

3.5 Methodology for Estimating CH₄ and CO₂ Emissions from Petroleum Systems

For the public review draft, this annex contains tables presenting methane emissions (in kt CH₄), activity data, average emission factors (in kg CH₄/unit) for the full 1990-2015 time series, and a short description of data sources and methods for each source, also in tabular format. Previous GHG Inventory annexes included the most recent year of information on activity data and average emission factors, and text describing data sources and methods for activity data and emission factors. EPA is seeking stakeholder feedback on the presentation of information in this format versus the previous annex discussion text. For information on CO₂ emissions, which have not been updated in this public review draft, please see the annexes of the 2016 GHG Inventory (1990-2014).

Petroleum Systems Emissions, kt CH₄

Segment/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Production													
<i>Vented</i>													
Large Tanks w/Flares	0.0	0.7	1.3	1.9	2.4	3.0	3.6	4.2	4.5	4.9	5.4	5.9	6.4
Large Tanks w/VRU	0.0	0.3	0.6	0.9	1.2	1.5	1.7	2.0	2.2	2.4	2.7	2.9	3.1
Large Tanks w/o Control	314.7	306.0	287.4	273.9	256.8	241.4	230.8	221.6	202.2	183.6	176.2	166.5	156.8
Small Tanks w/Flares	0.0	0.01	0.01	0.02	0.02	0.03	0.03	0.04	0.04	0.04	0.05	0.1	0.1
Small Tanks w/o Flares	10.3	10.2	9.8	9.6	9.2	8.9	8.8	8.7	8.1	7.6	7.6	7.5	7.3
Malfunctioning Separator Dump Valves	10.1	10.1	9.8	9.7	9.5	9.2	9.2	9.2	8.8	8.3	8.4	8.3	8.3
Pneumatic Devices, High Bleed	716.2	720.4	700.0	688.7	670.3	651.1	631.2	610.5	589.1	566.9	544.0	520.3	495.9
Pneumatic Devices, Low Bleed	48.9	49.2	47.8	47.0	46.9	46.7	46.5	46.3	46.1	45.8	45.5	45.3	44.9
Pneumatic Devices, Int Bleed	0.0	0.0	0.0	0.0	17.3	35.1	53.3	72.0	91.2	110.8	130.9	151.5	172.5
Chemical Injection Pumps	49.1	49.3	48.0	47.4	49.0	50.7	52.3	54.0	55.6	57.3	58.9	60.6	62.2
Vessel Blowdowns	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
Compressor Blowdowns	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Compressor Starts	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Associated Gas Flaring	78.7	79.1	76.9	76.0	74.0	72.3	71.9	72.0	68.6	65.3	65.7	65.3	64.8
Associated Gas Venting	628.9	632.4	614.9	607.4	591.1	577.6	574.8	575.6	548.5	521.6	525.0	521.8	518.1
Well Completion Venting (less HF Completions)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.1	0.1	0.1
Well Workovers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HF Well Completions, Uncontrolled	20.0	20.0	20.2	20.2	18.1	16.2	18.1	23.4	15.8	9.1	15.2	21.1	16.9
HF Well Completions, Controlled	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pipeline Pigging	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	205.9	205.4	202.0	196.9	196.9	195.0	194.0	189.8	190.6	185.9	183.5	183.2	179.6
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	5.1	5.0	5.5	5.4	5.7	6.4	6.9	7.4	7.8	9.5	9.9	10.3	11.2
<i>Fugitive</i>													
Oil Wellheads (heavy crude)	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Oil Wellheads (light crude)	64.7	65.0	63.2	62.5	60.8	59.4	59.1	59.2	56.4	53.6	54.0	53.7	53.3
Separators (heavy crude)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02
Separators (light crude)	11.1	11.2	10.9	10.7	11.2	11.7	12.2	12.7	13.2	13.7	14.2	14.6	15.1
Heater/Treaters (light crude)	11.8	11.8	11.5	11.3	11.6	12.0	12.4	12.7	13.1	13.4	13.8	14.1	14.5
Headers (heavy crude)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Headers (light crude)	3.7	3.7	3.6	3.5	3.8	4.0	4.3	4.5	4.7	5.0	5.2	5.4	5.7
Floating Roof Tanks	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Compressors	2.0	2.1	2.0	2.0	1.9	1.9	1.9	1.9	1.8	1.7	1.7	1.7	1.7
Large Compressors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales Areas	1.7	1.8	1.7	1.6	1.6	1.6	1.5	1.5	1.5	1.4	1.4	1.4	1.4
Pipelines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Well Drilling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Pumps	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.2	0.2
<i>Combustion</i>													
Gas Engines	84.9	85.4	82.9	81.5	79.3	77.6	77.1	77.2	73.7	70.0	70.3	69.9	69.4
Heaters	26.9	27.2	26.3	25.1	24.4	24.0	23.7	23.6	22.9	21.5	21.3	21.3	21.0

