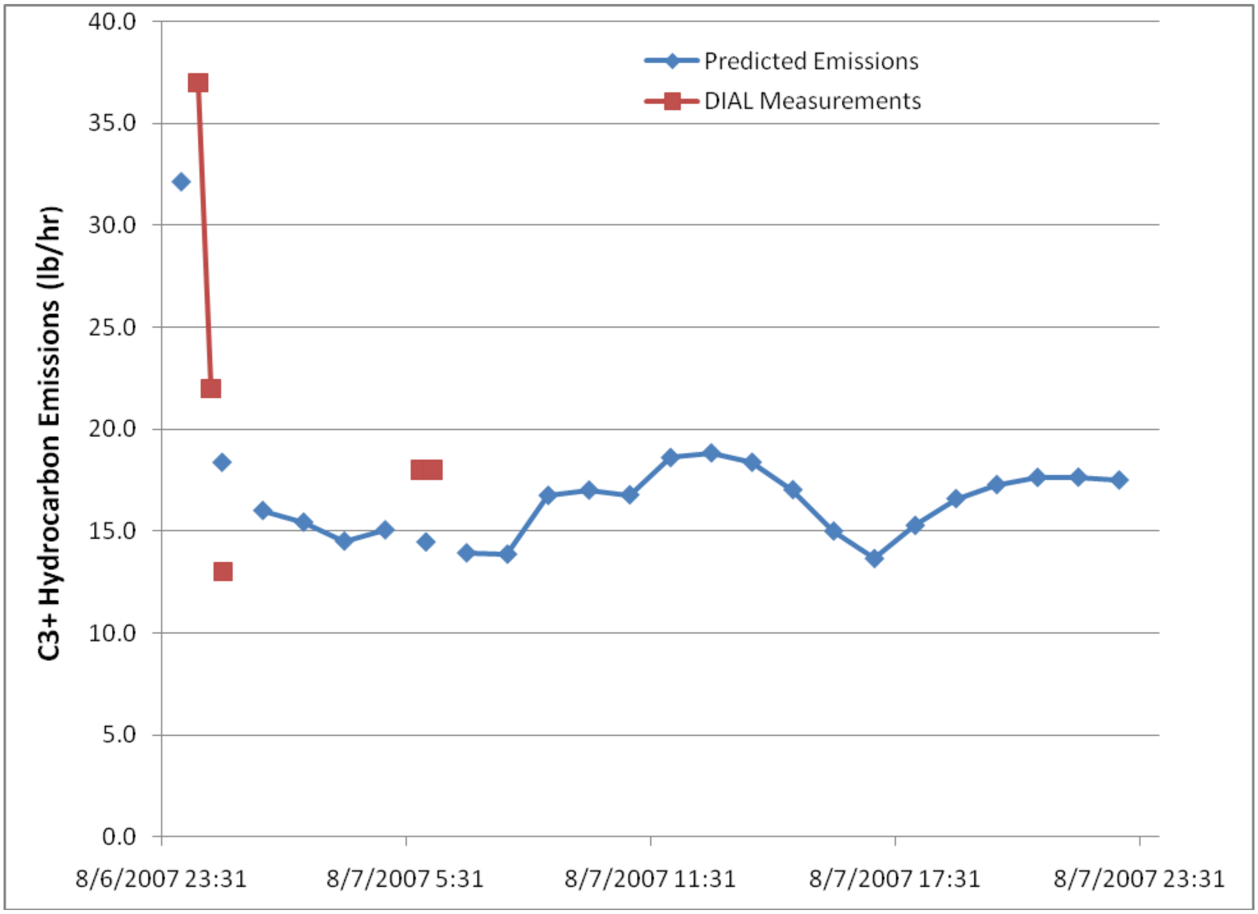

Figure 2. Comparison of the DIAL results and estimated C3+ emissions for Flare No. 6 on August 7, 2007.

The data for Flare No. 6 appear to indicate that the DIAL results and predicted emissions are in reasonable agreement. Both the DIAL testing and flare flow and composition monitors suggest that the emissions were high at midnight of August 7th but quickly dropped and stabilized near 18 lb/hr. The DIAL report suggests the emissions on August 7th averaged approximately 22 lb/hr, but this is due to the limited measurement and assuming the 37 lb/hr reading existed 20 percent of the time. The flare flow rate and composition measurements suggest that this higher emissions rate likely existed for only 4 percent of the day.

The emissions from Flare No. 6 reported in the TCEQ inventory for 2007 averaged 40 lb/hr, which is significantly more than the average emissions determined by the DIAL testing and at least twice as much as predicted based on the mass flow of hydrocarbons to Flare No. 6 during the two days of testing. Nevertheless, it is anticipated that the emissions reported for Flare No. 6 are likely estimated from the flare flow rate and hydrocarbon concentrations assuming a default flare efficiency of 98 percent. As the available data indicate, Flare No. 6 appears to achieve this 98 percent control efficiency. As such, the difference in the annual emissions and those predicted in Figures 1 and 2 are likely the result of the flare flow rate and/or hydrocarbon concentration being lower than average during the days of the test.

4.2 Temporary and Ultracracker Flares

On August 9th, 10th, and 11th, flare emissions were measured from a temporary flare and from the ultracracker (ULC) flare. The temporary flare was installed to combust a high hydrogen content gas stream from the ultracracker. This high hydrogen gas stream, under normal circumstances, is compressed and recycled back to the unit.[13] However, the hydrogen stream compressor was off-line (being repaired/replaced) and the temporary flare was being used to combust this gas stream until the compressor could be brought back on-line. The flow rate and composition of the gases combusted in the flares were measured hourly by BP.[7] The temporary flare received approximately 13,700 standard cubic feet per minute (scfm) of hydrogen rich gas (approximately 80 vol%). The C3+ hydrocarbon content of this gas was approximately 10 percent on August 9th and 10th, and it was approximately 4 percent on August 11th. Based on the large flame of the temporary flare, the DIAL testing initially targeted only the temporary flare. While measuring the emissions from the temporary flare, a strong plume was observed, which correlated to the position of the ULC flare. The ULC flare received approximately 1,100 scfm during August 9th and most of August 10th. Starting at around 7 PM on August 10th and for all of August 11th, the ULC flare received approximately 3,800 scfm. While the ULC flare flow was 1,100 scfm, the average C3+ hydrocarbon content averaged 2 vol% (and nitrogen and methane were both about 40 vol%); when the ULC flare flow was 3,800 scfm, the average C3+ hydrocarbon content averaged 1 vol% (and methane was 70-85 vol%). All DIAL testing on August 10th was conducted before the flow rate jumped up.

All of the DIAL measurements of the ULC flare also included the temporary flare. Based on plume visualization, the majority of the combined emissions were attributed to the ULC flare. Additionally, a limited number of scans were conducted on August 11th of just the temporary flare. These scans support the conclusion that the majority of the combined emissions from the ULC and temporary flares were released from the ULC flare.

The flow rate and composition of the gases combusted in both the temporary and ULC flare were measured hourly by BP. See Appendix F for BP's flare gas flow and composition monitoring data. These data were used to determine the mass rate of C3+ hydrocarbons sent to each flare. Emissions from each flare were then projected assuming the flare had a control efficiency of 98 percent (i.e., the emissions from the flare were assumed to be 2% of the total mass rate of C3+ hydrocarbons fed to the flare). Figure 3 provides a comparison of the calculated DIAL fluxes and the predicted emissions combined for the two flares. From Figure 3, it appears that there is reasonable agreement in the combined emissions from these two flares. However, contrary to the DIAL results, the large majority of the predicted emissions from these flares arises from the much higher flow and hydrocarbon content of the gases sent to the temporary flare. When the concentration of C3+ hydrocarbons in the gas sent to the temporary flare dropped on August 11th, there was no corresponding drop in the DIAL emissions rates. On the contrary, the average of the DIAL emissions on August 11th is approximately twice that of the DIAL emissions on August 9th or 10th. Most of the DIAL results fall below the predicted emissions for both flares on August 9th and 10th, whereas most of the DIAL results on August 11th are well above the predicted emissions from both flares. The higher DIAL emissions on August 11th tend to correspond to the higher flow rate to the ULC flare, which appears to support the DIAL study results that the emissions from the two flares were predominately arising from the ULC flare.

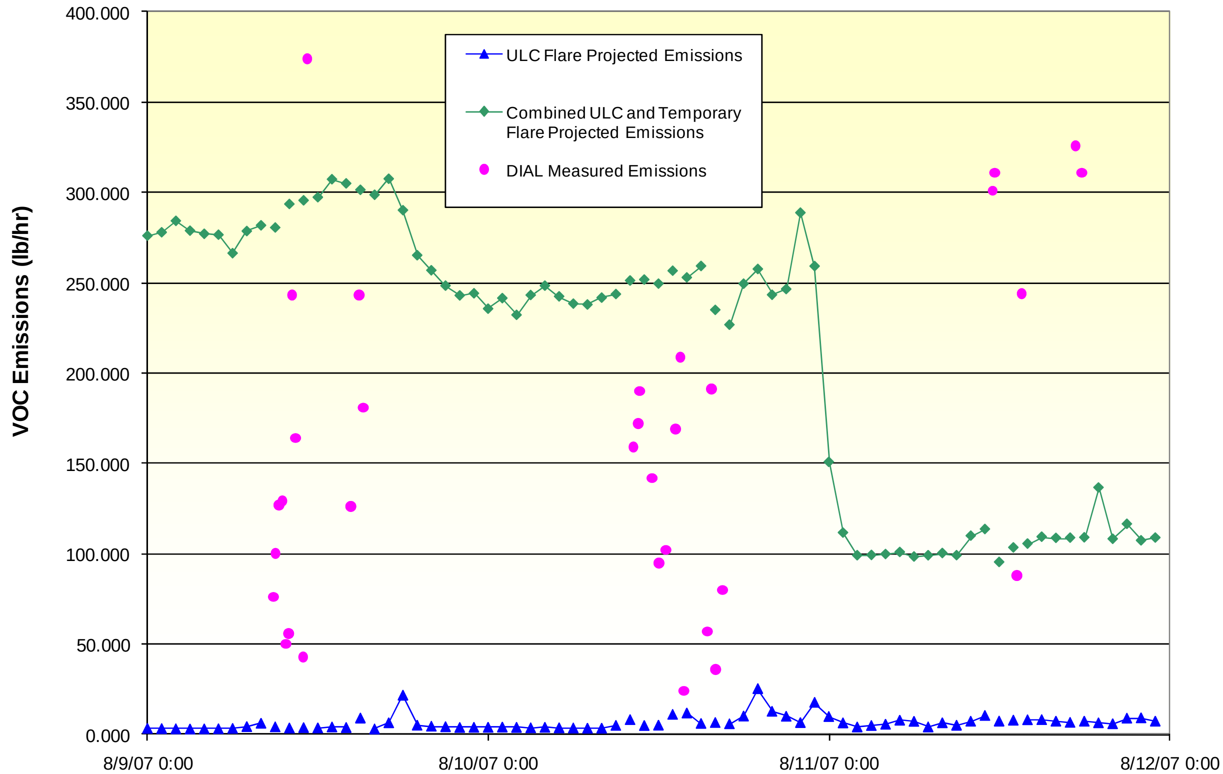

Figure 3. Comparison of DIAL results and estimated C3+ emissions from the temporary and ULC flares.

Based on the limited scans of just the temporary flare, which were conducted between 12 pm and 1 pm on August 11th, the control efficiency of the temporary flare was estimated to be approximately 99.8 percent. Using the inlet hydrocarbon rate to the temporary flare, the emissions from the temporary flare were re-calculated assuming this higher (99.8%) control efficiency is accurate and that it applied throughout the 3-day test period. These values were then added to the predicted emissions for the ULC flare assuming two different ULC flare control efficiencies (50 and 90 percent). The results of this analysis are provided in Figure 4 and in Table F-3 in Appendix F.

The DIAL and predicted emissions compare reasonably well when one assumes the temporary flare is highly efficient and the ULC flare is inefficient. Looking at both Figures 3 and 4, the improved correlation between the DIAL and predicted emissions seen in Figure 4 also supports the DIAL study conclusion that most of the emissions are released from the ULC flare. Based on the data as presented in Figure 4, the ULC flare control efficiency appears variable between 50 and 90 percent.

It is unclear why the ULC flare control efficiency was so poor. The testers noted that the flare had "an almost invisible flame during daylight, but was observed to be lit at night." The lack of a visible flame may be caused by the sheer size of the flare. The actual dimensions of the flare are confidential.[9] However, the ULC flare is an emergency-sized flare with a large diameter.

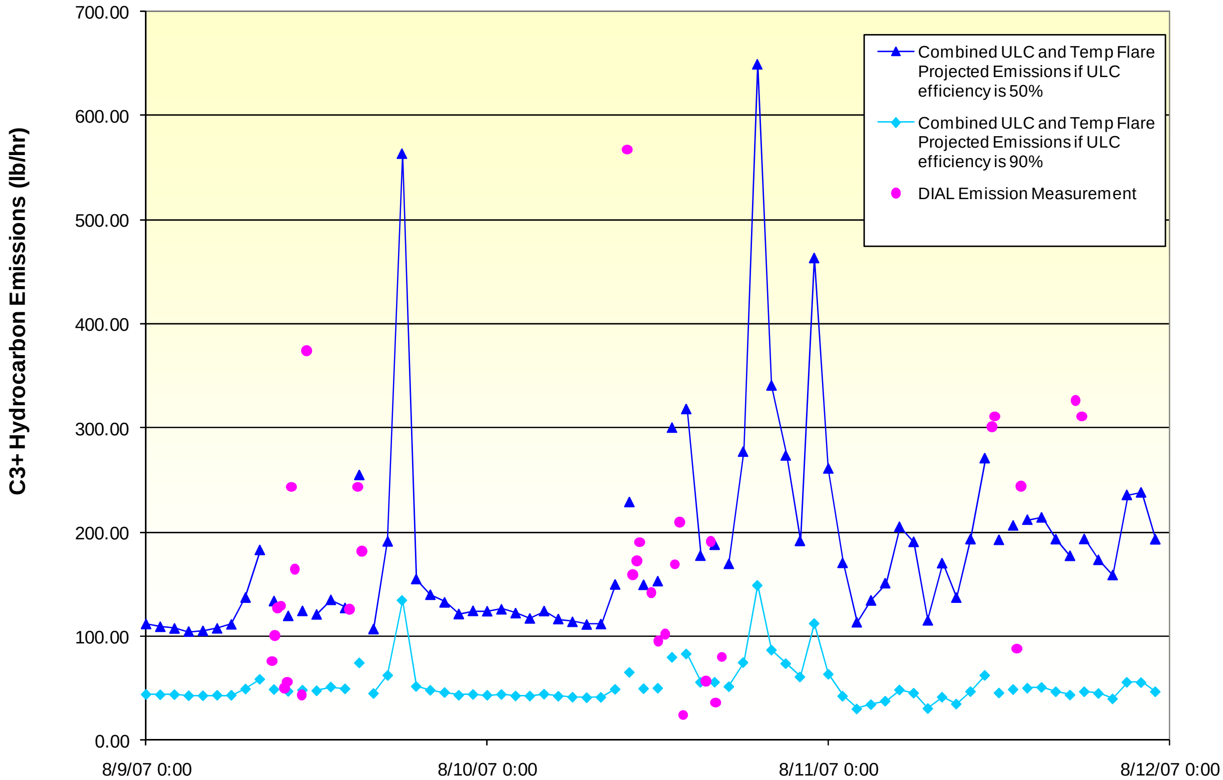

Figure 4. Comparison of DIAL results and estimated C3+ emissions from the temporary and ULC flares assuming the temporary flare is highly efficient (99.8%) and the ULC flare efficiency is 50 or 90 percent.

Using the reported diameter and the highest measured flow rate results in a very small flow velocity at the flare tip. Due to the large diameter of the ULC flare, there may have been inadequate mixing for complete combustion. That is, pilot flames on the circumference of the flare may not effectively light off the flare gas near the center of the flare. The increased flow on August 11th, however, would suggest that the efficiency should have increased rather than decreased. Also, the ULC flare is steam assisted. While the steam should help to mix the gases, too much steam may impact the efficiency of the flare. An EPA study determined that flare efficiency (both combustion efficiency and hydrocarbon destruction efficiency) declines with increases in the steam-to-flare gas ratio above 4.[14] Using flare gas composition data and approximate steam addition rates provided by BP, the steam-to-flare gas ratios (i.e., lb steam per lb of total flare gas, including methane and ethane) were determined to be greater than 6 for most hours on August 9th and 10th.[7,15] See Table F-3 in Appendix F for the steam and flare gas data and resulting ratios. These high steam rates could account for the low estimated control efficiencies on these days. However, over steaming does not appear to be the cause of the low control efficiency on August 11th because the steam-to-flare gas ratio most hours was between 2 and 3. Finally, the ULC flare has a steam tip near the center of the flare with pilot lights around the circumference. This design may contribute to poor combustion of gases in the center flow region of the flare. Over steaming the flare gas may also explain why the flame was nearly invisible during the day.

The TCEQ inventory for the temporary flare shows the average estimated emissions to be 196 lb/hr.[2] This is very close to the estimated average emissions of 205 lb/hr on August 9th through August 11th obtained when assuming the inlet C3+ compounds are controlled to 98 percent. Thus if the average inlet C3+ load to the flare on August 9th through August 11th was close to the annual average inlet load used to develop the inventory estimate, then the much lower DIAL emissions suggest the modeling estimates overstate the actual emissions from the temporary flare.

In contrast to the temporary flare, the apparent control efficiency for the ULC flare was well below 98 percent. The TCEQ inventory for the ULC flare show that the average projected C3+ emissions rate for the flare was estimated to be 28 lb/hr. However, at the flow rate and compositions measured during the testing program, the average emissions projected for the flare assuming a 98 percent control efficiency suggests that the average emissions rate would be under 7 lb/hr. This might suggest that the flow to the ULC flare during the DIAL testing program may have been lower than average ULC flare flows or that the hydrocarbon content of the gas was unusually low (assuming the inventory estimates are based on a control efficiency of 98 percent). BP confirmed that both the flow and composition at the time of the DIAL test were not representative of normal operation.[16] Based on the DIAL results and the projected emissions for the flare at lower control efficiencies (i.e., approximately 50 percent), the ULC flare emissions appear to be 100 to 200 lb/hr. If the hydrocarbon flow to the ULC flare is typically higher than when the DIAL testing was conducted, the annual emissions may be even higher. On the other hand, if the steam addition rate is fixed based on the typically higher gas flow rate, this may explain why the flare was getting poor control efficiency (over steaming) at the lower flow rates and the flare control efficiency may be much improved at higher flare gas flow rates. Due to the limited duration of the DIAL testing, it is difficult to draw strong conclusions regarding the accuracy of the annual inventory for the ULC flare. Additional testing also is needed to determine the control efficiency when the flare is operating under normal conditions.

5. Coker Emissions

Delayed coking is a semibatch process utilizing two coke drums and a single fractionator tower (distillation column) and coking furnace. A feed stream of heavy residues is introduced to the fractionating tower. The bottoms from the fractionator are heated to about 900 to 1000°F in the coking furnace, and then fed to an insulated coke drum where thermal cracking produces lighter (cracked) reaction products and coke. The reaction products produced in the coke drum are fed back to the fractionator for product separation. After the coke drum becomes filled with coke, the feed is alternated to the parallel (empty) coke drum, and the filled coke drum is purged and cooled, first by steam injection, and then by water addition. A coke drum blowdown system recovers hydrocarbon and steam vapors generated during the quenching and steaming process. Once cooled, the coke drum is vented to the atmosphere, opened, and then high pressure water jets are used to cut the coke from the drum. After the coke cutting cycle, the drum is closed and preheated to prepare the vessel for going back on-line (i.e., receiving heated feed). A typical coking cycle will last for 16 to 24 hours on-line and 16 to 24 hours cooling and decoking. Volatile organic compounds may be emitted throughout the coking/decoking cycle, but the primary periods when emissions are expected are from blowdown (if not controlled) and from the atmospheric venting and opening of the coke drum.

At BP, numerous DIAL scans were conducted downwind of coker unit C. The scans were conducted over 40 to 120 minute spans on five different days. Emissions calculated from the DIAL test data ranged from about 4 lb/hr in one set of scans, to 11 lb/hr in two sets of scans, and 31 lb/hr in two sets of scans. According to the DIAL report, the scans were conducted during parts of several operating cycles of the coker. Process data, however, are not available, which means the DIAL results cannot be correlated with any specific step(s) in the operating cycle. Without process data, it is also not clear whether the measured emissions can be extrapolated to estimate total emissions from an entire cycle of coker operation. Due to a lack of accepted procedures for estimating emissions from cokers, the 2007 emission inventory report also did not include estimates of emissions from the coker that could be compared with the DIAL results.

Total VOC emissions calculated from the DIAL test data at BP appear to be considerably lower than emissions obtained from a DIAL test of a coker in Alberta.[17] At least a small difference is to be expected because the Alberta test data included ethane emissions. However, a more complete comparison is not possible because design and operating characteristics of both cokers are not available, and as noted above, it is not clear what portions of the coking cycle were operating during the testing at BP.

Based on test data from several refineries, C3+ VOC emissions from coker atmospheric vents are about 60 lb/cycle.[18-22] If the average measured emissions at BP were extrapolated over the entire 20-hour coker cycle, the total emissions would be significantly more than 60 lb. This is to be expected because the BP data supposedly include emissions from more than the atmospheric vent (and the atmospheric vent operates for only a small portion of the coker cycle).

A separate set of scans measured benzene emissions from the coker. Generally, benzene emissions calculated from the test data were at or below detection, but during coke cutting operations the calculated emissions were nearly 2 lb/hr. These results appear to be in line with results from other tests, but comparisons are difficult because the various tests were not conducted on the same basis. For example, stack testing at two refineries in California found benzene emissions from coker atmospheric vents to be about 0.1 lb/cycle (or 0.1 to 0.4 lb/hr if the total emissions are averaged over the entire time the vents were open), but these data do not include coke cutting or other fugitive emissions.[20,21] Benzene emissions from the atmospheric vent on the coker at another refinery may have been as high as 6 lb/cycle, assuming the ratio of benzene to toluene concentrations obtained during the pretest also applied during the actual test runs when only toluene was measured above the detection limit.[22] Averaged over the 3 hours the vent was open, the benzene emissions would have been about 2 lb/hr, but about half of the total emissions may have occurred in the first hour if the trend in the benzene emissions matches the trend for toluene emissions. Finally, in the DIAL test at an Alberta refinery, benzene emissions from the entire coker area were calculated to be about 3 lb/hr over the coker cycle, but emissions for specific steps in the cycle are not available.[17]

6. Recommendations for Future Testing

For DIAL tests of any sources, measure upwind conditions simultaneously with downwind measurements to ensure emissions from the tested unit can be isolated. Minimize the number of scans for which only combined fluxes from two or more sources can be determined.

For DIAL tests of cokers, collect process data during the testing, and conduct testing during each step in the cycle, to provide a better understanding of how emissions vary over the cycle. If possible, test coker operation and ancillary facilities (e.g., coke piles and wastewater holding ponds) separately.