Petroleum Systems Emissions, kt CH₄

Segment/Source	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Well Drilling	0.8	0.8	0.6	0.6	0.5	0.5	0.5	0.7	0.5	0.3	0.4	0.5	0.4
<i>Process Upset</i>													
Pressure Relief Valves	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Well Blowouts Onshore	2.8	2.7	2.0	1.9	1.5	1.7	1.8	2.3	1.5	0.9	1.5	1.6	1.3
Transportation													
<i>Vented</i>													
Tanks	1.9	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.1	2.2	2.2	2.2
Truck Loading	0.6	0.7	0.7	0.8	0.7	0.7	0.7	0.7	0.7	0.6	0.5	0.5	0.5
Marine Loading	2.5	2.4	2.3	2.1	2.0	1.9	1.8	1.7	1.7	1.5	1.2	1.2	1.2
Rail Loading	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Pump Station Maintenance	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0003	0.0004	0.0004	0.0004
Pipeling Pigging	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
<i>Fugitive</i>													
Pump Stations	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.03	0.03
Pipelines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Floating Roof Tanks	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
<i>Combustion</i>													
Pump Engine Drivers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heaters	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Refining													
<i>Vented</i>													
Uncontrolled Blowdowns	4.8	4.7	4.8	4.9	4.9	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.3
Asphalt Blowing	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Process Vents	3.5	3.5	3.6	3.6	3.7	3.7	3.8	3.9	3.9	3.9	4.0	4.0	3.9
CEMS	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
<i>Fugitive</i>													
Equipment Leaks	2.5	2.4	2.5	2.5	2.5	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.7
Storage Tanks	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Wastewater Treating	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cooling Towers	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.2
Loading Operations	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.03	0.03
<i>Combustion</i>													
Catalytic Cracking, Coking, Reforming	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.5	1.4	1.5	1.5	1.5
Flares	8.9	8.8	8.9	9.0	9.2	9.3	9.5	9.7	9.9	9.8	10.0	10.0	9.9
Delay Cokers	1.1	1.1	1.1	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3
Coke Calcining	0.03	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Voluntary Reductions	0	0	0	-1	-2	-1	-2	-3	-16	-16	-17	-21	-24
Total Potential	2,330	2,332	2,261	2,218	2,178	2,142	2,130	2,127	2,063	1,994	1,996	1,988	1,965
Total Net	2,330	2,332	2,261	2,217	2,176	2,141	2,129	2,124	2,047	1,978	1,979	1,968	1,942

Petroleum Systems Emissions, kt CH₄

Segment/Source	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production													
<i>Vented</i>													
Large Tanks w/Flares	6.9	7.5	8.2	8.9	9.4	10.5	11.0	11.9	12.8	13.4	13.8	14.2	13.9
Large Tanks w/VRU	3.4	3.7	4.0	4.3	4.6	5.1	5.4	5.8	6.3	6.6	6.8	7.0	6.8
Large Tanks w/o Control	148.0	140.3	133.2	126.9	118.0	115.0	105.3	98.2	91.4	95.4	98.2	101.1	99.1
Small Tanks w/Flares	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Small Tanks w/o Flares	7.2	7.1	7.1	7.1	7.0	7.3	7.2	7.2	7.3	7.7	7.9	8.1	8.0
Malfunctioning Separator Dump Valves	8.3	8.3	8.4	8.6	8.6	9.0	9.0	9.2	9.5	9.9	10.2	10.5	10.3
Pneumatic Devices, High Bleed	470.7	444.7	418.1	390.6	362.5	333.5	303.8	273.4	242.2	168.9	100.5	87.1	88.0
Pneumatic Devices, Low Bleed	44.6	44.2	43.9	43.5	43.0	42.6	42.1	41.6	41.1	46.0	29.3	28.4	25.7
Pneumatic Devices, Int Bleed	194.0	215.9	238.4	261.3	284.6	308.5	332.7	357.5	382.7	399.6	609.4	650.9	657.9
Chemical Injection Pumps	63.9	65.5	67.2	68.8	70.4	72.1	73.7	75.4	77.0	80.4	82.8	85.3	83.6
Vessel Blowdowns	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
Compressor Blowdowns	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Compressor Starts	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5
Associated Gas Flaring	64.7	65.1	65.8	67.1	67.0	70.6	70.3	71.9	74.1	107.6	150.6	154.1	109.2
Associated Gas Venting	517.2	520.1	526.0	536.1	535.7	564.0	562.0	574.5	591.8	497.1	221.0	91.9	44.0
Well Completion Venting (less HF Completions)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.0	0.0	0.0	0.1
Well Workovers	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HF Well Completions, Uncontrolled	23.7	25.3	31.2	40.9	42.2	52.5	31.8	51.4	78.4	101.4	106.7	119.1	72.4
HF Well Completions, Controlled	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.2	0.3	0.4	0.4	0.4	0.3
Pipeline Pigging	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	174.8	171.6	170.2	170.2	175.7	172.1	167.1	168.3	168.3	168.3	168.3	168.3	168.3
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	11.5	12.5	14.8	15.3	16.6	17.2	18.4	19.3	19.3	19.3	19.3	19.3	19.3
<i>Fugitive</i>													
Oil Wellheads (heavy crude)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Oil Wellheads (light crude)	53.2	53.5	54.1	55.1	55.1	58.0	57.8	59.1	60.9	63.5	65.4	67.4	66.0
Separators (heavy crude)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03
Separators (light crude)	15.6	16.1	16.6	17.1	17.6	18.1	18.6	19.0	19.5	20.4	21.0	21.6	21.2
Heater/Treaters (light crude)	14.8	15.2	15.6	15.9	16.3	16.6	17.0	17.3	17.7	18.5	19.0	19.6	19.2
Headers (heavy crude)	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Headers (light crude)	5.9	6.1	6.4	6.6	6.8	7.1	7.3	7.6	7.8	8.1	8.4	8.6	8.4
Floating Roof Tanks	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Compressors	1.7	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.9	2.0	2.1	2.2	2.2
Large Compressors	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sales Areas	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.5	1.8	2.1	2.2
Pipelines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Well Drilling	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Pumps	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
<i>Combustion</i>													
Gas Engines	69.1	69.1	69.3	70.3	70.2	73.3	73.7	75.3	77.6	82.0	85.8	90.2	90.0
Heaters	20.7	19.9	19.0	18.6	18.6	18.3	19.6	20.1	20.7	23.7	27.3	31.9	34.5
Well Drilling	0.4	0.5	0.6	0.7	0.7	0.9	0.6	0.8	0.8	0.8	0.8	0.8	0.8
<i>Process Upset</i>													