Conduct DIAL tests of flares under a range of operating conditions. Collect data on flare gas flow rate and chemical composition during the test. Also collect steam rates, if applicable, and determine the flare tip diameter.

Shortly before DIAL tests of storage tanks with external floating roofs, conduct inspections and seal gap measurements to assess whether the seals and fittings are in better or worse than average condition. For DIAL tests of fixed roof tanks, assess the integrity of the roofs. Use optical imaging camera during DIAL testing to scan floating and fixed roofs for leaks.

As part of DIAL tests for storage tanks, determine the composition of stored material so that vapor pressure of the stored material (and for crude oil, the degree of stabilization) can be determined. Also measure temperature and throughput of the stored material during the test and for a few hours before the test.

Reevaluate the AP-42 product factor for crude oil by comparing the crude oil handling procedures and actual storage tank operating procedures with the procedures used in the original API tests from which the current product factor was developed.

In DIAL test reports, include more figures showing plume images and identify the scan range over which fluxes are calculated.

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Appendix A

Storage Tank Characteristics and Properties of Stored Materials Reported by BP and TCEQ

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Table A-1. Dimensions of Storage Tanks at BP Refinery in Texas City, Texas

Tank	Product Stored	Roof Type	Tank Diameter (feet)	Tank Height (feet)
43	High Sulfur Fuel Oil #6	FRT	117	41.67
60	High Sulfur Fuel Oil #6	FRT	117	41.67
63	High Sulfur Decant Oil	FRT	117	41.8
53	Low Sulfur Diesel Fuel	FRT	120	39.96
55	Low Sulfur Diesel Fuel	FRT	150	39.44
66	Mid Virgin Distillate	FRT	70	46.4
54	Diesel	FRT	120	39.79
56	Diesel	FRT	150	39.35
98	Light naphtha	EFRT	150	48
11	Light naphtha	EFRT	117	41.8
12	Light naphtha	EFRT	117	41.8
501	Regular Gasoline	EFRT	144	40.44
502	Heavy Virgin Naphtha	EFRT	144	40.17
503	Heavy Raffinate	EFRT	144	40.04
504	Alkylate	EFRT	144	40.29
1020	Crude Oil	EFRT	219	47.54
1021	Low Sulfur Crude Oil	EFRT	219	47.6
1024	Low Sulfur Crude Oil	EFRT	219	47.63
1025	Low Sulfur Crude Oil	EFRT	219	47.65
1052	Heavy Crude Oil	EFRT	345	47.54
1053	Crude Oil	EFRT	345	47.27
1055	Low Sulfur Crude Oil	EFRT	345	47.96

Table A-2. Streams in BP Texas City TANKS Database

Name	Mol Wt	Vapor Mol Wt	Liquid density	REID VP	ASTM Slope	Total HAP wt%	Benzene wt%	Vapor pressure constants		True vapor pressure at given temps		
								A	B	60	75	95
bp gasoline	92	64	6	13	3	24.02	4	11.644	5043.6	6.95	9.12	12.82
bp alkylate	97	67	6	11.6	1.89	30.66	3	12.054	5342.9	5.89	7.85	11.26
bp crude oil	217	50	7	9	0	4.73	0.25	10.695	4589.2	6.45	8.26	11.26
bp heavy virgin naphtha	112	90	6	3.4	1.39	17.03	2	12.858	6488.6	1.45	2.06	3.19
bp heavy raffinate	183	139	7	2.3	0.69	6.37	2	13.599	7126.8	0.89	1.31	2.12
bp diesel	202	151	8	0.025	2	0.34	0.03	14.532	10202.1	0.006	0.011	0.021
bp decanted oil	217	163	8	0.02	0.81	0	0.015	16.236	11276.3	0.004	0.008	0.017
bp furnace oil	217	163	8	0.0019	0.85		0.01	17.514	13317.9	0.000	0.001	0.002
bp resid	410	195	9	0.0000003	3	0	0.001	17.026	18025.6	0.000	0.000	0.000
kerosene	162	130		0.05	1.5							
light naphtha	123	92		12.3	0.77							

Table A-3. Type of Floating Roof, Rim Seal, and Guidepole for External Floating Roof Tanks at BP's Texas City Refinery

Rim Seal Type
Welded Tanks, Avg-Fitting Rim Seals
Mechanical-Shoe Primary Seal
A with NO Secondary Seal
B w/ Shoe-Mtd Secondary Seal
C w/ Rim-Mtd Secondary Seal
Liquid-Mounted Primary Seal
D with NO Secondary Seal
E with a Weather Shield
F w/ Rim-Mtd Secondary Seal
Vapor-Mounted Primary Seal
G with NO Secondary Seal
H with a Weather Shield
I w/ Rim-Mtd Secondary Seal
Add'l Mech-Shoe Seals, Special Conditions
J w/ NO Secondary Seal – tight fitting
K w/ Rim-Mtd Secondary Seal – tight fitting
L w/ NO Sec. – Riveted Tank (loose fitting)
M w/Rim-Mtd Sec.-Riveted Tank (loose fitting)

Floating Roof Type
A steel pontoon-type EFR (API 650 App. C-type) (default for EFRTs and Domed EFRTs)
B steel double-deck EFR (API 650 App. C-type)
C alum. bolted deck IFR (API 650 App. H-type) (default for IFRTs)
Click here to enter bolted deck constr.
D steel welded deck IFR (API 650 App. H-type) (includes steel-pan type)
OR
E no floating roof (Fixed-Roof Tank)

Guidepole Code	Type	Deck Cover Gasket	Float	Pole Wiper	Pole Sleeve
A	Unslotted	No	Na	No	No
B	Unslotted	Yes	Na	No	No
C	Unslotted	No	Na	No	Yes
D	Unslotted	Yes	Na	No	Yes
E	Unslotted	Yes	Na	Yes	No
F	Slotted	Y or N	No	No	No
G	Slotted	Y or N	Yes	No	No
H	Slotted	Yes	No	Yes	No
I	Slotted	Yes	No	No	Yes
J	Slotted	Yes	Yes	Yes	No
K	Slotted	Yes	No	Yes	Yes
L	Slotted	Yes	Yes	Yes	Yes

Tank ID No.	Floating Roof Type: Enter the code letter	Rim Seal Type: Enter the code letter	Guidepole: Code letter	Quantity
Tank 501	A	C	E	1
Tank 502	A	C	H	1
Tank 503	A	C	K	1
Tank 504	A	C	D	1
Tank 1020	A	C	D	2
Tank 1021	A	C	H	2
Tank 1024	A	C	I	1
Tank 1025	A	C	E	2
Tank 1052	B	C	E	1
Tank 1053	B	C	E	1
Tank 1055	B	C	E	1
Tank 98	A	B	K	1
Tank 11	A	C	E	1
Tank 12	A	C	E	1

Table A-4. Other Fittings for External Floating Roof Tanks at BP's Texas City Refinery[a]

Tank ID No.	Access Hatch		Gauge Float		Gauge Hatch		Vacuum Breaker		Deck Drain		Leg Pontoon Area (or IFR)		Leg Center Area (or Double Deck)		Rim Vent	
	Code	Quantity	Code	Quantity	Code	Quantity	Code	Quantity	Code	Quantity	Code	Quantity	Code	Quantity	Code	Quantity
Tank 501	C	1		0	B	1	B	2		0	A	10	A	25	B	2
Tank 502	C	2		0	B	1	B	3		0	A	10	A	28	B	2
Tank 503	C	2		0	B	1	B	3		0	A	10	A	28	B	2
Tank 504	C	2		0	B	1		0		0	A	10	A	28	A	1
Tank 1020	C	4		0	B	1	B	3		0	A	22	A	73	B	3
Tank 1021	C	3	C	1	A	1	B	3		0	A	22	A	73	B	2
Tank 1024	C	3		0	B	1	B	3		0	A	22	A	80	B	3
Tank 1025	C	3	B	1	B	1	B	3		0	A	22	A	74	B	2
Tank 1052	C	3		0	B	3	B	3	A	8		0	A	212	B	3
Tank 1053	C	3		0	B	2	B	3	A	12		0	A	212	B	3
Tank 1055	C	5	B	1	B	5	B	5	A	14		0	A	295	B	2
Tank 98	C	2		0	B	1	B	2		0	A	24	A	36	A	2
Tank 11	C	1		0	B	1	B	2		0	A	8	A	17	B	2
Tank 12	C	2		0	B	1	B	2		0	A	8	A	17	B	2

[a] Code "A" means ungasketed, code "B" means gasketed, and code "C" means bolted and gasketed.

Appendix B

Estimation of Emissions from External Floating Roof Tanks Storing Crude Oil

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Table B-1. Inputs for Estimating Emissions from External Floating Roof Tanks 1020, 1021, 1024, and 1025

Parameter	Characteristic	Variable	Value
Contents	Crude		
Diameter, ft			219
Color	White		
Condition	Good		
Shell	Lt rust		
Construction	Welded		
Primary seal	Mech shoe		
Secondary seal	Rim mounted		
Deck	Steel pontoon		
C			0.006
KRA			0.6
KRB			0.4
n			1
alpha			0.17
Vapor pressure coefficients		A	10.695
		B	4589.2
		C	
Vapor molecular weight		MV	50
Product factor		KC	0.4
Reid vapor pressure		RVP	0
Liquid molecular weight		ML	217
Liquid density, lb/gal		density	7
Atmospheric pressure, psia		P	14.703
City	Galveston, TX		

Table B-2. Wind Speeds Measured During DIAL Scans of External Floating Roof Tanks 1020, 1021, 1024, and 1025

Wind speeds in Table 2.4 of the DIAL final report:

Scan #	Wind Speed, m/s
138	2.3
139	2.5
140	1.9
141	2.2
148	3
Average	2.38 (5.32 mph)
173	4.1
174	4
175	4.1
176	3.2
Average	3.85 (8.61 mph)
319	2.8
320	2.9
321	2.9
322	3.3
Average	2.98 (6.65 mph)
178	3.4
180	3.6
181	4
Average	3.67 m/s (8.20 mph)
323	3.8
324	4.2
325	3.7
Average	3.90 m/s (8.72 mph)

Scan #	Wind Speed, m/s
338	2.9
340	2.2
Average	2.55 (5.70 mph)
179	3.30
	(7.38 mph)
182	3.7
183	4.3
184	3.7
186	3.9
187	3.8
188	4
Average	3.90 (8.72 mph)
235	3.5
236	3.7
Average	3.60 (8.05 mph)
241	3.5
242	3.6
243	3.2
Average	3.43 (7.68 mph)

Table B-3. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1020

					Scans 182+	Scans 235+	Scans 241+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	38.322	36.893	36.095
USl gp well, gsc w/wiper	2	8.6	12	0.81	121.12	114.60	110.93
Deck leg, adj, pt, ung	22	2	0.37	0.91	86.238	83.271	81.613
Deck leg, adj, ct, ung	73	0.82	0.53	0.14	109.70	109.14	108.82
Roof drain,open	0	1.5	0.21	1.7	0	0	0
Rim vent, wmag	3	0.71	0.1	1	3.9620	3.8211	3.7428
GH/SW, wma gask	1	0.47	0.02	0.97	0.5856	0.5770	0.5722
Auto gfw, u/g	0	4.3	17	0.38	0	0	0
Access Hatch, b/g	4	1.6	0	1	6.4	6.4	6.4
					366.33	354.71	348.17
					Emissions, lb/yr		
Vac Brk, gask					204.73	197.09	192.83
USl gp well, gsc w/wiper					647.08	612.23	592.63
Deck leg, adj, pt, ung					460.71	444.86	436.00
Deck leg, adj, ct, ung					586.07	583.10	581.36
Roof drain,open					0	0	0
Rim vent, wmag					21.166	20.413	19.995
GH/SW, wma gask					3.1288	3.0827	3.0570
Auto gfw, u/g					0	0	0
Access Hatch, b/g					34.190	34.190	34.190
			Total		1957.1	1895.0	1860.1

Table B-4. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1021

					Scans 182+	Scans 235+	Scans 241+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	38.322	36.893	36.095
Sl gp well, gsc w/wiper	2	41	48	1.4	1290.9	1162.7	1093.3
Deck leg, adj, pt, ung	22	2	0.37	0.91	86.238	83.271	81.613
Deck leg, adj, ct, ung	73	0.82	0.53	0.14	109.70	109.14	108.82
Roof drain,open	0	1.5	0.21	1.7	0	0	0
Rim vent, wmag	2	0.71	0.1	1	2.6413	2.5474	2.4952
GH/SW, wma ugask	1	2.3	0	1	2.3	2.3	2.3
Auto gfw, b/g	1	2.8	0	1	2.8	2.8	2.8
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8
					1537.7	1404.5	1332.3
					Emissions, lb/yr		
Vac Brk, gask					204.73	197.09	192.83
Sl gp well, gsc w/wiper					6896.6	6211.9	5841.2
Deck leg, adj, pt, ung					460.71	444.86	436.00
Deck leg, adj, ct, ung					586.07	583.10	581.36
Roof drain,open					0	0	0
Rim vent, wmag					14.110	13.609	13.330
GH/SW, wma ugask					12.287	12.287	12.287
Auto gfw, b/g					14.958	14.958	14.958
Access Hatch, b/g					25.643	25.643	25.643
			Total		8215.1	7503.5	7117.6

Table B-5. Calculation of Fitting Emissions for Scans of External Floating Roof Tank 1024

					Scans 178+	Scan 179	Scans 323+	Scans 338+	Scans 235+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	37.211	35.456	38.322	31.828	36.893
Sl gp well, gsc w/sleeve	1	11	46	1.4	542.35	469.48	590.28	330.56	528.87
Deck leg, adj, pt, ung	22	2	0.37	0.91	83.932	80.282	86.238	72.694	83.271
Deck leg, adj, ct, ung	80	0.82	0.53	0.14	119.75	118.96	120.22	117.06	119.61
Roof drain,open	0	1.5	0.21	1.7	0	0	0	0	0
Rim vent, wmag	3	0.71	0.1	1	3.8524	3.6801	3.9620	3.3278	3.8211
GH/SW, wma gask	1	0.47	0.02	0.97	0.5789	0.5683	0.5856	0.5466	0.5770
Auto gfw, b/g	0	2.8	0	1	0	0	0	0	0
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8	4.8	4.8
					792.48	713.22	844.41	560.83	777.85
					Emissions, lb/yr				
Vac Brk, gask					198.79	189.41	205.01	170.27	197.09
Sl gp well, gsc w/sleeve					2897.4	2508.1	3157.8	1768.4	2825.4
Deck leg, adj, pt, ung					448.40	428.89	461.35	388.89	444.86
Deck leg, adj, ct, ung					639.76	635.52	643.16	626.29	639.01
Roof drain,open					0	0	0	0	0
Rim vent, wmag					20.581	19.660	21.195	17.803	20.413
GH/SW, wma gask					3.0930	3.0364	3.1332	2.9242	3.0827
Auto gfw, b/g					0	0	0	0	0
Access Hatch, b/g					25.643	25.643	25.678	25.678	25.643
			Total		4233.7	3810.3	4517.4	3000.3	4155.5

Table B-6. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1025

					Scans 138+	Scans 173+	Scans 319+	Scans 178+	Scans 323+	Scans 338+	Scan 179	Scans 241+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	30.997	38.084	33.891	37.211	38.322	31.828	35.456	36.095
USl gp well, gsc w/wiper	2	14	3.7	0.78	48.647	58.046	52.572	56.924	58.350	49.788	54.642	55.478
Deck leg, adj, pt, ung	22	2	0.37	0.91	70.948	85.745	77.015	83.932	86.238	72.694	80.282	81.613
Deck leg, adj, ct, ung	74	0.82	0.53	0.14	107.83	111.11	109.32	110.77	111.20	108.28	110.03	110.31
Roof drain,open	0	1.5	0.21	1.7	0	0	0	0	0	0	0	0
Rim vent, wmag	2	0.71	0.1	1	2.1653	2.6256	2.3516	2.5682	2.6413	2.21857	2.4534	2.4952
GH/SW, wma gask	1	0.47	0.02	0.97	0.54164	0.58424	0.55896	0.57896	0.58568	0.54660	0.56837	0.57223
Auto gfw, b/ug	1	4.3	17	0.38	32.325	37.945	34.805	37.327	38.110	33.069	36.031	36.512
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
					298.25	338.94	315.32	334.11	340.25	303.23	324.27	327.881
					Emissions, lb/yr							
Vac Brk, gask					165.60	203.46	181.30	198.79	205.01	170.27	189.41	192.83
USl gp well, gsc w/wiper					259.88	310.10	281.25	304.10	312.16	266.35	291.91	296.38
Deck leg, adj, pt, ung					379.02	458.080	412.01	448.39	461.35	388.89	428.89	436.00
Deck leg, adj, ct, ung					576.06	593.61	584.87	591.77	594.92	579.31	587.86	589.32
Roof drain,open					0	0	0	0	0	0	0	0
Rim vent, wmag					11.567	14.027	12.580	13.720	14.130	11.868	13.107	13.330
GH/SW, wma gask					2.8936	3.1212	2.9903	3.0929	3.1332	2.9242	3.0364	3.0570
Auto gfw, b/ug					172.69	202.71	186.20	199.41	203.88	176.91	192.49	195.06
Access Hatch, b/g					25.643	25.643	25.678	25.643	25.678	25.678	25.643	25.643
			Total		1593.4	1810.8	1686.9	1784.9	1820.3	1622.2	1732.4	1751.6

Table B-7. Calculation of RIM Seal Emissions and Total Emissions for External Floating Roof Tanks 1020, 1021, 1024, and 1025

Tank	Scan #	Scan Date	TAA, R	TAA, F	TB, deg R	I	v, mph	TLA, R	TLA, F	Stock liq. temp, R (1)	Withdrawal rate during test, gal/hr	Pva	P*	RIM seal loss		Fitting loss		Withdrawal loss, lb/hr	Total loss, lb/hr
														lb/yr	lb/hr	lb/yr	lb/hr		
1025	138+	7/28	542.92 (July data)	83.25	542.94	1846	5.32	545.4	85.7	549	0	9.784	0.2671	3,193	0.365	1,593	0.182	0	0.55
1025	173+	7/29	542.92 (July data)	83.25	542.94	1846	8.61	545.4	85.7	549	0	9.784	0.2671	4,732	0.540	1,811	0.207	0	0.75
1025	319+	8/6	543.12 (Aug data)	83.45	543.14	1736	6.65	545.5	85.8	549	0	9.792	0.2675	3,822	0.436	1,687	0.193	0	0.63
1025	178+	7/29	542.92 (July data)	83.25	542.94	1846	8.20	545.4	85.7	549	0	9.784	0.2671	4,540	0.518	1,785	0.204	0	0.72
1025	323+	8/6	543.12 (Aug data)	83.45	543.14	1736	8.72	545.5	85.8	549	0	9.792	0.2675	4,791	0.547	1,820	0.208	0	0.75
1025	338+	8/6	543.12 (Aug data)	83.45	543.14	1736	5.70	545.5	85.8	549	0	9.792	0.2675	3,376	0.385	1,622	0.185	0	0.57
1025	179	7/29	542.92 (July data)	83.25	542.94	1846	7.38	545.4	85.7	549	0	9.784	0.2671	4,157	0.474	1,732	0.198	0	0.67
1025	241+	7/31	542.92 (July data)	83.25	542.94	1846	7.68	545.4	85.7	549	0	9.784	0.2671	4,296	0.490	1,752	0.200	0	0.69
1024	178+	7/29	542.92 (July data)	83.25	542.94	1846	8.20	545.4	85.7	549	0	9.784	0.2671	4,540	0.518	4,234	0.483	0	1.00
1024	179	7/29	542.92 (July data)	83.25	542.94	1846	7.38	545.4	85.7	545	0	9.784	0.2671	4,157	0.474	3,810	0.435	0	0.91
1024	323+	8/6	543.12 (Aug data)	83.45	543.14	1736	8.72	545.5	85.8	NA	0	9.792	0.2675	4,791	0.547	4,517	0.516	0	1.06
1024	338+	8/6	543.12 (Aug data)	83.45	543.14	1736	5.70	545.5	85.8	NA	0	9.792	0.2675	3,376	0.385	3,000	0.343	0	0.73
1024	235+	7/31	542.92 (July data)	83.25	542.94	1846	8.05	545.4	85.7	545	273000	9.784	0.2671	4,471	0.510	4,156	0.474	1.176	2.16
1021	182+	7/29	542.92 (July data)	83.25	542.94	1846	8.72	545.4	85.7	546	0	9.784	0.2671	4,785	0.546	8,215	0.938	0	1.48
1021	235+	7/31	542.92 (July data)	83.25	542.94	1846	8.05	545.4	85.7	546	0	9.784	0.2671	4,471	0.510	7,504	0.857	0	1.37
1021	241+	7/31	542.92 (July data)	83.25	542.94	1846	7.68	545.4	85.7	546	0	9.784	0.2671	4,296	0.490	7,118	0.813	0	1.30
1020	182+	7/29	542.92 (July data)	83.25	542.94	1846	8.72	545.4	85.7	543	105000	9.784	0.2671	4,785	0.546	1,957	0.223	0.452	1.22
1020	235+	7/31	542.92 (July data)	83.25	542.94	1846	8.05	545.4	85.7	544	105000	9.784	0.2671	4,471	0.510	1,895	0.216	0.452	1.18
1020	241+	7/31	542.92 (July data)	83.25	542.94	1846	7.68	545.4	85.7	544	105000	9.784	0.2671	4,296	0.490	1,860	0.212	0.452	1.15

(1) Using these temperatures reported by BP instead of the calculated liquid surface temperatures would increase Pva slightly.