Petroleum Systems Emissions, kt CH₄

Segment/Source	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pressure Relief Valves	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
Well Blowouts Onshore	1.5	1.6	1.9	2.4	2.4	3.0	2.0	2.9	2.9	2.9	2.9	2.9	2.9
Transportation													
<i>Vented</i>													
Tanks	2.2	2.2	2.2	2.2	2.2	2.1	2.1	2.1	2.1	2.2	2.2	2.3	2.3
Truck Loading	0.5	0.5	0.5	0.6	0.7	0.7	0.7	0.7	1.0	1.3	1.5	1.5	1.8
Marine Loading	1.2	1.2	1.1	1.0	1.0	0.9	0.9	0.9	0.8	1.1	1.5	1.8	1.9
Rail Loading	0.1	0.1	0.05	0.05	0.04	0.04	0.04	0.04	0.1	0.3	0.8	1.3	1.1
Pump Station Maintenance	0.0004	0.0004	0.0003	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Pipeling Pigging	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
<i>Fugitive</i>													
Pump Stations	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
Pipelines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Floating Roof Tanks	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Combustion													
Pump Engine Drivers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heaters	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Refining													
<i>Vented</i>													
Uncontrolled Blowdowns	5.5	5.5	5.4	5.4	5.4	5.2	5.1	5.5	5.2	5.1	5.4	5.4	5.3
Asphalt Blowing	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2
Process Vents	4.0	4.1	4.0	4.0	4.0	3.9	3.8	3.4	4.9	4.3	3.2	2.0	3.2
CEMS	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.1	0.02	0.05	0.02	0.03	0.04
<i>Fugitive</i>													
Equipment Leaks	2.8	2.8	2.8	2.8	2.8	2.7	2.6	2.7	2.7	2.7	2.8	2.7	2.7
Storage Tanks	1.1	1.2	1.1	1.1	1.1	1.1	1.1	0.5	1.1	1.6	1.3	1.4	0.5
Wastewater Treating	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Cooling Towers	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
Loading Operations	0.03	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.04	0.02	0.02	0.01	0.01
Combustion													
Catalytic Cracking, Coking, Reforming	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.5	1.5	1.5	1.4	1.4	1.5
Flares	10.2	10.3	10.1	10.1	10.1	9.8	9.5	10.4	10.6	9.5	9.3	9.1	10.7
Delay Cokers	1.3	1.3	1.3	1.3	1.3	1.3	1.2	1.0	1.5	1.3	1.3	1.1	0.9
Coke Calcining	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.02	0.02	0.02	0.01
Voluntary Reductions	-41	-36	-36	-35	-64	-77	-67	-61	-45	-45	-31	-31	-31
Total Potential	1,957	1,952	1,957	1,973	1,970	2,011	1,972	2,004	2,049	1,981	1,894	1,827	1,691
Total Net	1,917	1,916	1,921	1,939	1,906	1,935	1,905	1,943	2,004	1,935	1,864	1,796	1,660

Petroleum Systems Activity Data

Segment/Source	Activity Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Production														
<i>Vented</i>														
Large Tanks w/Flares	No. of tanks	0	9,037	17,573	26,040	33,790	41,269	49,281	57,582	62,708	67,081	75,020	82,018	88,839
Large Tanks w/VRU	No. of tanks	0	1,529	2,974	4,407	5,719	6,985	8,341	9,746	10,613	11,353	12,697	13,881	15,036
Large Tanks w/o Control	No. of tanks	319,160	310,356	291,489	277,805	260,485	244,860	234,064	224,803	205,046	186,259	178,700	168,892	159,036
Small Tanks w/Flares	No. of tanks	0	1,471	2,860	4,238	5,499	6,716	8,020	9,371	10,205	10,917	12,209	13,348	14,458
Small Tanks w/o Flares	No. of tanks	126,204	125,431	120,528	117,653	113,126	109,189	107,320	106,146	99,869	93,750	93,140	91,358	89,505
Malfunctioning Separator Dump Valves	No. of large tanks	319,160	320,922	312,036	308,252	299,993	293,114	291,686	292,131	278,367	264,693	266,416	264,792	262,911
Pneumatic Devices, High Bleed	No. of high-bleed devices	163,860	164,822	160,150	157,581	153,364	148,976	144,416	139,685	134,782	129,707	124,460	119,042	113,452
Pneumatic Devices, Low Bleed	No. of low-bleed devices	304,312	306,098	297,422	292,650	291,745	290,709	289,540	288,239	286,805	285,240	283,543	281,713	279,751
Pneumatic Devices, Int Bleed	No. of int-bleed devices	0	0	0	0	11,272	22,848	34,727	46,910	59,397	72,188	85,283	98,682	112,384
Chemical Injection Pumps	No. of pumps	32,379	32,557	31,656	31,272	32,359	33,446	34,533	35,620	36,707	37,794	38,882	39,969	41,056
Vessel Blowdowns	No. of vessels	214,128	215,390	209,276	205,865	214,082	222,300	230,517	238,734	246,951	255,169	263,386	271,603	279,821
Compressor Blowdowns	No. of compressors	2,914	2,931	2,848	2,799	2,724	2,665	2,648	2,650	2,532	2,404	2,413	2,400	2,382
Compressor Starts	No. of compressors	2,914	2,931	2,848	2,799	2,724	2,665	2,648	2,650	2,532	2,404	2,413	2,400	2,382
Associated Gas Flaring	No. of wells	27,111	27,260	26,506	26,184	25,483	24,898	24,777	24,815	23,646	22,484	22,631	22,493	22,333
Associated Gas Venting	No. of wells	42,694	42,930	41,741	41,235	40,130	39,210	39,019	39,079	37,237	35,408	35,639	35,421	35,170
Well Completion Venting (less HF Completions)	Oil well completions	9,883	9,625	6,408	5,865	4,666	5,853	6,160	7,748	5,352	3,464	5,841	5,773	4,274
Well Workovers	Oil well workovers	44,633	44,880	43,637	43,108	41,953	40,991	40,791	40,853	38,929	37,016	37,257	37,030	36,767
HF Well Completions, Uncontrolled	HF oil well completions	2,956	2,963	2,994	2,991	2,682	2,395	2,676	3,458	2,330	1,341	2,249	3,115	2,501
HF Well Completions, Controlled	HF oil well completions	0	0	0	0	0	0	0	0	0	0	0	0	0
Pipeline Pigging	No. of crude pig stations	0	0	0	0	0	0	0	0	0	0	0	0	0
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	No. of shallow water oil platforms	1,769	1,765	1,736	1,693	1,692	1,675	1,667	1,632	1,638	1,598	1,577	1,575	1,543
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	No. of deepwater oil platforms	8	8	8	8	9	10	10	11	12	14	15	16	17
<i>Fugitive</i>														
Total oil wells	No. of oil wells	595,109	598,395	581,826	574,770	559,371	546,543	543,880	544,711	519,047	493,549	496,763	493,734	490,227
Oil Wellheads (heavy crude)	No. of hvy. crude wells	41,955	42,187	41,019	40,521	39,436	38,531	38,344	38,402	36,593	34,795	35,022	34,808	34,561
Oil Wellheads (light crude)	No. of lt. crude wells	553,154	556,208	540,807	534,249	519,935	508,012	505,536	506,309	482,454	458,754	461,741	458,926	455,666
Separators (heavy crude)	No. of hvy. crude seps.	12,575	12,649	12,291	12,096	12,649	13,202	13,755	14,307	14,860	15,413	15,966	16,519	17,071

Petroleum Systems Activity Data

Segment/Source	Activity Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Separators (light crude)	No. of lt. crude seps.	114,447	115,116	111,858	110,087	115,118	120,149	125,180	130,211	135,242	140,273	145,304	150,335	155,366
Heater/Treaters (light crude)	No. of heater treaters	87,106	87,625	85,128	83,682	86,315	88,949	91,582	94,216	96,849	99,483	102,116	104,749	107,383
Headers (heavy crude)	No. of hvy. crude hdrs.	15,523	15,609	15,177	14,993	15,988	16,984	17,979	18,974	19,970	20,965	21,960	22,956	23,951
Headers (light crude)	No. of lt. crude hdrs.	48,124	48,390	47,050	46,480	49,565	52,651	55,737	58,823	61,908	64,994	68,080	71,166	74,251
Floating Roof Tanks	No. of floating roof tanks	24	24	24	24	24	24	24	24	24	24	24	24	24
Compressors	No. of compressors	2,914	2,931	2,848	2,799	2,724	2,665	2,648	2,650	2,532	2,404	2,413	2,400	2,382
Large Compressors	No. of large comprs.	0	0	0	0	0	0	0	0	0	0	0	0	0
Sales Areas	Loadings/year	2,236,788	2,255,643	2,180,830	2,082,296	2,026,034	1,995,000	1,966,123	1,962,169	1,901,346	1,788,518	1,770,575	1,764,189	1,746,854
Pipelines	Miles of gathering line	32,349	31,185	28,782	28,882	30,215	35,223	32,002	30,467	20,989	20,333	17,518	17,277	16,214
Well Drilling	No. of oil wells drilled	17,234	16,796	12,540	11,744	9,587	10,679	11,255	14,105	9,575	5,818	9,424	10,208	7,830
Battery Pumps	No. of battery pumps	178,533	179,519	174,548	172,431	167,811	163,963	163,164	163,413	155,714	148,065	149,029	148,120	147,068
<i>Combustion</i>														
Gas Engines	MMHP-hr	18,359	18,468	17,942	17,634	17,161	16,787	16,681	16,698	15,951	15,143	15,205	15,117	15,004
Heaters	MMbbl/yr	2,685	2,707	2,617	2,499	2,432	2,394	2,360	2,355	2,282	2,147	2,125	2,117	2,097
Well Drilling	Oil wells drilled	17,234	16,796	12,540	11,744	9,587	10,679	11,255	14,105	9,575	5,818	9,424	10,208	7,830
<i>Process Upset</i>														
Pressure Relief Valves	No. of PR valves	224,243	226,133	218,633	208,754	203,114	200,000	197,108	196,711	190,614	179,303	177,504	176,863	175,126
Well Blowouts Onshore	No. of blowouts/yr	57	56	42	39	32	36	38	47	32	19	31	34	26
Transportation														
<i>Vented</i>														
Tanks	MMbbl crude feed/yr	4,894	4,855	4,895	4,969	5,061	5,100	5,181	5,338	5,434	5,403	5,514	5,522	5,456
Truck Loading	MMbbl crude transported by truck	65	67	72	77	70	70	69	68	67	58	51	45	51
Marine Loading	1000 gal./yr loaded	50,886,144	49,608,126	46,841,113	42,693,225	41,754,745	38,666,930	37,461,558	35,283,919	35,314,579	30,624,321	24,173,516	24,318,300	24,019,796
Rail Loading	MMbbl crude by rail/yr	20	19	8	9	7	7	6	10	13	8	7	7	8
Pump Station Maintenance	No. of pump stations	555	590	547	553	520	587	570	555	536	490	514	524	529
Pipeling Pigging	No. of pig stations	1,110	1,181	1,094	1,105	1,039	1,174	1,140	1,110	1,072	980	1,027	1,048	1,057
<i>Fugitive</i>														