Table B-8. Summary of DIAL and Modeled Emissions for External Floating Roof Tanks 1020, 1021, 1024, and 1025

DIAL scans	DIAL emissions, lb/hr	Modeled range low, lb/hr	Modeled range high, lb/hr	EIQ low	EIQ high	Tanks clearly upwind of scans	Other tanks that may be upwind
Scans 138, 139, 140, 141, 148	5.4	0.55	0.55	1.9	1.9	1025	
Scans 173, 174, 175, 176	10.50	0.75	0.75	1.9	1.9	1025	
Scans 319, 320, 321, 322	2.9	0.63	0.63	1.9	1.9	1025	
Scans 179	5	0.91	1.58	1.8	3.7	1024	1025
Scans 178, 180, 181	14.7	1.72	1.72	3.7	3.7	1024, 1025	
Scans 323, 324, 325	6.3	1.82	1.82	3.7	3.7	1024, 1025	
Scans 338, 340	1.00	1.30	1.30	3.7	3.7	1024, 1025	
Scans 182, 183, 184, 185, 187, 188*	15.50	2.71	2.71	3.7	3.7	1020, 1021	
Scans 235, 236	1.3	1.18	4.71	1.8	5.5	1020	1021, 1024
Scans 241, 242, 243	1.3	1.15	3.15	1.8	5.6	1020	1021, 1025
	6.4	1.3	1.9	2.6	3.5		

*Not clear which scan path is used (or if any upwind tanks)

Table B-9. Inputs for Estimating Emissions from External Floating Roof Tanks 1052, 1053, and 1055

Parameter	Characteristic	Variable	Value
Contents	Crude		
Diameter, ft			345
Color	White		
Condition	Good		
Shell	Lt rust		
Construction	Welded		
Primary seal	Mech shoe		
Secondary seal	Rim mounted		
Deck	Double deck		
C			0.006
KRA			0.6
KRB			0.4
n			1
alpha			0.17
Vapor pressure coefficients		A	10.695
		B	4589.2
		C	
Vapor molecular weight		MV	50
Product factor		KC	0.4
Reid vapor pressure		RVP	9
Liquid molecular weight		ML	217
Liquid density, lb/gal		Density	7
Atmospheric pressure, psia		P	14.703
City	Galveston, TX		

Table B-10. Wind Speeds Measured During DIAL Scans of External Floating Roof Tanks 1052, 1053, and 1055

Wind speeds from Table 2.4 of the DIAL report:

Scan #	Wind Speed, m/s
157	4.3
158	4.1
159	3.8
Average	4.07 (9.10 mph)
164	3
	(6.71 mph)
279	3.2
280	2.5
281	3.4
282	3.9
283	3.0
Average	3.20 (7.16 mph)
284	3.1
285	3.9
286	4.6
287	4.2
288	2.8
Average	3.72 (8.32 mph)

Scan #	Wind Speed, m/s
328	3.9
329	3.6
330	3.1
331	3.4
Average	3.50 (7.83 mph)
156	4.60
	(10.29 mph)
163	1.8
165	4.3
166	4.8
167	4.5
168	3.8
Average	3.84 (8.59 mph)
231	3.2
232	3.0
233	3.3
Average	3.17 (7.08 mph)

Table B-11. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1052

					Scans 157+	Scan 164	Scans 279+	Scans 284+	Scans 328+	Scan 156	Scans 163+	Scans 231+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	39.113	34.011	34.9758	37.465	36.415	41.633	38.037	34.815
USl gp well, gsc w/wiper	1	14	3.7	0.78	29.678	26.366	27.005	28.626	27.946	31.260	28.992	26.899
Deck leg, adj, pt, ung	0	2	0.37	0.91	0	0	0	0	0	0	0	0
Deck leg, dbl deck	212	0.82	0.53	0.14	319.44	313.37	314.63	317.63	316.41	321.97	318.27	314.43
Roof drain,open	8	1.5	0.21	1.7	51.091	35.306	38.009	45.597	42.289	60.202	47.460	37.550
Rim vent, wmag	3	0.71	0.1	1	4.0403	3.5392	3.6332	3.8774	3.7741	4.2908	3.9338	3.6175
GH/SW, wma gask	3	0.47	0.02	0.97	1.7714	1.6790	1.6964	1.7414	1.7224	1.817	1.7518	1.6935
Auto gfw, u/g	0	4.3	17	0.38	0	0	0	0	0	0	0	0
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
					449.93	419.07	424.75	439.74	433.36	465.98	443.25	423.80
					Emissions, lb/yr							
Vac Brk, gask					208.95	181.70	187.11	200.43	194.81	222.41	203.20	185.99
USl gp well, gsc w/wiper					158.55	140.85	144.47	153.14	149.50	167.00	154.88	143.70
Deck leg, adj, pt, ung					0	0	0	0	0	0	0	0
Deck leg, dbl deck					1706.5	1674.1	1683.2	1699.2	1692.7	1720.0	1700.3	1679.7
Roof drain,open					272.94	188.62	203.34	243.93	226.239	321.61	253.54	200.60
Rim vent, wmag					21.584	18.907	19.436	20.743	20.190	22.923	21.015	19.326
GH/SW, wma gask					9.4634	8.9700	9.0756	9.3166	9.2147	9.7086	9.3590	9.0474
Auto gfw, u/g					0	0	0	0	0	0	0	0
Access Hatch, b/g					25.643	25.643	25.678	25.678	25.678	25.643	25.643	25.643
			Total		2403.7	2238.8	2272.4	2352.5	2318.4	2489.4	2368.0	2264.1

Table B-12. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1053

					Scans 157+	Scan 156	Scans 163+	Scan 164	Scans 231+	Scans 279+	Scans 328+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	39.113	41.633	38.037	34.011	34.815	34.975	36.415
USl gp well, gsc w/wiper	1	14	3.7	0.78	29.678	31.260	28.992	26.366	26.899	27.005	27.946
Deck leg, adj, pt, ung	0	2	0.37	0.91	0	0	0	0	0	0	0
Deck leg, dbl deck	212	0.82	0.53	0.14	319.44	321.97	318.27	313.37	314.43	314.63	316.41
Roof drain,open	12	1.5	0.21	1.7	76.637	90.303	71.190	52.960	56.325	57.014	63.434
Rim vent, wmag	3	0.71	0.1	1	4.0403	4.2908	3.9338	3.5392	3.6175	3.6332	3.7741
GH/SW, wma gask	2	0.47	0.02	0.97	1.1809	1.2115	1.1679	1.1193	1.1290	1.1309	1.1483
Auto gfw, u/g	0	4.3	17	0.38	0	0	0	0	0	0	0
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8	4.8	4.8	4.8	4.8
					474.89	495.47	466.40	436.16	442.01	443.19	453.93
					Emissions, lb/yr						
Vac Brk, gask					208.96	222.41	203.20	181.70	185.99	187.11	194.81
USl gp well, gsc w/wiper					158.55	167.00	154.88	140.85	143.70	144.47	149.50
Deck leg, adj, pt, ung					0	0	0	0	0	0	0
Deck leg, dbl deck					1706.6	1720.0	1700.3	1674.1	1679.7	1683.2	1692.7
Roof drain,open					409.42	482.42	380.32	282.93	300.91	305.01	339.35
Rim vent, wmag					21.585	22.923	21.015	18.907	19.326	19.436	20.190
GH/SW, wma gask					6.3090	6.4724	6.2393	5.9800	6.0316	6.0504	6.1431
Auto gfw, u/g					0	0	0	0	0	0	0
Access Hatch, b/g					25.643	25.643	25.643	25.643	25.643	25.678	25.678
			Total		2537.0	2647.0	2491.7	2330.2	2361.4	2371.0	2428.4

Table B-13. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 1055

					Scans 279+
Fitting	nf	KFA	KFb	m	Ffi
Vac Brk, gask	5	6.2	1.2	0.94	58.293
USl gp well, gsc w/wiper	1	14	3.7	0.78	27.005
Deck leg, adj, pt, ung	0	2	0.37	0.91	0
Deck leg, dbl deck	295	0.82	0.53	0.14	437.82
Roof drain,open	14	1.5	0.21	1.7	66.516
Rim vent, wmag	2	0.71	0.1	1	2.4221
GH/SW, wma gask	5	0.47	0.02	0.97	2.8274
Auto gfw, u/g	1	4.3	17	0.38	35.662
Access Hatch, b/g	5	1.6	0	1	8
					638.54
					Emissions, lb/yr
Vac Brk, gask					311.41
USl gp well, gsc w/wiper					144.27
Deck leg, adj, pt, ung					0
Deck leg, dbl deck					2338.9
Roof drain,open					355.35
Rim vent, wmag					12.939
GH/SW, wma gask					15.104
Auto gfw, u/g					190.51
Access Hatch, b/g					42.738
			Total		3411.3

Table B-14. Calculation of RIM Seal Emissions and Total Emissions for External Floating Roof Tanks 1052, 1053, and 1055

Tank	Scan #	Scan Date	TAA, R	TAA, F	TB, deg R	I	v, mph	TLA, R	TLA, F	Stock liq. temp, R (1)	Withdrawal rate during test, gal/hr	Pva (psi)	P*	RIM seal loss		Fitting loss		Withdrawal loss, lb/hr	Total loss, lb/hr
														lb/yr	lb/hr	lb/yr	lb/hr		
1052	157+	7/28/2007	542.92 (July data)	83.25	542.9	1846	9.10	545.4	85.7	538	0	9.784	0.2671	7,812	0.892	2,404	0.274	0.0	1.2
1052	164	7/29/2007	542.92 (July data)	83.25	542.9	1846	6.71	545.4	85.7	538	84000 (2)	9.784	0.2671	6,053	0.691	2,239	0.256	0.23	1.2
1052	279+	8/2/2007	543.12 (Aug data)	83.45	543.1	1736	7.16	545.5	85.8	NA	0 (3)	9.792	0.2675	6,392	0.730	2,272	0.259	0.0	1.0
1052	284+	8/2/2007	543.12 (Aug data)	83.45	543.1	1736	8.32	545.5	85.8	NA	0 (4)	9.792	0.2675	7,251	0.828	2,353	0.269	0.0	1.1
1052	328+	8/6/2007	543.12 (Aug data)	83.45	543.1	1736	7.83	545.5	85.8	539	0	9.792	0.2675	6,887	0.786	2,318	0.265	0.0	1.1
1052	156	7/28/2007	542.92 (July data)	83.25	542.9	1846	10.29	545.4	85.7	538	0	9.784	0.2671	8,692	0.992	2,489	0.284	0.0	1.3
1052	163+	7/29/2007	542.92 (July data)	83.25	542.9	1846	8.59	545.4	85.7	538	35000	9.784	0.2671	7,439	0.849	2,368	0.270	0.1	1.2
1052	231+	7/31/2007	542.92 (July data)	83.25	542.9	1846	7.08	545.4	85.7	538	77000	9.784	0.2671	6,328	0.722	2,264	0.258	0.2	1.2
1053	157+	7/28/2007	542.92 (July data)	83.25	542.9	1846	9.10	545.4	85.7	546	105000	9.784	0.2671	7,812	0.892	2,537	0.290	0.3	1.5
1053	156	7/28/2007	542.92 (July data)	83.25	542.9	1846	10.29	545.4	85.7	546	105000	9.784	0.2671	8,692	0.992	2,647	0.302	0.29	1.6
1053	163+	7/29/2007	542.92 (July data)	83.25	542.9	1846	8.59	545.4	85.7	NA	0	9.784	0.2671	7,439	0.849	2,492	0.284	0.0	1.1
1053	164	7/29/2007	542.92 (July data)	83.25	542.9	1846	6.71	545.4	85.7	NA	0	9.784	0.2671	6,053	0.691	2,330	0.266	0.0	1.0
1053	231+	7/31/2007	542.92 (July data)	83.25	542.9	1846	7.08	545.4	85.7	NA	0	9.784	0.2671	6,328	0.722	2,361	0.270	0.0	1.0
1053	279+	8/2/2007	543.12 (Aug data)	83.45	543.1	1736	7.16	545.5	85.8	NA	0	9.792	0.2675	6,392	0.730	2,371	0.271	0.0	1.0
1053	328+	8/6/2007	543.12 (Aug data)	83.45	543.1	1736	7.83	545.5	85.8	549	0	9.792	0.2675	6,887	0.786	2,428	0.277	0.0	1.1
1055	279+	8/2/2007	543.12 (Aug data)	83.45	543.1	1736	7.16	545.5	85.8	NA	0	9.792	0.2675	6,392	0.730	3,411	0.389	0.0	1.1

(1) Using these temperatures reported by BP instead of the calculated liquid surface temperatures would increase Pva slightly.
(2) Several hours of alternately filling and withdrawing. Withdrew 84000 gal in hour during which this scan was conducted.
(3) No data from BP; TCEQ noted withdrawal rate of 58,780 gal/hr for tank 1052 on 8/2.
(4) No data from BP; TCEQ noted withdrawal rate of 73,903 gal/hr for tank 1052 on Aug 2.
(5) Using these temperatures reported by BP instead of the calculated liquid surface temperatures would have little effect on Pva.

Table B-15. Summary of DIAL and Modeled Emissions for External Floating Roof Tanks 1052, 1053, and 1055

DIAL scans	DIAL emissions, lb/hr	Modeled range		EIQ low	EIQ high	Tanks clearly upwind of scans	Other tanks that may be upwind
		low, lb/hr	high, lb/hr				
Scans 157, 158, 159	22.3	2.6	2.6	2.9	2.9	1052, 1053	
Scan 164	6	2.1	2.1	2.9	2.9	1052, 1053	
Scans 279, 280, 281, 282, 283	24.6	3.1	3.1	4.6	4.6	1052, 1053, 1055	
Scans 284, 285, 286, 287, 288	39.6	1.1	1.1	1.5	1.5	1052	
Scans 328, 329, 330, 331	24.3	2.1	2.1	2.9	2.9	1052, 1053	
Scan 156	7	1.6	2.9	1.4	2.9	1053	1052
Scans 163, 165, 166, 167, 168	5.2	1.1	2.3	1.4	2.9	1053	1052
Scans 231, 232, 233	1.5	1.0	2.2	1.4	2.9	1053	1052
Average	16.3	1.8	2.3	2.4	2.9		

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Appendix C

Estimation of Emissions from External Floating Roof Tanks Storing Gasoline and Other Light Distillates

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Table C-1. Inputs for Estimating Emissions from External Floating Roof Tanks 501, 502, 503, and 504

Parameter	Variable	Tank 501	Tank 502	Tank 503	Tank 504
Contents		gasoline	naphtha	raffinate	alkylate
Diameter		144 ft	144 ft	144 ft	144 ft
Color		white	white	white	white
Condition		Good	Good	Good	Good
Shell		Lt rust	Lt rust	Lt rust	Lt rust
Construction		Welded	Welded	Welded	Welded
Primary seal		Mech shoe	Mech shoe	Mech shoe	Mech shoe
Secondary seal		RIM mounted	RIM mounted	RIM mounted	RIM mounted
Deck		pontoon	pontoon	pontoon	pontoon
Shell clingage factor (Cs)		0.0015	0.0015	0.0015	0.0015
Rim seal loss factor (KRA)		0.6	0.6	0.6	0.6
Rim seal loss factor (KRB)		0.4	0.4	0.4	0.4
Wind speed exponent (n)		1	1	1	1
Solar absorptance (alpha)		0.17	0.17	0.17	0.17
Vapor pressure coefficients	A	11.644	12.858	13.599	12.054
	B	5043.6	6488.6	7126.8	5342.9
	C				
Vapor molecular weight	MV	62	90	139	67
Product factor	KC	1	1	1	1
Reid vapor pressure, psia	RVP	13	3.4	2.3	11.6
Liquid molecular weight	ML	92	112	183	97
Slope of ASTM distillation curve	S	3	1.39	0.69	1.89
Liquid density, lb/gal	Density	5.6	6	7	6
Atmospheric pressure, psia	P	14.703	14.703	14.703	14.703

City	Galveston, TX			

Table C-2. Wind Speeds Measured During DIAL Scans of External Floating Roof Tanks 501, 502, 503, and 504

Wind speeds from Table 2.4 of the DIAL report:

Scan #	Wind Speed, m/s
196	2.5
198	2.2
Average	2.35
	(5.26 mph)
205	5.5
207	4.9
208	3.5
Average	4.63
	(10.36 mph)
218	4.1
221	4.5
Average	4.3
	(9.62 mph)

Scan #	Wind Speed, m/s
220	4
224	4.5
Average	4.25
	(9.51 mph)
347	3.1
353	2.7
354	2.6
355	2.9
Average	2.825
	(6.32 mph)
356	2.7
	(6.04 mph)

Table C-3. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 501

					Scans 196+	Scans 205+	Scans 220+	Scans 347+	Scans 218+
Fitting	nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	2	6.2	1.2	0.94	20.567	27.860	26.654	22.110	26.812
Unsl gp well, gsc w/wiper	1	14	3.7	0.78	24.222	31.358	30.227	25.800	30.376
Deck leg, adj, pt, ung	10	2	0.37	0.91	32.108	42.458	40.761	34.316	40.983
Deck leg, adj, ct, ung	25	0.82	0.53	0.14	36.401	37.986	37.776	36.816	37.804
Rim vent, wmag	2	0.71	0.1	1	2.1559	2.8710	2.7509	2.3046	2.7666
GH/SW, wma gask	1	0.47	0.02	0.97	0.5407	0.6067	0.5957	0.5546	0.5971
Auto gfw, u/u	0	14	5.4	1.1	0	0	0	0	0
Access Hatch, b/g	3	1.6	0	1	4.8	4.8	4.8	4.8	4.8
					120.79	147.94	143.56	126.70	144.14
					Emissions, lb/yr				
Vac Brk, gask					421.91	571.52	546.79	454.36	550.02
Unsl gp well, gsc w/wiper					496.88	643.27	620.08	530.20	623.13
Deck leg, adj, pt, ung					658.67	870.99	836.17	705.21	840.73
Deck leg, adj, ct, ung					746.73	779.25	774.94	756.58	775.52
Rim vent, wmag					44.226	58.895	56.433	47.361	56.754
GH/SW, wma gask					11.093	12.446	12.220	11.397	12.250
Auto gfw, u/u					0	0	0	0	0
Access Hatch, b/g					98.467	98.467	98.467	98.640	98.467
			Total		2478.0	3034.9	2945.1	2603.8	2956.9

Table C-4. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 502

					Scans 196+	Scans 220+	Scans 347+	Scans 205+	Scans 218+
Fitting	Nf	KFA	KFb	m	Ffi	Ffi	Ffi	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	30.850	39.982	33.165	41.790	40.218
Sl gp well, gsc w/wiper	1	41	48	1.4	338.42	722.75	425.86	810.37	734.01
Deck leg, adj, pt, ung	10	2	0.37	0.91	32.108	40.761	34.316	42.458	40.983
Deck leg, adj, ct, ung	28	0.82	0.53	0.14	40.769	42.309	41.234	42.544	42.341
Rim vent, wmag	2	0.71	0.1	1	2.1559	2.7509	2.3046	2.8710	2.7666
GH/SW, wma gask	1	0.47	0.02	0.97	0.5407	0.5957	0.5546	0.6067	0.5971
Auto gfw, u/u	0	14	5.4	1.1	0	0	0	0	0
Access Hatch, b/g	2	1.6	0	1	3.2	3.2	3.2	3.2	3.2
					448.05	852.35	540.64	943.84	864.12
					Emissions, lb/yr				
Vac Brk, gask					135.83	176.03	146.20	183.99	177.07
Sl gp well, gsc w/wiper					1490.0	3182.2	1877.4	3567.9	3231.7
Deck leg, adj, pt, ung					141.36	179.46	151.28	186.94	180.44
Deck leg, adj, ct, ung					179.50	186.28	181.77	187.32	186.42
Rim vent, wmag					9.4923	12.112	10.160	12.640	12.181
GH/SW, wma gask					2.3809	2.6229	2.4449	2.6713	2.6292
Auto gfw, u/u					0	0	0	0	0
Access Hatch, b/g					14.089	14.089	14.106	14.089	14.089
			Total		1972.7	3752.8	2383.4	4155.6	3804.6

Table C-5. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 503

Tank 503					Scans 196+	Scan 356
Fitting	nf	KFA	KFb	m	Ffi	Ffi
Vac Brk, gask	3	6.2	1.2	0.94	30.850	32.558
Sl gp well, gsc w/sl&wiper	1	8.3	4.4	1.6	43.679	52.480
Deck leg, adj, pt, ung	10	2	0.37	0.91	32.108	33.739
Deck leg, adj, ct, ung	28	0.82	0.53	0.14	40.769	41.118
Rim vent, wmag	2	0.71	0.1	1	2.1559	2.2655
GH/SW, wma gask	1	0.47	0.02	0.97	0.5407	0.5509
Auto gfw, u/u	0	14	5.4	1.1	0	0
Access Hatch, b/g	2	1.6	0	1	3.2	3.2
					153.30	165.91
					Emissions, lb/yr	
Vac Brk, gask					131.89	139.38
Sl gp well, gsc w/sl&wiper					186.74	224.66
Deck leg, adj, pt, ung					137.27	144.43
Deck leg, adj, ct, ung					174.30	176.03
Rim vent, wmag					9.2173	9.6988
GH/SW, wma gask					2.3119	2.3587
Auto gfw, u/u					0	0
Access Hatch, b/g					13.681	13.699
			Total		655.4	710.3

Table C-6. Calculation of Fittings Emissions for Scans of External Floating Roof Tank 504

					Scans 196+	Scans 205+	Scans 218+	Scans 220+	Scans 347+
Fitting	nf	KFA	KFb	m	Ffi				
Vac Brk, gask	0	6.2	1.2	0.94	0	0	0	0	0
Unsl gp well, gsc w/sleeve	1	14	3.7	0.78	24.222	31.358	30.376	30.227	25.800
Deck leg, adj, pt, ung	10	2	0.37	0.91	32.108	42.458	40.983	40.761	34.316
Deck leg, adj, ct, ung	28	0.82	0.53	0.14	40.769	42.544	42.341	42.309	41.234
Rim vent, wmaug	1	0.71	0.1	1	1.0779	1.4355	1.3833	1.3754	1.1523
GH/SW, wma gask	1	0.47	0.02	0.97	0.5407	0.6067	0.5971	0.5957	0.5546
Auto gfw, u/u	0	14	5.4	1.1	0	0	0	0	0
Access Hatch, b/g	2	1.6	0	1	3.2	3.2	3.2	3.2	3.2
					101.91	121.60	118.88	118.46	106.25
					Emissions, lb/yr				
Vac Brk, gask					0	0	0	0	0
Unsl gp well, gsc w/sleeve					416.85	539.66	522.76	520.20	444.72
Deck leg, adj, pt, ung					552.57	730.69	705.31	701.48	591.52
Deck leg, adj, ct, ung					701.62	732.18	728.68	728.13	710.75
Rim vent, wmaug					18.551	24.704	23.806	23.671	19.863
GH/SW, wma gask					9.3065	10.441	10.277	10.252	9.5598
Auto gfw, u/u					0	0	0	0	0
Access Hatch, b/g					55.0709	55.070	55.070	55.070	55.158
			Total		1754.0	2092.8	2045.9	2038.8	1831.6

Table C-7. Calculation of RIM Seal Emissions and Total Emissions for External Floating Roof Tanks 501, 502, 503, and 504

Tank	Scan #	Scan Date	TAA, R		TAA, F	TB, deg R	I	v, mph	TLA, R	TLA, F	Stock liq. temp, R (1)	Withdrawal rate during test, gal/hr	Pva (psi)	P*	RIM seal loss		Fitting loss		Withdrawal loss, lb/hr	Total loss, lb/hr
															lb/yr	lb/hr	lb/yr	lb/hr		
501	196+	7/30/2007	542.92	(July data)	83.25	542.94	1846	5.26	545.41	85.74	NA	NA	10.9863	0.3309	7,984	0.911	2,478	0.283	0.00	1.2
501	205+	7/30/2007	542.92	(July data)	83.25	542.94	1846	10.36	545.41	85.74	NA	NA	10.9863	0.3309	14,019	1.600	3,035	0.346	0.00	1.9
501	220+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.51	545.41	85.74	NA	NA	10.9863	0.3309	13,006	1.485	2,945	0.336	0.00	1.8
501	347+	8/7/2007	543.12	(Aug data)	83.45	543.14	1736	6.32	545.46	85.79	82	0	10.9961	0.3315	9,256	1.057	2,604	0.297	0.00	1.4
501	218+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.62	545.41	85.74	NA	NA	10.9863	0.3309	13,138	1.500	2,957	0.338	0.00	1.8
502	196+	7/30/2007	542.92	(July data)	83.25	542.94	1846	5.26	545.41	85.74	83	0	2.6150	0.0489	1,714	0.196	1,973	0.225	0.00	0.4
502	220+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.51	545.41	85.74	83	58800	2.6150	0.0489	2,791	0.319	3,753	0.428	0.08	0.8
502	347+	8/7/2007	543.12	(Aug data)	83.45	543.14	1736	6.32	545.46	85.79	85	0	2.6180	0.0490	1,986	0.227	2,383	0.272	0.00	0.5
502	205+	7/30/2007	542.92	(July data)	83.25	542.94	1846	10.36	545.41	85.74	83	0	2.6150	0.0489	3,009	0.343	4,156	0.474	0.00	0.8
502	218+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.62	545.41	85.74	83	58800	2.6150	0.0489	2,820	0.322	3,805	0.434	0.08	0.8
503	196+	7/30/2007	542.92	(July data)	83.25	542.94	1846	5.26	545.41	85.74	79	0	1.7026	0.0308	1,664	0.190	655	0.075	0.00	0.3
503	356	8/7/2007	543.12	(Aug data)	83.45	543.14	1736	6.04	545.46	85.79	88	0	1.7047	0.0308	1,859	0.212	710	0.081	0.00	0.3
504	196+	7/30/2007	542.92	(July data)	83.25	542.94	1846	5.26	545.41	85.74	90	0	9.5629	0.2569	6,698	0.765	1,754	0.200	0.00	1.0
504	205+	7/30/2007	542.92	(July data)	83.25	542.94	1846	10.36	545.41	85.74	90	0	9.5629	0.2569	11,761	1.343	2,093	0.239	0.00	1.6
504	218+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.62	545.41	85.74	90	0	9.5629	0.2569	11,022	1.258	2,046	0.234	0.00	1.5
504	220+	7/30/2007	542.92	(July data)	83.25	542.94	1846	9.51	545.41	85.74	90	0	9.5629	0.2569	10,911	1.246	2,039	0.233	0.00	1.5
504	347+	8/7/2007	543.12	(Aug data)	83.45	543.14	1736	6.32	545.46	85.79	90	0	9.5719	0.2573	7,763	0.886	1,832	0.209	0.00	1.1

(1) Using these temperatures reported by BP instead of the calculated liquid surface temperature typically would increase Pva slightly.