Petroleum Systems Activity Data

Segment/Source	Activity Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Pump Stations	No. of miles of crude p/l	55,504	59,034	54,675	55,269	51,955	58,720	57,012	55,486	53,614	48,990	51,373	52,386	52,854
Pipelines	MM bbl crude piped	6,562	6,685	6,541	6,708	6,785	6,952	6,976	6,795	7,639	7,551	6,923	7,082	7,019
Floating Roof Tanks	No. of floating roof tanks	824	824	824	824	824	824	824	824	824	824	824	824	824
<i>Combustion</i>														
Pump Engine Drivers	No. of hp-hrs	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Heaters	No. of bbl. burned	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Refining														
<i>Vented</i>														
Uncontrolled Blowdowns	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Asphalt Blowing	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Process Vents	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
CEMS	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
<i>Fugitive</i>														
Equipment Leaks	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Storage Tanks	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Wastewater Treating	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Cooling Towers	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Loading Operations	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
<i>Combustion</i>														
Catalytic Cracking, Coking, Reforming	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Flares	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Delay Cokers	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530
Coke Calcining	Mbbl Refinery Feed	4,894,379	4,855,016	4,908,603	4,968,641	5,061,111	5,100,317	5,195,265	5,351,466	5,434,383	5,403,450	5,514,395	5,521,637	5,455,530

Petroleum Systems Activity Data

Segment/Source	Activity Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production														
<i>Vented</i>														
Large Tanks w/Flares	No. of tanks	96,081	104,062	112,752	122,579	130,136	145,076	152,586	164,183	177,597	185,370	190,811	196,566	192,679
Large Tanks w/VRU	No. of tanks	16,262	17,612	19,083	20,746	22,025	24,554	25,825	27,788	30,058	31,374	32,294	33,269	32,611
Large Tanks w/o Control	No. of tanks	150,128	142,293	135,108	128,745	119,692	116,596	106,788	99,560	92,678	96,734	99,573	102,577	100,548
Small Tanks w/Flares	No. of tanks	15,636	16,935	18,349	19,948	21,178	23,609	24,832	26,719	28,902	30,167	31,052	31,989	31,356
Small Tanks w/o Flares	No. of tanks	88,152	87,445	87,207	87,636	86,320	89,572	87,944	88,560	89,858	93,791	96,543	99,455	97,488
Malfunctioning Separator Dump Valves	No. of large tanks	262,471	263,967	266,943	272,070	271,853	286,225	285,199	291,531	300,333	313,478	322,679	332,411	325,837
Pneumatic Devices, High Bleed	No. of high-bleed devices	107,691	101,758	95,653	89,376	82,928	76,308	69,516	62,553	55,418	38,649	22,991	19,921	20,143
Pneumatic Devices, Low Bleed	No. of low-bleed devices	277,657	275,431	273,073	270,582	267,960	265,205	262,318	259,299	256,148	286,470	182,646	176,810	159,783
Pneumatic Devices, Int Bleed	No. of int-bleed devices	126,391	140,701	155,315	170,232	185,454	200,979	216,808	232,941	249,378	260,377	397,042	424,126	428,652
Chemical Injection Pumps	No. of pumps	42,143	43,230	44,317	45,404	46,491	47,578	48,665	49,752	50,839	53,065	54,622	56,270	55,157
Vessel Blowdowns	No. of vessels	288,038	296,255	304,472	312,690	320,907	329,124	337,341	345,559	353,776	369,260	380,097	391,562	383,818
Compressor Blowdowns	No. of compressors	2,372	2,372	2,379	2,413	2,411	2,517	2,531	2,587	2,665	2,817	2,947	3,098	3,091
Compressor Starts	No. of compressors	2,372	2,372	2,379	2,413	2,411	2,517	2,531	2,587	2,665	2,817	2,947	3,098	3,091
Associated Gas Flaring	No. of wells	22,295	22,422	22,675	23,111	23,092	24,313	24,226	24,764	25,512	31,474	39,515	45,555	59,398
Associated Gas Venting	No. of wells	35,111	35,311	35,709	36,395	36,366	38,289	38,151	38,998	40,176	37,089	31,060	27,148	11,867
Well Completion Venting (less HF Completions)	Oil well completions	4,624	5,043	6,159	7,332	7,127	8,283	6,130	7,577	3,291	0	0	0	4,244
Well Workovers	Oil well workovers	36,706	36,915	37,331	38,048	38,018	40,027	39,884	40,769	42,000	43,839	45,125	46,486	45,567
HF Well Completions, Uncontrolled	HF oil well completions	3,505	3,746	4,620	6,053	6,244	7,766	4,706	7,604	11,590	14,997	15,777	17,609	10,703
HF Well Completions, Controlled	HF oil well completions	0	0	0	0	0	585	354	572	872	1,129	1,188	1,325	806
Pipeline Pigging	No. of crude pig stations	0	0	0	0	0	0	0	0	0	0	0	0	0
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	No. of shallow water oil platforms	1,503	1,475	1,463	1,463	1,510	1,479	1,436	1,447	1,447	1,447	1,447	1,447	1,447
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	No. of deepwater oil platforms	17	19	22	23	25	26	28	29	29	29	29	29	29
<i>Fugitive</i>														
Total oil wells	No. of oil wells	489,407	492,196	497,744	507,305	506,900	533,699	531,786	543,592	560,005	584,515	601,670	619,818	607,559
Oil Wellheads (heavy crude)	No. of hvy. crude wells	34,503	34,700	35,091	35,765	35,736	37,626	37,491	38,323	39,480	41,208	42,418	43,697	42,833
Oil Wellheads (light crude)	No. of lt. crude wells	454,904	457,496	462,653	471,540	471,164	496,073	494,295	505,269	520,525	543,307	559,252	576,121	564,726
Separators (heavy crude)	No. of hvy. crude seps.	17,624	18,177	18,730	19,283	19,835	20,388	20,941	21,494	22,047	23,011	23,687	24,401	23,919