Table C-8. Summary of DIAL and Modeled Emissions for External Floating Roof Tanks 501, 502, 503, and 504

DIAL Scans	DIAL emissions, lb/hr	Modeled Range		EIQ Low	EIQ High	Tanks upwind of scans (low end of range)	Other tanks that may be upwind (high end)
		low, lb/hr	high, lb/hr				
Scans 196, 198	3.5	2.84	2.84	8.6	8.6	501,502,503,504	
Scans 205, 207, 208	8.7	3.53	4.35	7	7.8	501.504	502
Scans 218, 221	5	1.5	4.17	3.5	7.8	504	501,502
Scans 220, 224*	17	4.13	4.13	7.8	7.8	501,502,504	
Scans 347, 353, 354, 355*	2.5	2.95	2.95			501,502,504	
Scan 356	1	0.3	0.3			503	
Average:	8.6	3.0	3.9	6.7	8.0		

*Flux not good for calculating DIAL emissions.

Appendix D

Estimation of Emissions from Vertical Fixed Roof Tanks and External Floating Roof Tanks Storing Various Products

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Table D-1. Estimation of Emissions for Vertical Fixed Roof Product Tanks 53, 54, 55, and 56

		Tank 55	Tank 54	Tank 56	Tank 53	Tank 55	Tank 54	Tank 56	Tank 55
Given:									
Diameter, D		150	120 (2)	150 (2)	120	150	120 (2)	150 2)	150
Shell Height, HS		39.44	39.79 (2)	39.35 (2)	39.96	39.44	39.79 (2)	39.35 2)	39.44
Max Liq. Height, HLX									
Working Vol, V	gal								
Turnovers, N									
Filling rate during DIAL, Q	gal	0	0	0	58,000	0	0	0	0
	bbl	0	0	0	1,381.0	0	0	0	0
Color		White	White (2)	White (2)	White	White	White (2)	White (2)	White
Condition		Good	Poor (2)	Good (2)	Good	Good	Poor (2)	Good (2)	Good
alpha		0.17	0.34	0.17	0.17	0.17	0.34	0.17	0.17
Roof (cone or dome)		cone	cone	cone	cone	cone	cone	cone	cone
cone roof slope, SR		0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
Location		Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX
PA, psia		14.703	14.703	14.703	14.703	14.703	14.703	14.703	14.703
Pressure vent, PBP	psig	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Vacuum Vent, PBV	psig	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
DIAL test date		25-Jul	25-Jul	25-Jul	7-Aug	26-Jul	26-Jul	25-Jul	7-Aug
scan numbers		79, 80, 82, 84	79, 80, 82, 84	79, 80, 82, 84	377,378,379,380	96, 97, 98, 99, 100	96, 97, 98, 99, 100	96, 97, 98, 99, 100	377, 378,
						101, 102, 106, 107, 108	101, 102, 106, 107, 108	101, 102, 106, 107, 108	379, 380
Tank shell radius		75	60	75	60	75	60	75	75
TAX	R	546.97 (3)	546.97 (3)	546.97 (3)	547.37 (3)	546.97 (3)	546.97 (3)	546.97 (3)	547.37 (3)
	C	30.72	30.72	30.72	30.94	30.72	30.72	30.72	30.94
TAN	R	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)
	C	26.22	26.22	26.22	26.22	26.22	26.22	26.22	26.22
TAA	R	542.92	542.92	542.92	543.12	542.92	542.92	542.92	543.12
	C	28.47	28.47	28.47	28.58	28.47	28.47	28.47	28.58
Solar insolation, I		1846 (3)	1846 (3)	1846 (3)	1736 (3)	1846 (3)	1846 (3)	1846 (3)	1736 (3)

(continued)

Table D-1. Estimation of Emissions for Vertical Fixed Roof Product Tanks 53, 54, 55, and 56 (continued)

		Tank 55	Tank 54	Tank 56	Tank 53	Tank 55	Tank 54	Tank 56	Tank 55
Contents:		Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel	Diesel
A		14.532	14.532	14.532	14.532	14.532	14.532	14.532	14.532
B		10202.1	10202.1	10202.1	10202.1	10202.1	10202.1	10202.1	10202.1
C									
MV		151	151	151	151	151	151	151	151
Avg. Liq. Height, HL		14 (4)	16.5 (5)	20 (6)	21	20.9	16.5 (5)	20 (6)	4.35
(during DIAL scans)									
Vapor Space Volume	ft3	477,174	277,541	369,554	228,570	355,240	277,541	369,554	647,703
Vapor Space Outage	ft	27.003	24.540	20.913	20.210	20.103	24.540	20.913	36.653
Roof Outage	ft	1.563	1.250	1.563	1.250	1.563	1.250	1.563	1.563
Roof Height	ft	4.6875	3.7500	4.6875	3.7500	4.6875	3.7500	4.6875	4.6875
Vapor Density	lb/ft3	0.0005982	0.0004713	0.0004934	0.0005668	0.0005982	0.0004713	0.0004934	0.0005971
Liquid Surface Temp	R	558.32	550.72	552.16	556.58	558.32	550.72	552.16	558.26
	F	98.65	91.05	92.49	96.91	98.65	91.05	92.49	98.59
	C	37.03	32.81	33.61	36.06	37.03	32.81	33.61	37.00
Bulk Temp	R	566 (7)	548 (2)	555 (8)	563	566	548 (2)	555 (8)	566 (2)
	F	106.33	88.33	95.33	103.33	106.33	88.33	95.33	106.33
Vapor pressure	psia	0.0237	0.0184	0.0194	0.0224	0.0237	0.0184	0.0194	0.0237
Vapor Space Expansion Factor, Ke		0.0263	0.0421	0.0263	0.0259	0.0263	0.0421	0.0263	0.0259
Delta TV	R	14.61896	23.40592	14.61896	14.38336	14.61896	23.40592	14.61896	14.38336

(continued)

Table D-1. Estimation of Emissions for Vertical Fixed Roof Product Tanks 53, 54, 55, and 56 (continued)

		Tank 55	Tank 54	Tank 56	Tank 53	Tank 55	Tank 54	Tank 56	Tank 55
Highlighted calcs below not needed when true VP<0.1 psia									
TLX	R	562.0	556.6	555.8	560.2	562.0	556.6	555.8	561.9
	C	39.1	36.1	35.6	38.1	39.1	36.1	35.6	39.0
	F	102.3	96.9	96.1	100.5	102.3	96.9	96.1	102.2
TLN	R	554.7	544.9	548.5	553.0	554.7	544.9	548.5	554.7
	C	35.0	29.6	31.6	34.1	35.0	29.6	31.6	35.0
	F	95.0	85.2	88.8	93.3	95.0	85.2	88.8	95.0
PVX	psia	0.02673	0.02241	0.02186	0.02522	0.02673	0.02241	0.02186	0.02663
PVN	psia	0.02104	0.01512	0.01712	0.01990	0.02104	0.01512	0.01712	0.02104
Delta PV	psia	0.00569	0.00729	0.00474	0.00532	0.00569	0.00729	0.00474	0.00559
Vented Vapor Saturation Factor, Ks		0.9671	0.9766	0.9790	0.9765	0.9753	0.9766	0.9790	0.9560
STANDING LOSS	lb/hr	0.3027	0.2242	0.1957	0.1365	0.2273	0.2242	0.1957	0.3989
Turnover factor		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
KP		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WORKING LOSS	lb/hr	0.0000	0.0000	0.0000	4.67	0.00	0.0000	0.0000	0.00
TOTAL LOSS	lb/hr	0.303	0.224	0.196	4.81	0.227	0.224	0.196	0.399

(1) Data in Table are from BP or calculated, except where noted.
(2) From TCEQ.
(3) Value based on historical averages for July and August in Galveston; actual data for test dates not available.
(4) Approximation; slightly less than level at midnight on 7/26. No data from BP before midnight on 7/26. TCEQ did not indicate filling on 7/25.
(5) No data available for 7/25 or 7/26. Value listed is from 7/27.
(6) Assumed half full; no data available.
(7) Elevated temperature reported by BP; not a calculated value.
(8) Assumed. Temp 93 F on 7/27 and dropping slowly. No data for 7/25-7/26.

Table D-2. AP-42 Modeling Input Parameters for EFR Tank 98[a]

Contents	light naphtha
Diameter, ft	150
Color	white
Condition	poor
Shell	Lt rust
Construction	Welded
Primary seal	Mech shoe
Secondary seal	Shoe mounted
Deck	pontoon
Shell clingage factor (Cs)	0.0015
Zero wind speed rim seal loss factor (KRA)	1.6
Wind speed dependent rim seal loss factor (KRB)	0.3
Seal-related wind speed exponent (n)	1.6
Tank paint solar absorptance (alpha)	0.34
Vapor pressure coefficients	
A	12.542
B	5590.15
C	
Vapor molecular weight (MV)	92
Product factor (KC)	1
Reid vapor pressure (RVP)	12.3
Liquid molecular weight (ML)	123
Slope of ASTM distillation	0.77
curve (S)	
Liquid density, lb/gal	
Atmospheric pressure, psia	14.703
City	Galveston, TX

[a]Most of the data are from the TCEQ report, reference 8. Vapor pressure coefficients are from BP, reference 3. Factors are from AP-42, reference 5.

Table D-3. Wind Speeds Measured During DIAL Scans of EFR Tank 98[a]

Date	Scan No.	Wind speed, m/s	Date	Scan No.	Wind speed, m/s
7/25/2007	79	4.5	7/26/2007	96	6
	80	4.1		97	5.3
	82	4.7		98	5.9
	84	4.9		99	4.5
	Average	4.55		100	4.6
		(10.18 mph)		101	5.2
				102	5.3
				106	7.4
				107	7.6
				108	6.3
				Average	5.81
					(13.00 mph)

[a]Data are from Table 2.2 in reference 1.

Table D-4. Calculated Emissions from Fittings on EFR Tank 98 Using Conditions During DIAL Test

Fitting	nf[a]	KFA	KFb	m	Scans 79+ Ffi	Scans 96+ Ffi
Vac Brk, gask	2	6.2	1.2	0.94	27.5986	27.599
Sl gp well, gsc w/wiper&sleeve	1	8.3	4.4	1.6	110.13	110.13
Deck leg, adj, pt, ung	24	2	0.37	0.91	101.02	101.02
Deck leg, adj, ct, ung	36	0.82	0.53	0.14	54.637	54.637
Rim vent, wmaug	2	0.68	1.8	1	27.008	27.008
GH/SW, wma gask	1	0.47	0.02	0.97	0.60434	0.60434
Auto gfw, u/u	0	14	5.4	1.1	0	0
Access Hatch, b/g	2	1.6	0	1	3.2	3.2
					324.19	324.19
					Emissions, lb/yr[b]	
Vac Brk, gask					766.65	766.65
Sl gp well, gsc w/wiper&sleeve					3059.2	3059.2
Deck leg, adj, pt, ung					2806.1	2806.1
Deck leg, adj, ct, ung					1517.7	1517.7
Rim vent, wmaug					750.26	750.26
GH/SW, wma gask					16.788	16.788
Auto gfw, u/u					0	0
Access Hatch, b/g					88.892	88.892
Total					9,005.6	9,005.6

[a]Data are from reference 1.

[b]Emissions estimated using AP-42 procedures, assuming conditions during the DIAL test applied all year.

Table D-5. Calculated Rim Seal and Withdrawal Emissions for EFR Tank 98 When Using Conditions During the DIAL Test

Parameters	Scans 79+	Scans 96+
Scan date	7/25/2007	7/26/2007
Daily average ambient temperature (TAA), °R	542.92	542.92
	(July data)	(July data)
Daily average ambient temperature, °F	83.25	83.25
Liquid bulk temperature, °R	543.96	543.96
Solar insolation factor (I), Btu/ft2·d	1846	1846
Average wind speed (v), mph	10.18	13.00
Daily average liquid surface temperature (TLA), °R	548.5	548.5
Daily average liquid surface temperature, °F	88.8	88.8
Stock liquid temperature, °R	NA	NA
Withdrawal rate during test, gal/hr	0	0
True vapor pressure (Pva), psia	10.476	10.476
Vapor pressure function (P*)	0.3019	0.3019
Rim seal emissions, lb/yr[a]	57,856	82,358
Withdrawal emissions, lb/hr	0	0

[a]Emissions estimated using AP-42 procedures, assuming conditions during the DIAL test applied all year.

Table D-6. Modeled Average Hourly Emissions From EFR Tank 98 During DIAL Test

Scans	Rim seal loss, lb/hr	Fitting loss, lb/hr	Withdrawal loss, lb/hr	Total loss, lb/hr
79+	6.605	1.028	0	7.6
96+	9.402	1.028	0	10.4

Table D-7. Summary of DIAL and Modeled Emissions for Vertical Fixed Roof Product Tanks 53, 54, 55, 56, and EFR Tank 98

DIAL scans	DIAL Emissions, lb/hr	Modeled Range		EIQ low	EIQ high	Tanks clearly upwind of DIAL scans	Other tanks possibly upwind
		Low, b/hr	High, lb/hr				
Scans 79, 80, 82, 84*	1.9	0.3	8.4	1.0	NA	55	54, 56, 98
Scans 96, 97, 98, 99, 100, 101, 102, 106, 107, 108*	4.3	0.2	11.1	1.0	NA	55	54, 56, 98
Average:	3.1	0.3	9.7	1.0			
Scans 377,378,379,380*	23.8	4.8	5.2			53	55

* Maybe others as well, depending on length of scan.

Table D-8. Estimation of Emissions for Vertical Fixed Roof Product Tanks 43, 18, 42, 60, 61, 63, and 65

		Tank 43	Tank 60	Tank 63	Tank 61	Tank 42	Tank 65	Tank 18
Diameter, D		117	117	117	117 (2)	117 (2)	117 (2)	117 (2)
Shell Height, HS		41.67	41.67	41.8	41.8 (2)	39.44 (2)	41.5 (2)	41.29 (2)
Max Liq. Height, HLX								
Working Vol, V	gal							
Turnovers, N								
Filling rate during DIAL, Q	gal	41000	0	0	0	0	0	27300 (2)
	bbl	976.2	0	0	0	0	0	650
Color		Black (2)	Black (2)	Black (2)	Black (2)	Black (2)	Black (2)	White (2)
Condition		Poor (2)	Good (2)	Poor (2)	Poor (2)	Poor (2)	Good (2)	Good (2)
alpha		0.97	0.97	0.97	0.97	0.97	0.97	0.17
Roof (cone or dome)		cone	cone	cone	cone	cone	cone	cone
cone roof slope, SR		0.0625	0.0625	0.0625	0.0625	0.0625	0.0625	0.0625
Location		Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX	Texas City, TX
PA, psia		14.703	14.703	14.703	14.703	14.703	14.703	14.703
Pressure vent, PBP	psig	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Vacuum Vent, PBV	psig	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03
DIAL test date		8-Aug	8-Aug	8-Aug	8-Aug	8-Aug	8-Aug	8-Aug
scan numbers		382,383,384,	399,400,401,	399,400,401,	399,400,401,	399,400,401,	399,400,401,	399,400,401,
		388,389,390	402,403,404	402,403,404	402,403,404	402,403,404	402,403,404	402,403,404
Tank shell radius		58.5	58.5	58.5	58.5	58.5	58.5	58.5
TAX	R	547.37 (3)	547.37 (3)	547.37 (3)	547.37 (3)	547.37 (3)	547.37 (3)	547.37 (3)
	C	30.94	30.94	30.94	30.94	30.94	30.94	30.94
TAN	R	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)	538.87 (3)
	C	26.22	26.22	26.22	26.22	26.22	26.22	26.22
TAA	R	543.12	543.12	543.12	543.12	543.12	543.12	543.12
	C	28.58	28.58	28.58	28.58	28.58	28.58	28.58
Solar insolation, I		1736 (3)	1736 (3)	1736 (3)	1736 (3)	1736 (3)	1736 (3)	1736 (3)
Contents:		Furnaceoil (4)	Furnaceoil (4)	Decantoil	LCCO	LCCO	furnaceoil	kerosene
S					2.05 (2)	2.05 (2)	0.85 (2)	1.5 (2)
RVP					0.06 (2)	0.06 (2)	0.0019 (2)	0.05 (2)

(continued)

Table D-8. Estimation of Emissions for Vertical Fixed Roof Product Tanks 43, 18, 42, 60, 61, 63, and 65 (continued)

		Tank 43		Tank 60		Tank 63		Tank 61		Tank 42		Tank 65		Tank 18	
A		17.514		17.514		16.236		14.124	(5)	14.124	(5)	17.514	(5)	14.785	(5)
B		13317.9		13317.9		11276.3		9478.69	(5)	9478.69	(5)	13317.88	(5)	9950.12	(5)
C															
MV		163		163		163		163		163		163		130	
Avg. Liq. Height, HL		24.5		3.7		21.9		21	(6)	20	(6)	21	(6)	21	(6)
(during DIAL scans)															
Vapor Space Volume	ft3	197,704		421,332		227,055		236,731		222,109		233,506		231,248	
Vapor Space Outage	ft	18.389		39.189		21.119		22.019		20.659		21.719		21.509	
Roof Outage	ft	1.219		1.219		1.219		1.219		1.219		1.219		1.219	
Roof Height	ft	3.6563		3.6563		3.6563		3.6563		3.6563		3.6563		3.6563	
Vapor Density	lb/ft3	0.0001808		0.0000508		0.0006328		0.0017948		0.0026743		0.0001122		0.0006390	
Liquid Surface Temp	R	592.76		559.72		564.20		563.08		577.64		579.88		542.58	
	F	133.09		100.05		104.53		103.41	(7)	117.97	(7)	120.21	(7)	82.91	(7)
	C	56.16		37.80		40.29		39.67		47.76		49.00		28.29	
Bulk Temp	R	608	(8)	549	(8)	557	(8)	555		581		585		538	
	F	148.33		89.33		97.33		95.33		121.33		125.33		78.33	
Vapor pressure	psia	0.0071		0.0019		0.0235		0.0665		0.1017		0.0043		0.0286	
Vapor Space Expansion Factor, Ke		0.0959		0.0959		0.0959		0.0959		0.0935		0.0959		0.0259	
Delta TV	R	53.26976		53.26976		53.26976		53.26976		53.26976		53.26976		14.38336	

(continued)

Highlighted calcs below not needed when true VP<0.1 psia															
TLX	R	606.1		573.0		577.5		576.4		591.0		593.2		546.2	
	C	63.6		45.2		47.7		47.1		55.2		56.4		30.3	
	F	146.4		113.4		117.8		116.7		131.3		133.5		86.5	
TLN	R	579.4		546.4		550.9		549.8		564.3		566.6		539.0	
	C	48.8		30.4		32.9		32.3		40.4		41.6		26.3	
	F	119.8		86.7		91.2		90.1		104.6		106.9		79.3	
PVX	psia	0.01156		0.00326		0.03727		0.09816		0.14720		0.00717		0.03229	
PVN	psia	0.00421		0.00105		0.01450		0.04425		0.06904		0.00250		0.02532	
Delta PV	psia	0.00735		0.00221		0.02277		0.05391		0.07816		0.00468		0.00697	

Table D-8. Estimation of Emissions for Vertical Fixed Roof Product Tanks 43, 18, 42, 60, 61, 63, and 65 (continued)

		Tank 43	Tank 60	Tank 63	Tank 61	Tank 42	Tank 65	Tank 18
Vented Vapor Saturation Factor, Ks		0.9932	0.9961	0.9744	0.9280	0.8998	0.9951	0.9684
STANDING LOSS	lb/hr	0.1419	0.0852	0.5594	1.5752	2.0814	0.1041	0.1544
Turnover factor		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
KP		1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
WORKING LOSS	lb/hr	1.1229	0.0000	0.0000	0.00	0.00	0.00	2.42
TOTAL LOSS	lb/hr	1.265	0.085	0.559	1.58	2.08	0.10	2.57

(1) Data in table from BP or calculated, except where noted.
(2) From TCEQ.
(3) Value based on historical averages for August in Galveston; actual data for test dates not available.
(4) BP information indicates this tank was storing fuel oil #6; assumed characteristics for furnace oil approximate those of fuel oil #6.
(5) Calculated using equations in Figure 7.1-15 of AP-42.
(6) Assumed half full.
(7) From TCEQ. Assumed bulk temperature that gives this result.
(8) Elevated temperature reported by BP; not a calculated value.

Table D-9. AP-42 Modeling input Parameters for EFR Tanks 11 and 12[a]

Parameters	tank 11	tank 12
Contents	light naphtha	light naphtha
Diameter, ft	117	117
Volume		
Turnovers		
Color	white	white
Condition	Good	Good
Shell	Lt rust	Lt rust
Construction	Welded	Welded
Primary seal	Mech shoe	Mech shoe
Secondary seal	Rim mounted	Rim mounted
Deck	pontoon	pontoon
Shell clingage factor (Cs)	0.0015	0.0015
Zero wind speed rim seal loss factor (KRA)	0.6	0.6
Wind speed dependent rim seal loss factor (KRB)	0.4	0.4
Seal-related wind speed exponent (n)	1	1
Tank paint solar absorptance factor (alpha)	0.17	0.17
Vapor pressure coefficients		
A	12.542	12.542
B	5590.15	5590.15
C		
Vapor molecular weight (MV)	92	92
Product factor (Kc)	1	1
Reid vapor pressure (RVP)	12.3	12.3
Liquid molecular weight (ML)	123	123
Slope of ASTM distillation curve (S)	0.77	0.77
Liquid density, lb/gal		
Atmospheric pressure (P), psia	14.703	14.703
City	Galveston, TX	Galveston, TX

[a]Most of the data are from the TCEQ report, reference 8. Vapor pressure coefficients are from BP, reference 3. Factors are from AP-42, reference 5.

Table D-10. Wind Speeds Measured During DIAL Scans of EFR Tanks 11 and 12[a]

Scan No.	Windspeed, m/s
399	2.2
400	1.9
401	2.1
402	2.2
403	2
404	1.6
Average	2 (4.47 mph)

[a]Data are from Table 2.2 in reference 1.

Table D-11. Calculated Emissions From Fittings on EFR Tank 11 Using Conditions During DIAL Test

Fitting	nf[a]	KFA	KFb	m	Scans 399+ Ffi
Vac Brk, gask	2	6.2	1.2	0.94	19.418
Unsl gp well, gsc w/wiper	1	14	3.7	0.78	23.014
Deck leg, adj, pt, ung	8	2	0.37	0.91	24.365
Deck leg, adj, ct, ung	17	0.82	0.53	0.14	24.511
Rim vent, wmag	2	0.71	0.1	1	2.0463
GH/SW, wma gask	1	0.47	0.02	0.97	0.53052
Auto gfw, u/u	0	14	5.4	1.1	0
Access Hatch, b/g	1	1.6	0	1	1.6
					95.485
					Emissions, lb/yr[b]
Vac Brk, gask					487.52
Unsl gp well, gsc w/wiper					577.79
Deck leg, adj, pt, ung					611.71
Deck leg, adj, ct, ung					615.39
Rim vent, wmag					51.376
GH/SW, wma gask					13.319
Auto gfw, u/u					0
Access Hatch, b/g					80.340
Total					2437.4

[a]Data are from reference 1.
[b]Emissions estimated using AP-42 procedures, assuming conditions during the DIAL test applied all year.

Table D-12. Calculated Emissions From Fittings on EFR Tank 12 Using Conditions During DIAL Test

Fitting	nf[a]	KFA	KFb	m	Scans 399+ Ffi
Vac Brk, gask	2	6.2	1.2	0.94	19.418
Unsl gp well, gsc w/wiper	1	14	3.7	0.78	23.014
Deck leg, adj, pt, ung	8	2	0.37	0.91	24.365
Deck leg, adj, ct, ung	17	0.82	0.53	0.14	24.511
Rim vent, wmag	2	0.71	0.1	1	2.0463
GH/SW, wma gask	1	0.47	0.02	0.97	0.53052
Auto gfw, u/u	0	14	5.4	1.1	0
Access Hatch, b/g	2	1.6	0	1	3.2
					97.085
					Emissions, lb/yr[b]
Vac Brk, gask					487.52
Unsl gp well, gsc w/wiper					577.79
Deck leg, adj, pt, ung					611.71
Deck leg, adj, ct, ung					615.39
Rim vent, wmag					51.376
GH/SW, wma gask					13.319
Auto gfw, u/u					0
Access Hatch, b/g					80.340
Total					2437.4

[a]Data are from reference 1.
[b]Emissions estimated using AP-42 procedures, assuming conditions during the DIAL test applied all year.

Table D-13. Calculated Rim Seal and Withdrawal Emissions for EFR Tanks 11 and 12 When Using Conditions During the DIAL Test

Scans	Scans 399+
Scan date	8/8/2007
Daily average ambient temperature (TAA), °R	543.12
	(Aug data)
Daily average ambient temperature, °F	83.45
Liquid bulk temperature, °R	543.14
Solar insolation factor (I), Btu/ft2·d	1736
Average wind speed (v), mph	4.47
Daily average liquid surface temperature (TLA), °R	545.46
Daily average liquid surface temperature, °F	85.793
Stock liquid temperature, °R	NA
Withdrawal rate during test, gal/hr	0
True vapor pressure (Pva), psia	9.9055
Vapor pressure function (P*)	0.2729
Rim seal emissions, lb/yr[a]	7,019
Withdrawal emissions, lb/hr	0

[a]Emissions estimated using AP-42 procedures, assuming conditions during the DIAL test applied all year.

Table D-14. Modeled Average Hourly Emissions From EFR Tank 98 During DIAL Test

Scans	Rim seal loss, lb/hr	Fitting loss, lb/hr	Withdrawal loss, lb/hr	Total loss, lb/hr
11	399+	0.801	0.274	0.00
12	399+	0.801	0.278	0.00

Table D-15. Summary of DIAL and Modeled Emissions for Vertical Fixed Roof Product Tanks 53, 54, 55, 56, and EFR Tank 98

DIAL scans	DIAL Emissions, lb/hr	Modeled Range		EIQ, Low	EIQ, High	Tanks clearly upwind of DIAL scans	Other tanks that may be upwind
		Low, b/hr	High, lb/hr				
Scans 382, 383, 384	2	1.3	1.3	0.2	0.2	43	
Scans 388, 389, 390	9.3	1.3	1.3	0.2	0.2	43	
Scans 399-404	9	0.6	9.1	4.6	NA	60, 63	11, 12, 18, 42, 61, 65
Upwind	<1	4.7				11,12,18	

* Maybe others as well, depending on length of scan.

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Appendix E

Activated Sludge Unit Characteristics and Compound Properties Reported by BP

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Table E-1. Activated Sludge Unit Parameters for WATER9 Modeling

Unit Name	Parameter	WATER9 Input
F-8 Activated Sludge Unit	Wastewater Temperature (°C)	29
	Length of Aeration Unit (m)	56.8
	Width of Aeration Unit (m)	56.8
	Depth of Aeration Unit (m)	6.7
	Area of Agitation (each aerator, m^2)	400
	Total Number of Agitators in the Unit	5
	Power of agitation (each aerator, HP)	150
	Impeller Diameter (cm)	274.32
	Impeller Rotation (RPM)	47
	Agitator Mechanical Efficiency	0.83
	Aerator Effectiveness, alpha	0.83
	If there is a plug flow, enter 1	0
	Overall Biorate (mg/g bio-hour)	19
	Aeration Air Flow (m^3/s)	0.133
	Activated Sludge Biomass (g/l)	3
	If covered, then enter 1	0
	Agitator Pump Rate (m^3/s each)	4
	pH	7.25

Table E-2. Pollutant Properties in BP WATER9 Modeling

Parameter	Generic Organic Material	Ammonia	Benzene	Ethyl-benzene	MTBE	Naphthalene	Styrene	Toluene	1,3,5-TMB	Xylene	Xylene (m-)	Xylene (o-)	Propyl-benzene	1,2,4-TMB
Molecular Weight	100	17.03	78.11	106.2	83.1	128.2	104.2	92.4	120.2	106.2	106.2	106.17	120.19	120.21
Vapor Pressure, mmHg at 25°C	25	7470	95.2	10	185.949	0.23	7.3	30	2.4	8.5	8	7	0.73886	2.1
Density	1	0.6818	0.874	0.87	0.97	1.14	0.9	0.87	1.02	1.02	0.86	0.88	1	0.876
Boiling Point (°C)	125	-33.4	80	136.2	64	218	145	110.7	163.037	140	139	144.4	157.876	169
Antoine's Coefficients, a	6.859312	7.55466	6.905048	6.975	6.85249	7.3729	6.945357	6.954	7.07436	7.940135	7.009	6.998	6.873484	8.178473
Antoine's Coefficients, b	1354.71	1002.711	1211.033	1424.255	1103.737	1968.36	1437.432	1344.8	1569.22	2090.317	1462.266	1474.679	1465.873	2342.421
Antoine's Coefficients, c	215.5096	247.885	220.7996	213.21	222.72	222.61	208.38	219.48	209.58	273.16	215.11	213.69	209.2632	273.16
Henry's Law Constants	Measured-Ind. Estim.	DIPPR911	Yaws & Yang, 1992 S	Mackay & Shiu 1981 L S	Kartkopf 1973 M S	RTI	Yaws & Yang, 1992 S	Yaws & Yang, 1992 S	Mackay & Shiu 1981 L S	Superfund	Staudingner 1996 L S	DIPPR911	Yaws & Yang, 1992 S	Sanemasa (1982)
K, (y/x) 25 °C	1	3.3799	308.33	437.807	34.722	66.693	150.149	356.67	326.794	389.684	413	269.287	566.888	342.21
K, (y/x) 100 °C	10	0	1930	4270	267	710	1720	2100	1.13E+05	3786.025	3250	2550	6594.797	4285.293
D_l (cm^2/s)	9.57E-06	6.93E-05	1.02E-05	7.80E-06	1.05E-05	7.50E-06	8.00E-06	8.60E-06	8.67E-06	9.34E-06	7.80E-06	1.00E-05	8.57E-06	7.92E-06
D_v (cm^2/s)	0.0782	0.259	0.088	0.075	0.1024	0.059	0.071	0.087	0.0602	0.0737	0.07	0.087	0.0643	0.0606
Solubility (ppmw)	210.297	4.82E+05	1796.573	152	3.66E+04	80.318	300	515	2	169.334	200	175	11.451	57
Hydrolysis Rate (l/s)	0	5.60E-10	0	0	5012	0	0	0	0	0.091	0.07	0.12	0	0
Log_{10} Octanol-Water	0	0.23	2.15	3.15	0.94	3.37	3.16	2.69	3.9997	3.15	3.2	2.95	3.5953	3.63
K_{max} (mg/g-hr)	19	19	19.1	6.8	17.56	42.47	31.1	73.48	31.1	40.8	31.1	40.79	15.3	15.3
K_1 (l/g-hr)	1.1	0.043	120	2.1	0.712684	1	0.11	2.4	4.469394	1.8	2.219942	1.8	3.137307	3.23402

Table E-3. Default Pollutant Parameters in WATER9 that Differ from Values Used by BP

Parameter	Generic Organic Material	Ammonia	Benzene	Ethyl-benzene	MTBE	Naphthalene	Styrene	Toluene	1,3,5-TMB	Xylene	Xylene (m-)	Xylene (o-)	Propyl-benzene	1,2,4-TMB
Molecular Weight					88.13									
Vapor Pressure, mmHg at 25 °C					250								3.4	
Density										0			0.86	
Boiling Point (°C)					55.2								159	
Antoine's Coefficients, a										0			6.95142	0
Antoine's Coefficients, b										0			1491.297	0
Antoine's Coefficients, c										0			207.14	0
K, (y/x) 25 °C													593.516	
K, (y/x) 100 °C										0			0	0
Dl (cm^2/s)										0			0	0
Dv (cm^2/s)										0			0	0
Solubility (ppmw)	8,000		1,790							0			52	
Hydrolysis Rate (l/s)										0	0	0		
Log_{10} Octanol-Water			2.13										3.69	
K_{max} (mg/g-hr)		0											0	0
K_1 (l/g-hr)		0	1.4										0	0

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Appendix F

Flare Gas Flow and Composition Data and Estimated C3+ Controlled Emissions

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Table F-1. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for Flare No. 6

PV Label PV Name Eng Unit MW Agg Type Date	TORCH 6 Sel Flow Valid Flow Mscf/hr 1H Value	CO2 Carbon dioxide mole% 44.00 1H Value	C2H4 Ethylene mole% 28.05 1H Value	C2H6 Ethane mole% 30.07 1H Value	C2H2 Acetylene mole% 26.04 1H Value	H2 Hydrogen mole% 2.00 1H Value	O2 Oxygen mole% 16.00 1H Value	N2 Nitrogen mole% 28.00 1H Value	CH4 Methane mole% 16.04 1H Value
7/30/2007 0:00	32.613	0.5167	0	3.4919	0	0	0	2.4815	83.108
7/30/2007 1:00	32.659	0.5240	0	3.1919	0	0	0	2.7656	83.404
7/30/2007 2:00	33.024	0.5219	0	3.5339	0	0	0	2.5172	83.719
7/30/2007 3:00	32.849	0.5346	0	3.4284	0	0	0	2.7949	83.913
7/30/2007 4:00	33.244	0.5274	0	3.2423	0	0	0	2.5329	84.571
7/30/2007 5:00	33.375	0.5243	0	3.7864	0	0	0	2.8356	83.813
7/30/2007 6:00	33.213	0.5310	0	3.4451	0	0	0	2.6267	85.817
7/30/2007 7:00	33.414	0.5420	0	3.5173	0	0	0	2.8172	84.213
7/30/2007 8:00	33.559	0.5307	0	3.7420	0	0	0	2.5639	84.135
7/30/2007 9:00	36.978	0.5473	0	3.2971	0	0	0	2.8269	84.343
7/30/2007 10:00	36.993	0.5419	0	3.9721	0	0	0	2.5949	83.547
7/30/2007 11:00	37.340	0.5739	0	3.3550	0	0	0	2.7906	83.456
7/30/2007 12:00	37.998	0.5578	0	3.8770	0	0	0	2.5959	81.844
7/30/2007 12:38									
7/30/2007 12:50									
7/30/2007 13:00	38.841	0.5412	0	3.7654	0	0	0	2.7985	81.345
7/30/2007 14:00	37.237	0.5399	0	3.4987	0	0	0	2.7660	81.306
7/30/2007 14:52									
7/30/2007 15:00	34.741	0.5419	0	3.0280	0	0	0	2.4746	81.636
7/30/2007 15:03									
7/30/2007 15:16									
7/30/2007 15:55									
7/30/2007 16:00	29.996	0.5448	0	3.2335	0	0	0	2.6417	80.973
7/30/2007 16:44									
7/30/2007 16:55									
7/30/2007 17:00	28.226	0.5178	0	3.1107	0	0	0	2.7176	80.639
7/30/2007 18:00	27.552	0.5292	0	3.2531	0	0	0	2.4881	80.541
7/30/2007 19:00	28.878	0.5113	0	3.6702	0	0	0	2.6654	79.337
7/30/2007 20:00	31.722	0.5105	0	3.2158	0	0	0	2.6222	80.469
7/30/2007 21:00	32.469	0.5151	0	2.9536	0	0	0	2.5825	81.729
7/30/2007 22:00	36.385	0.5089	0	2.8610	0	0	0	2.5745	81.999
7/30/2007 23:00	41.731	0.4765	0	2.9099	0	0.8263	0	4.2064	72.323
8/7/2007 0:00	34.180	1.1882	0	2.7139	0	1.2264	0.0248	5.2379	58.904
8/7/2007 0:25									
8/7/2007 0:44									
8/7/2007 1:00	33.356	1.1194	0	3.5409	0	0.3031	0.0249	2.9891	77.200
8/7/2007 1:02									
8/7/2007 2:00	33.004	1.1512	0	3.5855	0	0.1256	0.0187	2.8070	79.939
8/7/2007 3:00	33.334	1.1371	0	3.8070	0	0	0	2.4933	81.040
8/7/2007 4:00	33.042	1.1251	0	3.6424	0	0	0	2.7251	81.687
8/7/2007 5:00	32.606	1.1339	0	3.6343	0	0	0	2.5741	81.267
8/7/2007 5:52									
8/7/2007 6:00	32.566	1.1497	0	3.5395	0	0	0	2.7481	81.641
8/7/2007 6:10									
8/7/2007 7:00	32.500	1.1441	0	3.6443	0	0	0	2.5459	82.080
8/7/2007 8:00	32.987	1.1555	0	3.5984	0	0	0	2.6923	82.196
8/7/2007 9:00	37.572	1.1447	0	3.6552	0	0	0	2.5220	81.689
8/7/2007 10:00	36.969	1.1443	0	3.5430	0	0	0	2.7030	81.251
8/7/2007 11:00	36.691	1.1494	0	3.6207	0	0	0	2.5989	81.327
8/7/2007 12:00	36.988	1.1433	0	3.5452	0	0	0	2.6780	80.090
8/7/2007 13:00	36.495	1.1314	0	3.5726	0	0	0	2.5947	79.974
8/7/2007 14:00	35.027	1.1386	0	3.5755	0	0	0	2.6141	79.794
8/7/2007 15:00	31.459	1.1131	0	3.5789	0	0	0	2.5809	79.437
8/7/2007 16:00	27.497	1.1223	0	3.5161	0	0	0	2.5824	79.412
8/7/2007 17:00	25.604	1.1122	0	3.5750	0	0	0	2.5147	79.742
8/7/2007 18:00	27.845	1.1161	0	3.5969	0	0	0	2.6393	79.206
8/7/2007 19:00	30.275	1.0983	0	3.6399	0	0	0	2.5323	79.312
8/7/2007 20:00	32.742	1.1041	0	3.6949	0	0	0	2.6270	79.549
8/7/2007 21:00	33.908	1.0918	0	3.7181	0	0	0	2.5889	79.742
8/7/2007 22:00	33.774	1.0969	0	3.6234	0	0	0	2.5866	79.880
8/7/2007 23:00	34.009	1.0897	0	3.6466	0	0	0	2.4449	80.197

Table F-1. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for Flare No. 6 (continued)

PV Label PV Name Eng Unit MW Agg Type Date	CO Carbon monoxide mole% 28.00 1H Value	C3H8 Propane mole% 44.09 1H Value	C4H10 Isobutane mole% 58.12 1H Value	H2S Hydrogen sulfide mole% 34.00 1H Value	C4H10 Butane mole% 58.12 1H Value	C4H8 1-Butene mole% 56.10 1H Value	C4H8 trans 2-Butene mole% 56.10 1H Value	C4H8 cis 2-Butene mole% 56.10 1H Value	C4H6 1,3-Butadiene mole% 54.09 1H Value
7/30/2007 0:00	0	0.3462	0.3119	0	0.1497	0	0	0	0
7/30/2007 1:00	0	0.3057	0.3015	0	0.1497	0	0	0	0
7/30/2007 2:00	0	0.3213	0.3067	0	0.1497	0	0	0	0
7/30/2007 3:00	0	0.3152	0.3214	0	0.1498	0	0	0	0
7/30/2007 4:00	0	0.2996	0.3245	0	0.1498	0	0	0	0
7/30/2007 5:00	0	0.3370	0.3204	0	0.1602	0	0	0	0
7/30/2007 6:00	0	0.3342	0.2884	0	0.1593	0	0	0	0
7/30/2007 7:00	0	0.3329	0.2746	0	0.1498	0	0	0	0
7/30/2007 8:00	0	0.4079	0.2851	0	0.1498	0	0	0	0
7/30/2007 9:00	0	0.3839	0.3225	0	0.1727	0.00208	0	0	0
7/30/2007 10:00	0	0.4992	0.3266	0	0.1747	0.00312	0	0	0
7/30/2007 11:00	0	0.4367	0.3140	0	0.1747	0	0	0	0
7/30/2007 12:00	0	0.5277	0.2472	0	0.1745	0	0	0	0
7/30/2007 12:38									
7/30/2007 12:50									
7/30/2007 13:00	0	0.7407	0.4291	0	0.2109	0	0	0	0
7/30/2007 14:00	0	0.6073	0.3406	0	0.1682	0.00207	0	0	0
7/30/2007 14:52									
7/30/2007 15:00	0	0.4557	0.3197	0	0.1516	0.00520	0	0	0
7/30/2007 15:03									
7/30/2007 15:16									
7/30/2007 15:55									
7/30/2007 16:00	0	0.4233	0.3600	0	0.1494	0.00310	0	0	0
7/30/2007 16:44									
7/30/2007 16:55									
7/30/2007 17:00	0	0.4171	0.3829	0	0.1557	0.00311	0	0	0
7/30/2007 18:00	0	0.4618	0.3341	0	0.1494	0	0	0	0
7/30/2007 19:00	0	0.5839	0.3682	0	0.1577	0.00311	0	0	0
7/30/2007 20:00	0	0.4971	0.3787	0	0.1598	0	0	0	0
7/30/2007 21:00	0	0.3895	0.3770	0	0.1527	0.00830	0	0	0
7/30/2007 22:00	0	0.3115	0.3697	0	0.1620	0.00415	0	0	0
7/30/2007 23:00	0	8.3158	0.3426	0	0.1319	0.01243	0	0	0
8/7/2007 0:00	0	18.6166	0.2091	0	0.1170	0	0	0	0
8/7/2007 0:25									
8/7/2007 0:44									
8/7/2007 1:00	0	3.5306	0.4991	0	0.1722	0	0	0	0
8/7/2007 1:02									
8/7/2007 2:00	0	1.6714	0.3031	0	0.1495	0	0	0	0
8/7/2007 3:00	0	0.8120	0.4892	0	0.1682	0	0	0	0
8/7/2007 4:00	0	0.6327	0.3303	0	0.1496	0	0	0	0
8/7/2007 5:00	0	0.6157	0.4569	0	0.1682	0	0	0	0
8/7/2007 5:52									
8/7/2007 6:00	0	0.5837	0.3500	0	0.1558	0	0	0	0
8/7/2007 6:10									
8/7/2007 7:00	0	0.5892	0.4499	0	0.1683	0	0	0	0
8/7/2007 8:00	0	0.5756	0.3398	0	0.1746	0	0	0	0
8/7/2007 9:00	0	0.6108	0.3781	0	0.1839	0	0	0	0
8/7/2007 10:00	0	0.6137	0.4850	0	0.1952	0	0	0	0
8/7/2007 11:00	0	0.7239	0.3416	0	0.1786	0	0	0	0
8/7/2007 12:00	0	0.9502	0.4564	0	0.1971	0	0	0	0
8/7/2007 13:00	0	0.7290	0.4086	0	0.1836	0	0	0	0
8/7/2007 14:00	0	0.6554	0.3806	0	0.1732	0	0	0	0
8/7/2007 15:00	0	0.6436	0.4602	0	0.1648	0	0	0	0
8/7/2007 16:00	0	0.6155	0.4196	0	0.1679	0	0	0	0
8/7/2007 17:00	0	0.6064	0.3743	0	0.1586	0	0	0	0
8/7/2007 18:00	0	0.6114	0.4426	0	0.1534	0	0	0	0
8/7/2007 19:00	0	0.6144	0.4009	0	0.1595	0	0	0	0
8/7/2007 20:00	0	0.8314	0.3721	0	0.1576	0	0	0	0
8/7/2007 21:00	0	0.8418	0.4044	0	0.1680	0	0	0	0
8/7/2007 22:00	0	0.6075	0.4023	0	0.1742	0	0	0	0
8/7/2007 23:00	0	0.6003	0.3971	0	0.1638	0	0	0	0

Table F-1. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for Flare No. 6 (continued)

PV Label PV Name Eng Unit MW Agg Type Date	H2O Water mole% 18.00 1H Value	C5 Plus mole% 1H Value	Propylene mole% 42.08 1H Value	Assumed MW C5+	Calculated C3+ entering Flare 6, lb/hr	Anticipated C3+ emissions, lb/hr (98% reduction)	DIAL Emissions, lb/hr
7/30/2007 0:00	0	9.5939	0	80	696.66	13.9	
7/30/2007 1:00	0	9.3576	0	80	679.29	13.6	
7/30/2007 2:00	0	8.9303	0	80	657.97	13.2	
7/30/2007 3:00	0	8.5423	0	80	628.09	12.6	
7/30/2007 4:00	0	8.3522	0	80	621.86	12.4	
7/30/2007 5:00	0	8.2233	0	80	617.00	12.3	
7/30/2007 6:00	0	6.7981	0	80	512.31	10.2	
7/30/2007 7:00	0	8.1528	0	80	609.70	12.2	
7/30/2007 8:00	0	8.0541	0.1311	80	613.73	12.3	
7/30/2007 9:00	0	8.0521	0.0520	80	675.35	13.5	
7/30/2007 10:00	0	8.2901	0.0499	80	699.48	14.0	
7/30/2007 11:00	0	8.8489	0.0499	80	746.47	14.9	
7/30/2007 12:00	0	10.1263	0.0499	80	862.19	17.2	
7/30/2007 12:38							3
7/30/2007 12:50							3
7/30/2007 13:00	0	10.1190	0.0499	80	903.36	18.1	3
7/30/2007 14:00	0	10.7217	0.0498	80	900.28	18.0	
7/30/2007 14:52							3
7/30/2007 15:00	0	11.3460	0.0415	80	877.42	17.5	
7/30/2007 15:03							11
7/30/2007 15:16							2
7/30/2007 15:55							3
7/30/2007 16:00	0	11.6341	0.0374	80	776.20	15.5	
7/30/2007 16:44							3
7/30/2007 16:55							4
7/30/2007 17:00	0	12.0058	0.0498	80	754.00	15.1	
7/30/2007 18:00	0	12.1714	0.0716	80	745.27	14.9	
7/30/2007 19:00	0	12.6739	0.0290	80	816.51	16.3	
7/30/2007 20:00	0	12.1030	0.0436	80	856.48	17.1	
7/30/2007 21:00	0	11.2540	0.0384	80	814.18	16.3	
7/30/2007 22:00	0	11.1670	0.0426	80	902.44	18.0	
7/30/2007 23:00	0	10.3817	0.0737	80	1352.73	27.1	
8/7/2007 0:00	0	11.7583	0.0041	80	1605.83	32.1	
8/7/2007 0:25							37
8/7/2007 0:44							22
8/7/2007 1:00	0	10.5955	0.0249	80	918.26	18.4	
8/7/2007 1:02							13
8/7/2007 2:00	0	10.2239	0.0249	80	800.24	16.0	
8/7/2007 3:00	0	10.0280	0.0249	80	771.61	15.4	
8/7/2007 4:00	0	9.6910	0.0166	80	725.15	14.5	
8/7/2007 5:00	0	10.1350	0.0145	80	752.69	15.1	
8/7/2007 5:52							18
8/7/2007 6:00	0	9.8261	0.0062	80	723.05	14.5	
8/7/2007 6:10							18
8/7/2007 7:00	0	9.3718	0.0062	80	696.23	13.9	
8/7/2007 8:00	0	9.2589	0.0093	80	693.14	13.9	
8/7/2007 9:00	0	9.8056	0.0104	80	837.16	16.7	
8/7/2007 10:00	0	10.0587	0.0062	80	850.14	17.0	
8/7/2007 11:00	0	10.0399	0.0197	80	838.55	16.8	
8/7/2007 12:00	0	10.8807	0.0591	80	929.90	18.6	
8/7/2007 13:00	0	11.3629	0.0435	80	941.19	18.8	
8/7/2007 14:00	0	11.6437	0.0249	80	918.30	18.4	
8/7/2007 15:00	0	11.9970	0.0249	80	851.24	17.0	
8/7/2007 16:00	0	12.1398	0.0249	80	749.84	15.0	
8/7/2007 17:00	0	11.8917	0.0249	80	682.39	13.6	
8/7/2007 18:00	0	12.2097	0.0249	80	763.66	15.3	
8/7/2007 19:00	0	12.2174	0.0249	80	829.24	16.6	
8/7/2007 20:00	0	11.6395	0.0249	80	863.60	17.3	
8/7/2007 21:00	0	11.4204	0.0249	80	881.30	17.6	
8/7/2007 22:00	0	11.6048	0.0249	80	881.96	17.6	
8/7/2007 23:00	0	11.4355	0.0249	80	874.86	17.5	

Table F-2. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for the Temporary Flare

Date	Flare Header Flow Tag (High) MSCFH	Flare Header Flow Tag (Low) MSCFH	Carbon Dioxide 44.00 mole %	Ethylene 28.05 mole %	Ethane 30.07 mole %	Acetylene 26.04 mole %	Hydrogen 2.00 mole %	Oxygen 16.00 mole %	Nitrogen 28.00 mole %
8/9/07 0:00	858	399.74	0.11	0.00	1.94	0.00	80.48	0.00	1.17
8/9/07 1:00	859	399.74	0.11	0.00	1.96	0.00	80.24	0.03	1.24
8/9/07 2:00	895	399.74	0.08	0.01	1.96	0.00	80.66	0.04	1.26
8/9/07 3:00	892	399.77	0.04	0.01	1.89	0.00	82.05	0.03	1.15
8/9/07 4:00	861	399.78	0.05	0.00	1.92	0.00	80.58	0.03	1.26
8/9/07 5:00	877	399.78	0.04	0.01	1.95	0.00	80.38	0.03	1.14
8/9/07 6:00	872	399.81	0.04	0.00	1.92	0.00	80.59	0.02	1.29
8/9/07 7:00	898	399.81	0.04	0.00	1.96	0.00	80.31	0.03	1.32
8/9/07 8:00	858	399.78	0.05	0.01	1.96	0.00	79.94	0.04	1.34
8/9/07 9:00	859	399.76	0.04	0.00	1.95	0.00	79.87	0.04	1.30
8/9/07 10:00	839	399.74	0.04	0.00	2.03	0.00	78.92	0.04	1.44
8/9/07 11:00	855	399.72	0.04	0.01	1.99	0.00	79.21	0.04	1.43
8/9/07 12:00	842	399.70	0.04	0.00	1.99	0.00	79.06	0.03	1.42
8/9/07 13:00	839	399.70	0.04	0.01	2.00	0.00	78.73	0.03	1.46
8/9/07 14:00	868	399.68	0.04	0.01	1.99	0.00	79.16	0.03	1.45
8/9/07 15:00	856	399.67	0.04	0.01	1.98	0.00	79.67	0.00	1.11
8/9/07 16:00	869	399.67	0.04	0.01	1.95	0.00	80.46	0.00	0.43
8/9/07 17:00	804	399.64	0.04	0.01	2.38	0.00	77.27	0.00	0.39
8/9/07 18:00	753	399.63	0.04	0.00	2.28	0.00	78.02	0.00	0.66
8/9/07 19:00	753	399.65	0.04	0.00	2.21	0.00	78.20	0.00	1.15
8/9/07 20:00	759	399.68	0.05	0.00	2.19	0.00	78.67	0.00	1.12
8/9/07 21:00	767	399.70	0.08	0.00	2.12	0.00	79.27	0.00	1.07
8/9/07 22:00	754	399.71	0.09	0.00	2.10	0.00	79.37	0.00	1.06
8/9/07 23:00	772	399.72	0.10	0.00	2.07	0.00	79.61	0.00	1.08
8/10/07 0:00	753	399.74	0.10	0.00	2.03	0.00	79.88	0.00	1.04
8/10/07 1:00	758	399.74	0.10	0.00	2.04	0.00	79.80	0.00	1.05
8/10/07 2:00	769	399.75	0.10	0.00	1.99	0.00	80.37	0.00	1.03
8/10/07 3:00	756	399.78	0.10	0.00	2.01	0.00	79.87	0.00	1.06
8/10/07 4:00	767	399.78	0.10	0.00	1.95	0.00	80.04	0.00	1.00
8/10/07 5:00	769	399.78	0.09	0.00	1.96	0.00	80.21	0.00	0.96
8/10/07 6:00	792	399.81	0.08	0.00	1.91	0.00	80.67	0.00	1.02
8/10/07 7:00	778	399.81	0.08	0.00	1.90	0.00	80.61	0.00	1.05
8/10/07 8:00	776	399.78	0.07	0.01	1.92	0.00	80.43	0.00	1.01
8/10/07 9:00	765	399.76	0.07	0.01	1.91	0.00	80.41	0.01	0.94
8/10/07 10:00	756	399.74	0.06	0.01	1.89	0.00	79.95	0.01	1.20
8/10/07 11:00	761	399.70	0.05	0.01	1.91	0.00	80.00	0.00	1.13
8/10/07 12:00	748	399.69	0.05	0.01	1.89	0.00	79.82	0.01	1.34
8/10/07 13:00	748	399.67	0.04	0.00	1.90	0.00	79.84	0.01	1.22
8/10/07 14:00	755	399.67	0.04	0.01	1.82	0.00	80.69	0.00	0.82
8/10/07 15:00	743	399.66	0.04	0.01	1.81	0.00	80.34	0.00	0.87
8/10/07 16:00	764	399.66	0.04	0.01	1.75	0.00	81.55	0.00	0.83
8/10/07 17:00	756	399.63	0.05	0.01	1.78	0.00	81.66	0.00	0.84
8/10/07 18:00	777	399.63	0.04	0.01	1.69	0.00	81.93	0.00	0.74
8/10/07 19:00	773	399.64	0.04	0.00	1.69	0.00	81.34	0.00	0.75
8/10/07 20:00	777	399.68	0.04	0.00	1.64	0.00	81.80	0.00	0.53
8/10/07 21:00	767	399.70	0.04	0.00	1.77	0.00	80.89	0.00	0.20
8/10/07 22:00	800	399.70	0.04	0.00	2.22	0.00	77.74	0.00	0.21
8/10/07 23:00	825	399.71	0.04	0.00	1.85	0.00	80.71	0.00	0.25
8/11/07 0:00	805	399.71	0.07	0.00	1.70	0.00	82.51	0.00	0.48
8/11/07 1:00	779	399.74	0.09	0.00	1.69	0.00	82.09	0.00	0.53
8/11/07 2:00	800	399.76	0.08	0.00	1.73	0.00	83.83	0.00	0.54
8/11/07 3:00	834	399.78	0.08	0.01	1.70	0.00	84.27	0.00	0.54
8/11/07 4:00	847	399.78	0.10	0.01	1.66	0.00	83.57	0.00	0.52
8/11/07 5:00	839	399.78	0.10	0.01	1.67	0.00	83.95	0.00	0.51
8/11/07 6:00	860	399.78	0.12	0.00	1.62	0.00	83.40	0.00	0.50
8/11/07 7:00	873	399.78	0.12	0.00	1.65	0.00	83.21	0.00	0.51
8/11/07 8:00	865	399.77	0.12	0.01	1.62	0.00	83.46	0.00	0.50
8/11/07 9:00	845	399.74	0.12	0.01	1.64	0.00	83.09	0.00	0.50
8/11/07 10:00	884	399.71	0.09	0.01	1.68	0.00	84.28	0.00	0.51
8/11/07 11:00	904	399.69	0.09	0.01	1.70	0.00	84.22	0.00	0.49
8/11/07 12:00	860	399.67	0.11	0.00	1.52	0.00	84.66	0.00	0.48
8/11/07 13:00	858	399.65	0.14	0.00	1.65	0.00	82.92	0.00	0.50
8/11/07 14:00	872	399.63	0.13	0.00	1.72	0.00	82.64	0.00	0.49
8/11/07 15:00	893	399.63	0.10	0.00	1.70	0.00	84.11	0.00	0.49
8/11/07 16:00	866	399.62	0.09	0.01	1.70	0.00	84.20	0.00	0.51
8/11/07 17:00	891	399.60	0.10	0.01	1.71	0.00	83.85	0.00	0.45
8/11/07 18:00	888	399.63	0.09	0.00	1.71	0.00	84.20	0.00	0.49
8/11/07 19:00	906	399.66	0.09	0.00	1.72	0.00	83.79	0.00	0.51
8/11/07 20:00	895	399.69	0.10	0.01	1.66	0.00	84.23	0.00	0.50
8/11/07 21:00	922	399.70	0.10	0.00	1.67	0.00	84.03	0.00	0.53
8/11/07 22:00	934	399.70	0.11	0.00	1.57	0.00	83.67	0.00	0.49
8/11/07 23:00	915	399.73	0.11	0.00	1.61	0.00	82.82	0.00	0.51
8/12/07 0:00									

Table F-2. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for the Temporary Flare (continued)

Date	Methane 16.04 mole %	Carbon Monoxide 28.00 mole %	Propane 44.09 mole %	Isobutane 58.12 mole %	Hydrogen Sulfide 34.00 mole %	Butane 58.12 mole %	1-Butene/ Isobutylene 56.10 mole %	Trans - 2 - Butene 56.10 mole %	Cis - 2 - Butene 56.10 mole %
8/9/07 0:00	6.84	0.00	2.68	1.33	0.00	1.17	0.02	0.00	0.00
8/9/07 1:00	6.90	0.01	2.70	1.35	0.00	1.19	0.02	0.00	0.00
8/9/07 2:00	6.64	0.01	2.71	1.34	0.00	1.18	0.02	0.00	0.00
8/9/07 3:00	5.63	0.00	2.64	1.30	0.00	1.15	0.02	0.00	0.00
8/9/07 4:00	6.70	0.01	2.65	1.33	0.00	1.18	0.02	0.00	0.00
8/9/07 5:00	7.20	0.00	2.67	1.32	0.00	1.17	0.02	0.00	0.00
8/9/07 6:00	7.13	0.00	2.62	1.29	0.00	1.14	0.02	0.00	0.00
8/9/07 7:00	7.20	0.00	2.68	1.32	0.00	1.18	0.02	0.00	0.00
8/9/07 8:00	7.12	0.01	2.71	1.35	0.00	1.20	0.02	0.00	0.00
8/9/07 9:00	7.23	0.01	2.68	1.35	0.00	1.20	0.02	0.00	0.00
8/9/07 10:00	7.29	0.01	2.80	1.43	0.00	1.29	0.02	0.00	0.00
8/9/07 11:00	7.25	0.00	2.72	1.37	0.00	1.23	0.02	0.00	0.00
8/9/07 12:00	7.19	0.01	2.74	1.39	0.00	1.26	0.02	0.00	0.00
8/9/07 13:00	7.17	0.00	2.75	1.40	0.00	1.28	0.02	0.00	0.00
8/9/07 14:00	7.17	0.00	2.69	1.33	0.00	1.20	0.02	0.00	0.00
8/9/07 15:00	7.19	0.00	2.67	1.31	0.00	1.17	0.02	0.00	0.00
8/9/07 16:00	7.17	0.00	2.63	1.28	0.00	1.15	0.02	0.00	0.00
8/9/07 17:00	8.77	0.00	3.19	1.53	0.00	1.36	0.02	0.00	0.00
8/9/07 18:00	8.38	0.00	3.06	1.47	0.00	1.29	0.02	0.00	0.00
8/9/07 19:00	8.12	0.00	2.96	1.42	0.00	1.26	0.02	0.00	0.00
8/9/07 20:00	8.04	0.00	2.90	1.37	0.00	1.21	0.02	0.00	0.00
8/9/07 21:00	7.96	0.00	2.80	1.31	0.00	1.15	0.02	0.00	0.00
8/9/07 22:00	7.91	0.00	2.79	1.29	0.00	1.15	0.02	0.00	0.00
8/9/07 23:00	7.87	0.00	2.75	1.26	0.00	1.13	0.02	0.00	0.00
8/10/07 0:00	7.77	0.00	2.70	1.24	0.00	1.12	0.02	0.00	0.00
8/10/07 1:00	7.69	0.00	2.72	1.26	0.00	1.13	0.02	0.00	0.00
8/10/07 2:00	7.65	0.00	2.63	1.19	0.00	1.07	0.02	0.00	0.00
8/10/07 3:00	7.53	0.00	2.71	1.27	0.00	1.15	0.02	0.00	0.00
8/10/07 4:00	7.51	0.00	2.65	1.24	0.00	1.12	0.02	0.00	0.00
8/10/07 5:00	7.56	0.01	2.65	1.21	0.00	1.09	0.02	0.00	0.00
8/10/07 6:00	7.52	0.00	2.56	1.15	0.00	1.01	0.02	0.00	0.00
8/10/07 7:00	7.43	0.00	2.58	1.17	0.00	1.04	0.02	0.00	0.00
8/10/07 8:00	7.49	0.01	2.60	1.17	0.00	1.03	0.02	0.00	0.00
8/10/07 9:00	7.45	0.00	2.60	1.17	0.00	1.03	0.02	0.00	0.00
8/10/07 10:00	7.41	0.00	2.59	1.22	0.00	1.17	0.02	0.00	0.00
8/10/07 11:00	7.40	0.00	2.60	1.21	0.00	1.14	0.02	0.00	0.00
8/10/07 12:00	7.30	0.00	2.61	1.20	0.00	1.10	0.02	0.00	0.00
8/10/07 13:00	7.38	0.01	2.61	1.19	0.00	1.05	0.02	0.00	0.00
8/10/07 14:00	7.31	0.00	2.51	1.14	0.00	0.98	0.02	0.00	0.00
8/10/07 15:00	7.10	0.01	2.52	1.19	0.00	1.01	0.02	0.00	0.00
8/10/07 16:00	7.10	0.00	2.39	1.09	0.00	0.92	0.02	0.00	0.00
8/10/07 17:00	7.05	0.00	2.44	1.11	0.00	0.94	0.02	0.00	0.00
8/10/07 18:00	6.70	0.01	2.32	1.05	0.00	0.87	0.02	0.00	0.00
8/10/07 19:00	7.48	0.00	2.30	1.04	0.00	0.87	0.02	0.00	0.00
8/10/07 20:00	7.38	0.00	2.26	1.04	0.00	0.86	0.02	0.00	0.00
8/10/07 21:00	8.14	0.00	2.40	1.10	0.00	0.91	0.02	0.00	0.00
8/10/07 22:00	9.37	0.00	2.98	1.37	0.00	1.13	0.02	0.00	0.00
8/10/07 23:00	8.48	0.00	2.54	1.15	0.00	0.90	0.02	0.00	0.00
8/11/07 0:00	9.55	0.00	2.32	1.05	0.00	0.81	0.02	0.00	0.00
8/11/07 1:00	10.80	0.00	2.29	1.06	0.00	0.83	0.02	0.00	0.00
8/11/07 2:00	9.37	0.00	2.40	1.13	0.00	0.89	0.02	0.00	0.00
8/11/07 3:00	9.18	0.00	2.32	1.07	0.00	0.83	0.02	0.00	0.00
8/11/07 4:00	9.98	0.00	2.26	1.06	0.00	0.82	0.02	0.00	0.00
8/11/07 5:00	9.60	0.00	2.26	1.06	0.00	0.82	0.02	0.00	0.00
8/11/07 6:00	10.39	0.00	2.16	1.01	0.00	0.78	0.01	0.00	0.00
8/11/07 7:00	10.44	0.00	2.20	1.04	0.00	0.81	0.02	0.00	0.00
8/11/07 8:00	10.22	0.00	2.19	1.04	0.00	0.81	0.02	0.00	0.00
8/11/07 9:00	10.48	0.00	2.23	1.07	0.00	0.84	0.02	0.00	0.00
8/11/07 10:00	9.11	0.00	2.32	1.11	0.00	0.89	0.02	0.00	0.00
8/11/07 11:00	9.22	0.00	2.31	1.08	0.00	0.86	0.02	0.00	0.00
8/11/07 12:00	9.40	0.00	2.07	0.98	0.00	0.77	0.02	0.00	0.00
8/11/07 13:00	10.64	0.00	2.21	1.07	0.00	0.85	0.02	0.00	0.00
8/11/07 14:00	10.84	0.00	2.26	1.06	0.00	0.84	0.02	0.00	0.00
8/11/07 15:00	9.36	0.00	2.28	1.08	0.00	0.85	0.02	0.00	0.00
8/11/07 16:00	9.12	0.00	2.32	1.13	0.00	0.90	0.02	0.00	0.00
8/11/07 17:00	9.60	0.00	2.30	1.10	0.00	0.87	0.02	0.00	0.00
8/11/07 18:00	9.21	0.00	2.30	1.10	0.00	0.86	0.02	0.00	0.00
8/11/07 19:00	8.80	0.01	2.34	1.14	0.00	0.90	0.02	0.00	0.00
8/11/07 20:00	9.23	0.00	2.27	1.11	0.00	0.87	0.02	0.00	0.00
8/11/07 21:00	9.32	0.00	2.28	1.14	0.00	0.90	0.02	0.00	0.00
8/11/07 22:00	10.23	0.00	2.11	1.02	0.00	0.78	0.02	0.00	0.00
8/11/07 23:00	10.81	0.00	2.18	1.09	0.00	0.85	0.02	0.00	0.00
8/12/07 0:00									

Table F-2. Inlet Gas Flow Rate and Composition Monitoring Data and Estimated Controlled Emissions for the Temporary Flare (continued)

Date	1,3 Butadiene 54.09 mole %	Water 18.00 mole %	Total C5+ mole %	Propylene 42.08 mole %	GC Calculated Net Heating Value btu/scf	GC Calculated Molecular Weight mole %	Backout MW of C5+	Temp Flare VOC entering (C3+), lb/hr	Total C3+ in gas to temp flare, mole %	Predicted Temp Flare Emissions @ 99.8%, lb/hr
8/9/07 0:00	0.00	0.00	4.24	0.00	600.69	9.69	79.48	13634.34	9.45	27.269
8/9/07 1:00	0.00	0.00	4.25	0.00	602.53	9.77	79.70	13733.34	9.50	27.467
8/9/07 2:00	0.00	0.00	4.12	0.00	596.16	9.62	79.76	14054.57	9.37	28.109
8/9/07 3:00	0.00	0.00	4.10	0.00	585.10	9.32	79.69	13788.20	9.20	27.576
8/9/07 4:00	0.00	0.01	4.26	0.00	599.33	9.67	79.42	13699.11	9.45	27.398
8/9/07 5:00	0.00	0.00	4.08	0.00	597.29	9.60	80.06	13669.52	9.27	27.339
8/9/07 6:00	0.00	0.00	3.94	0.00	588.28	9.43	79.84	13147.60	9.00	26.295
8/9/07 7:00	0.00	0.00	3.95	0.00	592.59	9.53	79.62	13711.33	9.14	27.423
8/9/07 8:00	0.00	0.00	4.26	0.00	604.76	9.83	79.86	13779.02	9.54	27.558
8/9/07 9:00	0.00	0.00	4.32	0.00	606.10	9.83	79.12	13816.72	9.57	27.633
8/9/07 10:00	0.00	0.00	4.68	0.00	626.99	10.34	79.51	14500.75	10.23	29.002
8/9/07 11:00	0.00	0.00	4.70	0.00	622.32	10.24	79.83	14592.13	10.03	29.184
8/9/07 12:00	0.00	0.00	4.85	0.00	628.22	10.37	79.53	14685.38	10.25	29.371
8/9/07 13:00	0.00	0.00	5.10	0.00	637.42	10.61	79.75	15158.54	10.55	30.317
8/9/07 14:00	0.00	0.00	4.89	0.00	626.57	10.34	79.84	15058.35	10.14	30.117
8/9/07 15:00	0.00	0.00	4.84	0.00	622.70	10.15	79.55	14623.02	10.00	29.246
8/9/07 16:00	0.00	0.00	4.87	0.00	623.06	9.93	79.44	14781.59	9.95	29.563
8/9/07 17:00	0.00	0.00	5.02	0.00	668.02	10.90	79.56	15058.79	11.13	30.118
8/9/07 18:00	0.00	0.00	4.76	0.00	649.23	10.56	79.57	13437.19	10.62	26.874
8/9/07 19:00	0.00	0.00	4.61	0.00	635.33	10.42	79.55	13003.47	10.28	26.007
8/9/07 20:00	0.00	0.00	4.41	0.00	624.03	10.16	79.63	12613.40	9.91	25.227
8/9/07 21:00	0.00	0.00	4.21	0.00	611.02	9.87	79.68	12202.25	9.50	24.404
8/9/07 22:00	0.00	0.00	4.20	0.00	609.23	9.83	79.63	11951.33	9.45	23.903
8/9/07 23:00	0.00	0.00	4.12	0.00	603.06	9.72	79.73	12004.79	9.28	24.010
8/10/07 0:00	0.00	0.00	4.09	0.00	599.36	9.62	79.65	11576.75	9.17	23.154
8/10/07 1:00	0.00	0.00	4.18	0.00	603.41	9.71	79.59	11866.71	9.32	23.733
8/10/07 2:00	0.00	0.00	3.95	0.00	588.97	9.39	79.46	11408.33	8.86	22.817
8/10/07 3:00	0.00	0.01	4.26	0.00	604.79	9.75	79.31	11970.79	9.42	23.942
8/10/07 4:00	0.00	0.00	4.38	0.00	605.65	9.75	79.60	12217.92	9.41	24.436
8/10/07 5:00	0.00	0.00	4.22	0.00	599.50	9.60	79.77	11933.67	9.19	23.867
8/10/07 6:00	0.00	0.00	4.04	0.00	586.69	9.34	79.65	11737.86	8.79	23.476
8/10/07 7:00	0.00	0.00	4.12	0.00	589.97	9.41	79.42	11719.11	8.93	23.438
8/10/07 8:00	0.00	0.00	4.23	0.00	595.04	9.52	79.65	11909.11	9.06	23.818
8/10/07 9:00	0.00	0.00	4.37	0.01	599.43	9.59	79.41	11932.13	9.20	23.864
8/10/07 10:00	0.00	0.00	4.47	0.00	606.25	9.82	79.43	12150.22	9.47	24.300
8/10/07 11:00	0.00	0.00	4.54	0.00	608.52	9.84	79.72	12336.44	9.51	24.673
8/10/07 12:00	0.00	0.00	4.66	0.00	609.16	9.93	79.30	12216.12	9.58	24.432
8/10/07 13:00	0.00	0.00	4.72	0.00	611.31	9.94	79.53	12280.00	9.59	24.560
8/10/07 14:00	0.00	0.00	4.66	0.00	603.25	9.64	79.51	12056.96	9.31	24.114
8/10/07 15:00	0.00	0.00	5.09	0.00	619.10	10.01	79.68	12658.87	9.83	25.318
8/10/07 16:00	0.00	0.00	4.30	0.00	583.67	9.21	79.88	11415.38	8.72	22.831
8/10/07 17:00	0.00	0.00	4.10	0.00	579.25	9.09	79.54	11039.97	8.60	22.080
8/10/07 18:00	0.00	0.00	4.61	0.00	587.43	9.28	79.72	11964.93	8.88	23.930
8/10/07 19:00	0.00	0.00	4.46	0.00	586.48	9.26	79.90	11628.43	8.69	23.257
8/10/07 20:00	0.00	0.00	4.43	0.00	583.12	9.11	79.37	11528.61	8.61	23.057
8/10/07 21:00	0.00	0.00	4.53	0.00	600.05	9.37	79.56	11822.29	8.96	23.645
8/10/07 22:00	0.00	0.00	4.92	0.00	651.65	10.49	79.47	14114.37	10.42	28.229
8/10/07 23:00	0.00	0.00	4.04	0.00	590.73	9.17	79.76	12081.26	8.65	24.163
8/11/07 0:00	0.00	0.00	1.49	0.00	498.82	7.17	80.80	7036.56	5.68	14.073
8/11/07 1:00	0.00	0.00	0.52	0.00	473.47	6.63	83.90	5250.22	4.72	10.500
8/11/07 2:00	0.00	0.00		0.00	453.51	6.15		4734.53	4.44	9.469
8/11/07 3:00	0.00	0.00		0.00	446.68	6.00		4699.65	4.24	9.399
8/11/07 4:00	0.00	0.00		0.00	449.54	6.08		4692.85	4.16	9.386
8/11/07 5:00	0.00	0.01		0.00	447.17	6.02		4641.26	4.16	9.283
8/11/07 6:00	0.00	0.00		0.00	446.88	6.02		4544.65	3.97	9.089
8/11/07 7:00	0.00	0.00		0.00	450.29	6.10		4729.29	4.07	9.459
8/11/07 8:00	0.00	0.00		0.00	448.62	6.06		4681.49	4.06	9.363
8/11/07 9:00	0.00	0.00		0.00	452.83	6.15		4688.32	4.16	9.377
8/11/07 10:00	0.00	0.00		0.00	449.37	6.06		5118.76	4.34	10.238
8/11/07 11:00	0.00	0.00		0.00	448.04	6.02		5148.18	4.27	10.296
8/11/07 12:00	0.00	0.00		0.00	436.98	5.80		4388.33	3.82	8.777
8/11/07 13:00	0.00	0.00		0.00	453.72	6.18		4765.48	4.16	9.531
8/11/07 14:00	0.00	0.00		0.00	456.81	6.24		4860.99	4.18	9.722
8/11/07 15:00	0.00	0.00		0.00	448.41	6.02		5047.32	4.24	10.095
8/11/07 16:00	0.00	0.00		0.00	450.82	6.06		5057.53	4.37	10.115
8/11/07 17:00	0.00	0.00		0.00	451.43	6.08		5095.85	4.29	10.192
8/11/07 18:00	0.00	0.01		0.00	448.35	6.03		5073.14	4.28	10.146
8/11/07 19:00	0.00	0.00	0.69	0.00	469.25	6.51	71.32	6500.60	5.09	13.001
8/11/07 20:00	0.00	0.00		0.00	448.31	6.03		5101.59	4.27	10.203
8/11/07 21:00	0.00	0.00		0.00	450.84	6.10		5362.94	4.34	10.726
8/11/07 22:00	0.00	0.00		0.00	445.16	5.98		4898.64	3.93	9.797
8/11/07 23:00	0.00	0.00		0.00	454.19	6.18		5066.32	4.14	10.133
8/12/07 0:00										

Table F-3. Inlet Gas Flow Rate and Composition Data for the ULC Flare and Estimated Controlled Emissions for Both the Temporary and ULC Flares

Date	Flare Low Range Flow mscfh	Flare High Range Flow mscfh	Flare Gas Carbon Dioxide 44.00 mole %	Flare Gas Ethylene 28.05 mole %	Flare Gas Ethane 30.07 mole %	Flare Gas Acetylene 26.04 mole %	Flare Gas Hydrogen 2.00 mole %	Flare Gas Oxygen 16.00 mole %	Flare Gas Nitrogen 28.00 mole %	Flare Gas Methane 16.04 mole %	Flare Gas Carbon Monoxide 28.00 mole %	Flare Gas Propane 44.09 mole %	Flare Gas Isobutane 58.12 mole %
8/9/07 0:00	56.03	0.00	0.80	0.03	2.26	0.00	13.30	0.17	34.95	46.75	0.00	0.52	0.13
8/9/07 1:00	56.05	0.00	0.78	0.03	2.18	0.00	13.29	0.17	35.06	46.82	0.00	0.52	0.13
8/9/07 2:00	55.99	0.00	0.80	0.03	2.16	0.00	13.28	0.17	35.09	46.82	0.00	0.50	0.13
8/9/07 3:00	56.95	0.00	0.78	0.03	2.30	0.00	13.29	0.18	35.38	46.40	0.00	0.52	0.13
8/9/07 4:00	55.27	0.00	0.78	0.04	2.19	0.00	13.54	0.18	35.42	46.23	0.00	0.53	0.13
8/9/07 5:00	55.51	0.00	0.78	0.03	2.27	0.00	13.69	0.18	35.68	45.68	0.00	0.55	0.15
8/9/07 6:00	57.05	0.00	0.78	0.03	1.89	0.00	13.64	0.18	35.99	45.73	0.00	0.55	0.16
8/9/07 7:00	60.09	0.00	0.75	0.03	1.57	0.00	14.14	0.17	37.80	43.47	0.00	0.64	0.21
8/9/07 8:00	63.23	0.00	0.63	0.31	2.01	0.00	18.49	0.17	37.04	38.25	0.00	1.13	0.33
8/9/07 8:50													
8/9/07 9:00	58.17	0.00	0.71	0.18	2.31	0.00	15.35	0.18	36.07	42.90	0.00	0.86	0.22
8/9/07 9:01													
8/9/07 9:15													
8/9/07 9:29													
8/9/07 9:43													
8/9/07 9:57													
8/9/07 10:00	56.89	0.00	0.79	0.06	2.16	0.00	13.59	0.16	34.92	46.53	0.00	0.56	0.15
8/9/07 10:11													
8/9/07 10:27													
8/9/07 10:57													
8/9/07 11:00	60.85	0.00	0.80	0.05	2.15	0.00	12.96	0.15	34.33	47.79	0.00	0.52	0.15
8/9/07 11:15													
8/9/07 12:00	59.88	0.00	0.77	0.04	2.11	0.00	12.85	0.15	34.90	47.36	0.00	0.48	0.15
8/9/07 13:00	63.48	0.00	0.77	0.03	2.05	0.00	12.63	0.14	34.67	47.94	0.00	0.45	0.13
8/9/07 14:00	62.09	0.00	0.80	0.03	2.28	0.00	12.80	0.15	35.20	46.87	0.00	0.51	0.14
8/9/07 14:17													
8/9/07 14:53													
8/9/07 15:00	140.93	108.07	0.79	0.03	1.86	0.00	10.85	0.16	48.57	35.85	0.00	0.45	0.13
8/9/07 15:11													
8/9/07 16:00	78.53	84.72	0.39	0.01	1.07	0.00	58.82	0.09	16.44	22.07	0.00	0.23	0.05
8/9/07 17:00	92.60	11.95	0.77	0.03	2.22	0.00	13.92	0.13	35.43	45.36	0.00	0.55	0.19
8/9/07 18:00	114.76	19.22	0.37	0.01	1.78	0.00	24.89	0.11	44.37	23.18	0.00	1.26	0.46
8/9/07 19:00	74.01	0.00	0.77	0.03	2.36	0.00	12.12	0.15	35.83	46.72	0.00	0.56	0.13
8/9/07 20:00	61.90	0.00	0.71	0.03	2.08	0.00	13.92	0.17	36.92	43.93	0.00	0.59	0.20
8/9/07 21:00	61.66	0.00	0.66	0.03	1.85	0.00	14.46	0.18	39.82	40.98	0.00	0.51	0.15
8/9/07 22:00	60.80	0.00	0.66	0.03	1.97	0.00	14.36	0.18	40.40	40.48	0.00	0.50	0.13
8/9/07 23:00	61.13	0.00	0.65	0.03	1.84	0.00	14.41	0.18	40.44	40.52	0.00	0.50	0.13
8/10/07 0:00	60.69	0.00	0.66	0.03	1.91	0.00	14.44	0.18	40.54	40.36	0.00	0.50	0.13
8/10/07 1:00	61.22	0.00	0.65	0.03	1.84	0.00	14.40	0.18	40.56	40.50	0.00	0.50	0.13
8/10/07 2:00	60.34	0.00	0.66	0.03	1.86	0.00	14.51	0.18	40.68	40.28	0.00	0.50	0.13
8/10/07 3:00	59.60	0.00	0.66	0.03	1.90	0.00	14.69	0.18	40.73	40.05	0.00	0.49	0.13
8/10/07 4:00	60.42	0.00	0.67	0.03	1.84	0.00	14.46	0.18	39.93	41.15	0.00	0.48	0.13
8/10/07 5:00	58.93	0.00	0.67	0.03	1.99	0.00	14.47	0.18	40.26	40.65	0.00	0.49	0.13
8/10/07 6:00	58.30	0.00	0.66	0.03	1.86	0.00	14.41	0.18	40.07	41.02	0.00	0.51	0.13
8/10/07 7:00	59.46	0.00	0.67	0.03	1.85	0.00	14.42	0.18	40.14	40.99	0.00	0.49	0.13
8/10/07 8:00	59.26	0.00	0.67	0.03	1.88	0.00	14.41	0.18	39.99	41.13	0.00	0.50	0.13
8/10/07 9:00	65.74	0.00	0.68	0.04	1.89	0.00	14.67	0.16	38.31	41.94	0.00	0.58	0.28
8/10/07 9:51													
8/10/07 10:00	60.96	0.00	0.89	0.03	2.26	0.00	12.22	0.15	31.14	49.23	0.00	0.82	0.81
8/10/07 10:12													
8/10/07 10:31													
8/10/07 10:40													
8/10/07 11:00	61.06	0.00	0.70	0.05	1.98	0.00	13.26	0.16	37.21	44.34	0.00	0.58	0.29
8/10/07 11:32													
8/10/07 12:00	65.28	0.00	0.66	0.04	1.84	0.00	13.90	0.16	38.23	42.95	0.00	0.53	0.27
8/10/07 12:01													
8/10/07 12:29													
8/10/07 13:00	67.42	0.00	0.74	0.04	1.98	0.00	12.88	0.08	32.55	46.65	0.00	0.90	1.12
8/10/07 13:11													
8/10/07 13:30													
8/10/07 13:45													
8/10/07 14:00	65.73	0.00	0.89	0.03	2.40	0.00	10.46	0.12	29.53	51.18	0.00	0.87	1.03
8/10/07 15:00	64.00	0.00	0.74	0.03	1.96	0.00	12.48	0.15	36.71	45.44	0.00	0.51	0.26
8/10/07 15:23													
8/10/07 15:42													
8/10/07 16:00	63.73	0.00	0.75	0.03	1.95	0.00	13.20	0.15	36.33	44.79	0.00	0.58	0.30
8/10/07 16:01													
8/10/07 16:28													
8/10/07 17:00	66.57	0.00	0.71	0.03	2.05	0.00	13.54	0.15	38.01	43.12	0.00	0.52	0.22
8/10/07 18:00	103.42	95.26	0.75	0.03	1.83	0.00	13.31	0.15	35.89	45.09	0.00	0.63	0.43
8/10/07 19:00	200.00	324.07	1.23	0.01	3.09	0.00	7.42	0.03	11.68	73.86	0.00	0.83	0.47
8/10/07 20:00	200.00	510.32	1.39	0.00	2.99	0.00	5.53	0.03	11.63	77.53	0.00	0.47	0.07
8/10/07 21:00	200.00	379.32	1.07	0.00	2.65	0.00	31.40	0.01	4.52	59.56	0.00	0.36	0.04
8/10/07 22:00	200.00	252.55	1.46	0.00	3.01	0.00	3.12	0.09	7.76	83.62	0.00	0.52	0.08
8/10/07 23:00	200.00	248.81	1.15	0.00	2.10	0.00	9.89	0.14	18.19	66.39	0.00	0.84	0.20
8/11/07 0:00	200.00	297.89	1.41	0.00	3.52	0.00	3.19	0.03	7.43	83.42	0.00	0.65	0.09
8/11/07 1:00	200.00	295.31	1.39	0.00	2.53	0.00	2.93	0.03	6.89	85.59	0.00	0.31	0.06
8/11/07 2:00	200.00	291.31	1.54	0.00	2.41	0.00	2.88	0.03	7.07	85.61	0.00	0.23	0.05
8/11/07 3:00	200.00	289.26	1.48	0.00	3.36	0.00	2.83	0.03	7.12	84.67	0.00	0.30	0.04
8/11/07 4:00	200.00	288.73	1.40	0.00	3.14	0.00	3.01	0.04	7.57	84.21	0.00	0.38	0.05
8/11/07 5:00	200.00	288.62	1.52	0.00	4.07	0.00	2.96	0.04	7.13	83.51	0.00	0.43	0.05
8/11/07 6:00	200.00	294.17	1.42	0.00	2.73	0.00	2.88	0.05	7.20	85.13	0.00	0.31	0.05
8/11/07 7:00	200.00	161.04	1.47	0.00	3.38	0.00	3.50	0.14	9.36	81.52	0.00	0.29	0.05
8/11/07 8:00	200.00	140.40	1.35	0.00	3.32	0.00	4.38	0.15	11.46	78.52	0.00	0.37	0.06
8/11/07 9:00	200.00	140.82	1.40	0.00	2.70	0.00	4.27	0.15	11.44	79.29	0.00	0.34	0.06
8/11/07 10:00	200.00	144.40	1.34	0.00	3.39	0.00	4.78	0.15	12.38	76.77	0.00	0.43	0.15
8/11/07 11:00	200.00	142.48	1.34	0.00	2.63	0.00	4.27	0.15	11.38	78.68	0.00	0.41	0.26
8/11/07 11:30													
8/11/07 11:40													
8/11/07 12:00	178.32	72.47	1.33	0.00	2.83	0.00	4.86	0.15	13.40	76.26	0.00	0.36	0.13
8/11/07 12:21													
8/11/07 12:53													
8/11/07 13:00	152.50	33.91	1.19	0.00	3.22	0.00	6.34	0.08	17.96	69.38	0.00	0.46	0.20
8/11/07 13:12													
8/11/07 13:32													
8/11/07 14:00	153.68	32.83	1.21	0.00	2.38	0.00	6.13	0.15	17.56	71.18	0.00	0.35	0.09
8/11/07 15:00	154.48	30.11	1.27	0.00	2.80	0.00	6.33	0.15	17.22	71.00	0.00	0.32	0.08
8/11/07 16:00	153.64	29.19	1.23	0.00	2.69	0.00	6.34	0.15	17.14	71.22	0.00	0.33	0.08
8/11/07 17:00	160.91	43.12	1.28	0.00	2.62	0.00	6.30	0.15	17.11	71.31	0.00	0.38	0.08
8/11/07 17:21													
8/11/07 17:46													
8/11/07 18:00	178.30	69.54	1.28	0.00	3.58	0.00	5.39	0.15	14.79	73.70	0.00	0.39	0.07
8/11/07 19:00	174.11	70.88	1.27	0.00	2.61	0.00	5.30	0.15	14.45	75.10	0.00	0.38	0.08
8/11/07 20:00	173.40	72.06	1.35	0.00	3.11	0.00	5.48	0.15	14.74	74.06	0.00	0.43	0.10
8/11/07 21:00	173.62	70.97	1.31	0.00	3.35	0.00	5.33	0.15	14.27	73.96	0.00	0.52	0.18
8/11/07 22:00	195.08	133.80	1.34	0.00	2.90	0.00	4.80	0.15	13.01	76.39	0.00	0.44	0.16
8/11/07 23:00	200.00	149.47	1.41	0.00	3.37	0.00	4.13	0.14	10.84	79.13	0.00	0.43	0.08
8/12/07 0:00													

Table F-3. Inlet Gas Flow Rate and Composition Data for the ULC Flare and Estimated Controlled Emissions for Both the Temporary and ULC Flares (continued)

Date	Flare Gas Hydrogen Sulfide 34.00 mole %	Flare Gas Butane 58.12 mole %	Flare Gas 1-Butene/ Isobutylene 56.10 mole %	Flare Gas Trans - 2 -Butene 56.10 mole %	Flare Gas Cis - 2 -Butene 56.10 mole %	Flare Gas 1,3 Butadiene 54.09 mole %	Flare Gas Water 18.00 mole %	Flare Gas Total C5+ mole %	Flare Gas Propylene 42.08 mole %	Flare ULC NHV hourly avg Btu/scf	Flare Gas GC Calcd Molecular Weight MW	Backout MW of C5+	ULC Flare VOC entering (C3+), lb/hr
8/9/07 0:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.91	0.03	542.33	19.77	84.51	168.82
8/9/07 1:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.85	0.03	540.49	19.74	86.19	163.04
8/9/07 2:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.84	0.03	539.00	19.72	84.63	158.53
8/9/07 3:00	0.05	0.09	0.00	0.00	0.00	0.00	0.00	0.81	0.03	536.08	19.72	80.31	153.57
8/9/07 4:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.79	0.03	534.50	19.72	87.55	155.19
8/9/07 5:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.84	0.03	532.91	19.76	83.63	160.12
8/9/07 6:00	0.05	0.12	0.00	0.00	0.00	0.00	0.00	0.85	0.03	523.52	19.78	83.42	169.89
8/9/07 7:00	0.05	0.18	0.00	0.00	0.00	0.00	0.00	0.96	0.03	512.85	20.07	90.55	219.24
8/9/07 8:00	0.09	0.22	0.02	0.01	0.01	0.00	0.00	1.19	0.08	522.19	19.77	83.57	310.27
8/9/07 8:50													
8/9/07 9:00	0.06	0.14	0.01	0.00	0.00	0.00	0.00	0.94	0.05	537.29	19.77	81.60	212.03
8/9/07 9:01													
8/9/07 9:15													
8/9/07 9:29													
8/9/07 9:43													
8/9/07 9:57													
8/9/07 10:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.89	0.03	544.07	19.77	90.41	180.77
8/9/07 10:11													
8/9/07 10:27													
8/9/07 10:57													
8/9/07 11:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.92	0.03	548.70	19.77	86.62	189.97
8/9/07 11:15													
8/9/07 12:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	1.00	0.03	550.74	19.81	78.58	182.87
8/9/07 13:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	1.01	0.03	549.74	19.90	90.14	209.02
8/9/07 14:00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	1.03	0.03	536.49	19.90	78.66	193.82
8/9/07 14:17													
8/9/07 14:53													
8/9/07 15:00	0.04	0.10	0.00	0.00	0.00	0.00	0.00	1.14	0.03	423.18	21.73	76.45	450.87
8/9/07 15:11													
8/9/07 16:00	0.01	0.04	0.00	0.00	0.00	0.00	0.00	0.78	0.00	433.45	10.52	68.98	154.36
8/9/07 17:00	0.06	0.13	0.00	0.00	0.00	0.00	0.00	1.17	0.03	521.67	19.84	75.14	321.65
8/9/07 18:00	0.02	0.52	0.00	0.00	0.00	0.00	0.00	2.97	0.02	499.23	20.91	80.94	1072.23
8/9/07 19:00	0.04	0.10	0.00	0.00	0.00	0.00	0.00	1.12	0.04	523.63	20.18	81.82	257.51
8/9/07 20:00	0.09	0.12	0.00	0.00	0.00	0.00	0.00	1.18	0.04	523.67	20.07	79.56	229.06
8/9/07 21:00	0.09	0.10	0.00	0.00	0.00	0.00	0.00	1.13	0.03	496.21	20.25	83.07	215.98
8/9/07 22:00	0.08	0.10	0.00	0.00	0.00	0.00	0.00	1.07	0.03	490.48	20.25	79.48	194.61
8/9/07 23:00	0.08	0.10	0.00	0.00	0.00	0.00	0.00	1.08	0.03	489.03	20.25	81.51	200.53
8/10/07 0:00	0.08	0.10	0.00	0.00	0.00	0.00	0.00	1.04	0.03	487.70	20.30	85.83	201.46
8/10/07 1:00	0.07	0.10	0.00	0.00	0.00	0.00	0.00	1.02	0.03	486.25	20.30	88.13	203.94
8/10/07 2:00	0.07	0.10	0.00	0.00	0.00	0.00	0.00	0.99	0.03	483.64	20.30	89.21	198.40
8/10/07 3:00	0.07	0.09	0.00	0.00	0.00	0.00	0.00	0.97	0.03	485.11	20.23	85.47	185.98
8/10/07 4:00	0.07	0.10	0.00	0.00	0.00	0.00	0.00	0.95	0.03	489.27	20.23	94.56	199.21
8/10/07 5:00	0.07	0.10	0.00	0.00	0.00	0.00	0.00	0.95	0.03	488.89	20.23	87.42	184.99
8/10/07 6:00	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.95	0.03	488.28	20.17	85.47	180.52
8/10/07 7:00	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.92	0.03	487.31	20.13	83.19	175.49
8/10/07 8:00	0.07	0.10	0.00	0.00	0.00	0.00	0.00	0.89	0.03	489.09	20.13	85.76	175.58
8/10/07 9:00	0.13	0.15	0.00	0.00	0.00	0.00	0.00	1.13	0.03	560.06	20.15	82.47	251.35
8/10/07 9:51													
8/10/07 10:00	0.25	0.39	0.00	0.00	0.00	0.00	0.00	1.77	0.03	586.22	20.59	83.21	408.71
8/10/07 10:12													
8/10/07 10:31													
8/10/07 10:40													
8/10/07 11:00	0.10	0.15	0.00	0.00	0.00	0.00	0.00	1.14	0.03	532.18	20.32	89.52	249.16
8/10/07 11:32													
8/10/07 12:00	0.10	0.15	0.00	0.00	0.00	0.00	0.00	1.15	0.03	536.75	20.27	87.18	256.75
8/10/07 12:01													
8/10/07 12:29													
8/10/07 13:00	0.29	0.54	0.00	0.00	0.00	0.00	0.00	2.17	0.03	648.02	20.99	79.32	551.11
8/10/07 13:11													
8/10/07 13:30													
8/10/07 13:45													
8/10/07 14:00	0.39	0.50	0.00	0.00	0.00	0.00	0.00	2.47	0.07	650.25	21.35	84.51	587.68
8/10/07 15:00	0.11	0.16	0.00	0.00	0.00	0.00	0.00	1.39	0.03	554.91	20.60	94.73	303.72
8/10/07 15:23													
8/10/07 15:42													
8/10/07 16:00	0.15	0.18	0.00	0.00	0.00	0.00	0.00	1.52	0.03	541.23	20.58	93.17	329.81
8/10/07 16:01													
8/10/07 16:28													
8/10/07 17:00	0.08	0.13	0.00	0.00	0.00	0.00	0.00	1.36	0.03	529.02	20.49	90.43	294.47
8/10/07 18:00	0.15	0.22	0.00	0.00	0.00	0.00	0.00	1.45	0.03	636.82	20.36	81.76	506.18
8/10/07 19:00	0.25	0.21	0.00	0.00	0.00	0.00	0.00	0.90	0.01	790.81	18.29	78.46	1250.98
8/10/07 20:00	0.02	0.04	0.00	0.00	0.00	0.00	0.00	0.27	0.01	736.32	17.80	73.80	635.06
8/10/07 21:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.35	0.00	738.49	13.22	86.89	499.37
8/10/07 22:00	0.01	0.06	0.00	0.00	0.00	0.00	0.00	0.26	0.00	810.50	17.70	70.60	326.23
8/10/07 23:00	0.00	0.23	0.00	0.00	0.00	0.00	0.00	0.84	0.01	777.09	18.44	84.33	877.41
8/11/07 0:00	0.01	0.05	0.00	0.00	0.00	0.00	0.00	0.21	0.00	803.49	17.84	127.38	493.63
8/11/07 1:00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.20	0.00	830.92	17.51	106.90	319.70
8/11/07 2:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.15	0.00	830.32	17.45	83.26	207.62
8/11/07 3:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.15	0.00	830.80	17.63	101.96	249.72
8/11/07 4:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.16	0.00	835.34	17.63	99.53	282.75
8/11/07 5:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.24	0.00	837.45	17.86	114.73	391.30
8/11/07 6:00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.21	0.00	825.47	17.65	139.41	362.80
8/11/07 7:00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.24	0.00	806.57	17.86	97.83	211.26
8/11/07 8:00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.31	0.00	790.31	18.13	122.09	321.32
8/11/07 9:00	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.29	0.00	783.80	17.95	96.41	255.14
8/11/07 10:00	0.05	0.08	0.00	0.00	0.00	0.00	0.00	0.46	0.00	793.38	18.22	80.45	365.74
8/11/07 11:00	0.14	0.12	0.00	0.00	0.00	0.00	0.00	0.64	0.00	793.05	18.33	92.14	520.92
8/11/07 11:30													
8/11/07 11:40													
8/11/07 12:00	0.08	0.07	0.00	0.00	0.00	0.00	0.00	0.51	0.00	766.06	18.35	98.52	367.29
8/11/07 12:21													
8/11/07 12:53													
8/11/07 13:00	0.20	0.11	0.00	0.00	0.00	0.00	0.00	0.82	0.00	738.90	18.84	72.91	393.43
8/11/07 13:12													
8/11/07 13:32													
8/11/07 14:00	0.14	0.07	0.00	0.00	0.00	0.00	0.00	0.71	0.00	730.11	18.77	105.87	404.12
8/11/07 15:00	0.04	0.05	0.00	0.00	0.00	0.00	0.00	0.71	0.00	734.75	18.77	110.75	407.77
8/11/07 16:00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.70	0.01	734.99	18.63	97.22	365.91
8/11/07 17:00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.68	0.00	746.06	18.52	80.43	333.82
8/11/07 17:21													
8/11/07 17:46													
8/11/07 18:00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.56	0.00	759.87	18.52	94.40	366.10
8/11/07 19:00	0.03	0.05	0.00	0.00	0.00	0.00	0.00	0.56	0.00	760.14	18.27	81.41	320.48
8/11/07 20:00	0.02	0.06	0.00	0.00	0.00	0.00	0.00	0.50	0.00	766.90	18.32	73.05	296.79
8/11/07 21:00	0.09	0.10	0.00	0.00	0.00	0.00	0.00	0.73	0.00	776.91	18.58	81.26	449.59
8/11/07 22:00	0.06	0.09	0.00	0.00	0.00	0.00	0.00	0.64	0.00	791.37	18.38	84.94	456.21
8/11/07 23:00	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.39	0.00	797.24	18.17	112.10	365.62
8/12/07 0:00													

Table F-3. Inlet Gas Flow Rate and Composition Data for the ULC Flare and Estimated Controlled Emissions for Both the Temporary and ULC Flares (continued)

Date	Total HC entering ULC flare, lb/hr	Total flare gas mass, lb/hr	Approx. steam addition rate, lb/hr	Steam-to-HC ratio, lb/lb	Steam-to-total flare gas, lb/lb	Downwind DIAL Emissions Data Both Flares C3+ (lb/hr)	DIAL Temp Flare Only	Windspeed, m/s	Temp Flare VOC entering (C3+) (From Table F-2), lb/hr	Combined VOC from Temp Flare and ULC Flare (C3+), lb/hr
8/9/07 0:00	1378.59	2918.15	20000	14.5	6.9				13,634	13,803
8/9/07 1:00	1371.81	2914.31	20000	14.6	6.9				13,733	13,896
8/9/07 2:00	1364.96	2907.30	20000	14.7	6.9				14,055	14,213
8/9/07 3:00	1377.09	2958.74	20000	14.5	6.8				13,788	13,942
8/9/07 4:00	1334.12	2870.84	20000	15.0	7.0				13,699	13,854
8/9/07 5:00	1334.32	2889.42	20000	15.0	6.9				13,670	13,830
8/9/07 6:00	1360.67	2972.51	20000	14.7	6.7				13,148	13,317
8/9/07 7:00	1400.98	3182.72	20000	14.3	6.3				13,711	13,931
8/9/07 8:00	1449.35	3318.86	20000	13.8	6.0				13,779	14,089
8/9/07 8:50						76				
8/9/07 9:00	1382.54	3046.29	20000	14.5	6.6				13,817	14,029
8/9/07 9:01						100		1.8		
8/9/07 9:15						127		1.8		
8/9/07 9:29						129		1.5		
8/9/07 9:43						50		1.2		
8/9/07 9:57						56		0.6		
8/9/07 10:00	1400.91	2964.31	20000	14.3	6.7				14,501	14,682
8/9/07 10:11						243		1.7		
8/9/07 10:27						164		1.3		
8/9/07 10:57						43		1.3		
8/9/07 11:00	1526.83	3170.32	20000	13.1	6.3				14,592	14,782
8/9/07 11:15						374		3		
8/9/07 12:00	1485.03	3122.82	20000	13.5	6.4				14,685	14,868
8/9/07 13:00	1601.30	3324.00	20000	12.5	6.0				15,159	15,368
8/9/07 14:00	1539.16	3255.41	20000	13.0	6.1				15,058	15,252
8/9/07 14:17						126		4.1		
8/9/07 14:53						243		4.4		
8/9/07 15:00	2799.30	8073.26	20000	7.1	2.5				14,623	15,074
8/9/07 15:11						181		4.4		
8/9/07 16:00	1018.16	2111.33	20000	19.6	9.5				14,782	14,936
8/9/07 17:00	2264.13	4839.83	20000	8.8	4.1				15,059	15,380
8/9/07 18:00	2361.58	6348.69	20000	8.5	3.2				13,437	14,509
8/9/07 19:00	1860.81	3941.31	20000	10.7	5.1				13,003	13,261
8/9/07 20:00	1483.56	3275.20	20000	13.5	6.1				12,613	12,842
8/9/07 21:00	1376.87	3284.49	20000	14.5	6.1				12,202	12,418
8/9/07 22:00	1332.30	3238.23	20000	15.0	6.2				11,951	12,146
8/9/07 23:00	1339.27	3256.01	20000	14.9	6.1				12,005	12,205
8/10/07 0:00	1331.36	3239.99	20000	15.0	6.2				11,577	11,778
8/10/07 1:00	1343.78	3268.20	20000	14.9	6.1				11,867	12,071
8/10/07 2:00	1317.23	3220.35	20000	15.2	6.2				11,408	11,607
8/10/07 3:00	1287.08	3168.42	20000	15.5	6.3				11,971	12,157
8/10/07 4:00	1340.50	3211.67	20000	14.9	6.2				12,218	12,417
8/10/07 5:00	1292.87	3133.77	20000	15.5	6.4				11,934	12,119
8/10/07 6:00	1279.81	3092.57	20000	15.6	6.5				11,738	11,918
8/10/07 7:00	1295.25	3146.26	20000	15.4	6.4				11,719	11,895
8/10/07 8:00	1296.69	3136.30	20000	15.4	6.4				11,909	12,085
8/10/07 9:00	1518.54	3488.09	20000	13.2	5.7				11,932	12,183
8/10/07 9:51						567		3.8		
8/10/07 10:00	1789.76	3330.75	20000	11.2	6.0				12,150	12,559
8/10/07 10:12						159		2.7		
8/10/07 10:31						172		3.1		
8/10/07 10:40						190		3.1		
8/10/07 11:00	1492.96	3271.94	20000	13.4	6.1				12,336	12,586
8/10/07 11:32						142		3		
8/10/07 12:00	1540.67	3484.97	20000	13.0	5.7				12,216	12,473
8/10/07 12:01						95		2.6		
8/10/07 12:29						102		3		
8/10/07 13:00	1989.85	3759.39	20000	10.1	5.3				12,280	12,831
8/10/07 13:11						169		3.3		
8/10/07 13:30						209		3.2		
8/10/07 13:45						24		3.1		
8/10/07 14:00	2137.84	3732.59	20000	9.4	5.4				12,057	12,645
8/10/07 15:00	1635.46	3474.09	20000	12.2	5.8				12,659	12,963
8/10/07 15:23						57		2.4		
8/10/07 15:42						191		3.2		
8/10/07 16:00	1638.28	3460.03	20000	12.2	5.8				11,415	11,745
8/10/07 16:01						36				
8/10/07 16:28						80				
8/10/07 17:00	1618.89	3592.92	20000	12.4	5.6				11,040	11,334
8/10/07 18:00	2631.66	5560.25	20000	7.6	3.6				11,965	12,471
8/10/07 19:00	12176.38	15825.97	50000	4.1	3.2				11,628	12,879
8/10/07 20:00	18591.76	24095.21	50000	2.7	2.1				11,529	12,164
8/10/07 21:00	10859.98	12756.16	50000	4.6	3.9				11,822	12,322
8/10/07 22:00	9867.49	11906.30	50000	5.1	4.2				14,114	14,441
8/10/07 23:00	8283.21	12216.18	20000	2.4	1.6				12,081	12,959
8/11/07 0:00	11842.52	14197.50	46000	3.9	3.2				7,037	7,530
8/11/07 1:00	11608.67	13705.09	46000	4.0	3.4				5,250	5,570
8/11/07 2:00	11319.91	13446.18	46000	4.1	3.4				4,735	4,942
8/11/07 3:00	11386.12	13508.41	46000	4.0	3.4				4,700	4,949
8/11/07 4:00	11292.66	13508.45	46000	4.1	3.4				4,693	4,976
8/11/07 5:00	11524.85	13703.32	46000	4.0	3.4				4,641	5,033
8/11/07 6:00	11598.90	13760.77	46000	4.0	3.3				4,545	4,907
8/11/07 7:00	7646.93	9458.11	46000	6.0	4.9				4,729	4,941
8/11/07 8:00	7494.51	9607.67	20000	2.7	2.1				4,681	5,003
8/11/07 9:00	7394.35	9505.79	20000	2.7	2.1				4,688	4,943
8/11/07 10:00	7402.07	9667.65	20000	2.7	2.1				5,119	5,484
8/11/07 11:00	7597.17	9722.02	20000	2.6	2.1				5,148	5,669
8/11/07 11:30						301				
8/11/07 11:40						311				
8/11/07 12:00	6522.77	8662.04	20000	3.1	2.3		15		4,388	4,756
8/11/07 12:21							4			
8/11/07 12:53							1			
8/11/07 13:00	5260.90	7610.47	20000	3.8	2.6				4,765	5,159
8/11/07 13:12						88				
8/11/07 13:32						244				
8/11/07 14:00	5323.84	7625.55	20000	3.8	2.6				4,861	5,265
8/11/07 15:00	5393.28	7659.33	20000	3.7	2.6				5,047	5,455
8/11/07 16:00	5325.10	7562.14	20000	3.8	2.6				5,058	5,423
8/11/07 17:00	5524.18	7882.05	20000	3.6	2.5				5,096	5,430
8/11/07 17:21						326				
8/11/07 17:46						311				
8/11/07 18:00	6433.80	8744.64	20000	3.1	2.3				5,073	5,439
8/11/07 19:00	6215.13	8423.36	20000	3.2	2.4				6,501	6,821
8/11/07 20:00	6158.73	8420.31	20000	3.2	2.4				5,102	5,398
8/11/07 21:00	6345.02	8568.67	20000	3.2	2.3				5,363	5,813
8/11/07 22:00	7211.91	9512.44	20000	2.8	2.1				4,899	5,355
8/11/07 23:00	7597.79	9646.37	20000	2.6	2.1				5,066	5,432
8/12/07 0:00										

Table F-3. Inlet Gas Flow Rate and Composition Data for the ULC Flare and Estimated Controlled Emissions for Both the Temporary and ULC Flares (continued)

Date	Anticipated C3+ Emissions (assuming 98% reduction), lb/hr			Estimated Temp flare C3+ emissions (assuming 99.8% reduction) (From Table F-2), lb/hr	Combined C3+ emissions assuming 99.8% reduction in temp flare and the following reduction in ULC flare, lb/hr	
	From ULC flare	From Temp flare	From both flares		50%	90%
8/9/07 0:00	3.376	272.69	276.06	27.27	111.68	44.15
8/9/07 1:00	3.261	274.67	277.93	27.47	108.99	43.77
8/9/07 2:00	3.171	281.09	284.26	28.11	107.38	43.96
8/9/07 3:00	3.071	275.76	278.84	27.58	104.36	42.93
8/9/07 4:00	3.104	273.98	277.09	27.40	104.99	42.92
8/9/07 5:00	3.202	273.39	276.59	27.34	107.40	43.35
8/9/07 6:00	3.398	262.95	266.35	26.30	111.24	43.28
8/9/07 7:00	4.385	274.23	278.61	27.42	137.04	49.35
8/9/07 8:00	6.205	275.58	281.79	27.56	182.70	58.59
8/9/07 8:50						
8/9/07 9:00	4.241	276.33	280.58	27.63	133.65	48.84
8/9/07 9:01						
8/9/07 9:15						
8/9/07 9:29						
8/9/07 9:43						
8/9/07 9:57						
8/9/07 10:00	3.615	290.02	293.63	29.00	119.38	47.08
8/9/07 10:11						
8/9/07 10:27						
8/9/07 10:57						
8/9/07 11:00	3.799	291.84	295.64	29.18	124.17	48.18
8/9/07 11:15						
8/9/07 12:00	3.657	293.71	297.37	29.37	120.81	47.66
8/9/07 13:00	4.180	303.17	307.35	30.32	134.83	51.22
8/9/07 14:00	3.876	301.17	305.04	30.12	127.02	49.50
8/9/07 14:17						
8/9/07 14:53						
8/9/07 15:00	9.017	292.46	301.48	29.25	254.68	74.33
8/9/07 15:11						
8/9/07 16:00	3.087	295.63	298.72	29.56	106.74	45.00
8/9/07 17:00	6.433	301.18	307.61	30.12	190.94	62.28
8/9/07 18:00	21.445	268.74	290.19	26.87	562.99	134.10
8/9/07 19:00	5.150	260.07	265.22	26.01	154.76	51.76
8/9/07 20:00	4.581	252.27	256.85	25.23	139.76	48.13
8/9/07 21:00	4.320	244.04	248.36	24.40	132.39	46.00
8/9/07 22:00	3.892	239.03	242.92	23.90	121.21	43.36
8/9/07 23:00	4.011	240.10	244.11	24.01	124.27	44.06
8/10/07 0:00	4.029	231.54	235.56	23.15	123.88	43.30
8/10/07 1:00	4.079	237.33	241.41	23.73	125.70	44.13
8/10/07 2:00	3.968	228.17	232.13	22.82	122.02	42.66
8/10/07 3:00	3.720	239.42	243.14	23.94	116.93	42.54
8/10/07 4:00	3.984	244.36	248.34	24.44	124.04	44.36
8/10/07 5:00	3.700	238.67	242.37	23.87	116.36	42.37
8/10/07 6:00	3.610	234.76	238.37	23.48	113.74	41.53
8/10/07 7:00	3.510	234.38	237.89	23.44	111.18	40.99
8/10/07 8:00	3.512	238.18	241.69	23.82	111.61	41.38
8/10/07 9:00	5.027	238.64	243.67	23.86	149.54	49.00
8/10/07 9:51						
8/10/07 10:00	8.174	243.00	251.18	24.30	228.66	65.17
8/10/07 10:12						
8/10/07 10:31						
8/10/07 10:40						
8/10/07 11:00	4.983	246.73	251.71	24.67	149.25	49.59
8/10/07 11:32						
8/10/07 12:00	5.135	244.32	249.46	24.43	152.81	50.11
8/10/07 12:01						
8/10/07 12:29						
8/10/07 13:00	11.022	245.60	256.62	24.56	300.12	79.67
8/10/07 13:11						
8/10/07 13:30						
8/10/07 13:45						
8/10/07 14:00	11.754	241.14	252.89	24.11	317.95	82.88
8/10/07 15:00	6.074	253.18	259.25	25.32	177.18	55.69
8/10/07 15:23						
8/10/07 15:42						
8/10/07 16:00	6.596	228.31	234.90	22.83	187.73	55.81
8/10/07 16:01						
8/10/07 16:28						
8/10/07 17:00	5.889	220.80	226.69	22.08	169.31	51.53
8/10/07 18:00	10.124	239.30	249.42	23.93	277.02	74.55
8/10/07 19:00	25.020	232.57	257.59	23.26	648.75	148.35
8/10/07 20:00	12.701	230.57	243.27	23.06	340.59	86.56
8/10/07 21:00	9.987	236.45	246.43	23.64	273.33	73.58
8/10/07 22:00	6.525	282.29	288.81	28.23	191.34	60.85
8/10/07 23:00	17.548	241.63	259.17	24.16	462.87	111.90
8/11/07 0:00	9.873	140.73	150.60	14.07	260.89	63.44
8/11/07 1:00	6.394	105.00	111.40	10.50	170.35	42.47
8/11/07 2:00	4.152	94.69	98.84	9.47	113.28	30.23
8/11/07 3:00	4.994	93.99	98.99	9.40	134.26	34.37
8/11/07 4:00	5.655	93.86	99.51	9.39	150.76	37.66
8/11/07 5:00	7.826	92.83	100.65	9.28	204.93	48.41
8/11/07 6:00	7.256	90.89	98.15	9.09	190.49	45.37
8/11/07 7:00	4.225	94.59	98.81	9.46	115.09	30.58
8/11/07 8:00	6.426	93.63	100.06	9.36	170.02	41.49
8/11/07 9:00	5.103	93.77	98.87	9.38	136.94	34.89
8/11/07 10:00	7.315	102.38	109.69	10.24	193.11	46.81
8/11/07 11:00	10.418	102.96	113.38	10.30	270.76	62.39
8/11/07 11:30						
8/11/07 11:40						
8/11/07 12:00	7.346	87.77	95.11	8.78	192.42	45.51
8/11/07 12:21						
8/11/07 12:53						
8/11/07 13:00	7.869	95.31	103.18	9.53	206.25	48.87
8/11/07 13:12						
8/11/07 13:32						
8/11/07 14:00	8.082	97.22	105.30	9.72	211.78	50.13
8/11/07 15:00	8.155	100.95	109.10	10.09	213.98	50.87
8/11/07 16:00	7.318	101.15	108.47	10.12	193.07	46.71
8/11/07 17:00	6.676	101.92	108.59	10.19	177.10	43.57
8/11/07 17:21						
8/11/07 17:46						
8/11/07 18:00	7.322	101.46	108.78	10.15	193.20	46.76
8/11/07 19:00	6.410	130.01	136.42	13.00	173.24	45.05
8/11/07 20:00	5.936	102.03	107.97	10.20	158.60	39.88
8/11/07 21:00	8.992	107.26	116.25	10.73	235.52	55.68
8/11/07 22:00	9.124	97.97	107.10	9.80	237.90	55.42
8/11/07 23:00	7.312	101.33	108.64	10.13	192.94	46.69
8/12/07 0:00						

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