Petroleum Systems Activity Data

Segment/Source	Activity Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Separators (light crude)	No. of lt. crude seps.	160,397	165,428	170,459	175,491	180,522	185,553	190,584	195,615	200,646	209,428	215,574	222,076	217,684
Heater/Treaters (light crude)	No. of heater treaters	110,016	112,650	115,283	117,917	120,550	123,183	125,817	128,450	131,084	136,821	140,837	145,085	142,215
Headers (heavy crude)	No. of hvy. crude hdrs.	24,946	25,942	26,937	27,933	28,928	29,923	30,919	31,914	32,909	34,350	35,358	36,424	35,704
Headers (light crude)	No. of lt. crude hdrs.	77,337	80,423	83,508	86,594	89,680	92,766	95,851	98,937	102,023	106,488	109,613	112,920	110,686
Floating Roof Tanks	No. of floating roof tanks	24	24	24	24	24	24	24	24	24	24	24	24	24
Compressors	No. of compressors	2,372	2,372	2,379	2,413	2,411	2,517	2,531	2,587	2,665	2,817	2,947	3,098	3,091
Large Compressors	No. of large comprs.	0	0	0	0	0	0	0	0	0	0	0	0	0
Sales Areas	Loadings/year	1,717,963	1,654,706	1,576,548	1,547,048	1,544,007	1,520,894	1,628,248	1,665,350	1,714,313	1,969,468	2,266,896	2,648,260	2,868,137
Pipelines	Miles of gathering line	14,187	15,193	13,804	12,141	14,911	11,694	11,249	10,437	12,868	14,077	14,590	14,571	16,010
Well Drilling	No. of oil wells drilled	9,251	9,877	12,053	14,893	14,816	18,478	12,537	17,774	17,774	17,774	17,774	17,774	17,774
Battery Pumps	No. of battery pumps	146,822	147,659	149,323	152,192	152,070	160,110	159,536	163,078	168,002	175,355	180,501	185,945	182,268
<i>Combustion</i>														
Gas Engines	MMHP-hr	14,947	14,941	14,988	15,202	15,187	15,860	15,943	16,299	16,789	17,748	18,568	19,518	19,472
Heaters	MMbbl/yr	2,062	1,986	1,892	1,857	1,853	1,825	1,954	1,999	2,058	2,364	2,721	3,178	3,442
Well Drilling	Oil wells drilled	9,251	9,877	12,053	14,893	14,816	18,478	12,537	17,774	17,774	17,774	17,774	17,774	17,774
<i>Process Upset</i>														
Pressure Relief Valves	No. of PR valves	172,229	165,888	158,052	155,095	154,790	152,473	163,235	166,955	171,863	197,443	227,261	265,493	287,537
Well Blowouts Onshore	No. of blowouts/yr	31	33	40	50	49	62	42	59	59	59	59	59	59
<i>Transportation</i>														
<i>Vented</i>														
Tanks	MMbbl crude feed/yr	5,586	5,664	5,555	5,563	5,532	5,361	5,233	5,374	5,404	5,490	5,589	5,785	5,909
Truck Loading	MMbbl crude transported by truck	54	49	55	58	66	69	68	72	95	131	145	152	177
Marine Loading	1000 gal./yr loaded	24,620,196	23,996,326	22,670,611	20,040,105	20,477,426	19,379,714	18,606,697	17,473,919	17,319,309	23,026,454	30,628,007	36,405,195	38,045,505
Rail Loading	MMbbl crude by rail/yr	8	6	5	5	4	4	4	4	6	30	76	133	111
Pump Station Maintenance	No. of pump stations	501	507	462	476	467	502	496	502	500	513	500	564	565
Pipeling Pigging	No. of pig stations	1,003	1,015	925	952	933	1,004	992	1,004	1,000	1,027	999	1,128	1,130
<i>Fugitive</i>														

Petroleum Systems Activity Data

Segment/Source	Activity Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Pump Stations	No. of miles of crude p/l	50,149	50,749	46,234	47,617	46,658	50,214	49,585	50,198	50,004	51,349	49,974	56,375	56,517
Pipelines	MM bbl crude piped	6,941	6,612	6,675	6,668	7,038	6,858	6,431	7,204	7,032	7,471	8,122	9,289	10,865
Floating Roof Tanks	No. of floating roof tanks	824	824	824	824	824	824	824	824	824	824	824	824	824
<i>Combustion</i>														
Pump Engine Drivers	No. of hp-hrs	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Heaters	No. of bbl. burned	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
Refining														
<i>Vented</i>														
Uncontrolled Blowdowns	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Asphalt Blowing	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Process Vents	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
CEMS	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
<i>Fugitive</i>														
Equipment Leaks	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Storage Tanks	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Wastewater Treating	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Cooling Towers	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Loading Operations	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
<i>Combustion</i>														
Catalytic Cracking, Coking, Reforming	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Flares	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Delay Cokers	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550
Coke Calcining	Mbbl Refinery Feed	5,585,875	5,663,861	5,555,332	5,563,354	5,532,097	5,361,287	5,232,656	5,374,094	5,404,347	5,489,516	5,589,006	5,784,637	5,908,550

Petroleum Systems Emission Factors

Segment/Source	Emission Factor Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Production														
<i>Vented</i>														
Large Tanks w/Flares	kg/tank	NA	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3
Large Tanks w/VRU	kg/tank	NA	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1
Large Tanks w/o Control	kg/tank	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0
Small Tanks w/Flares	kg/tank	NA	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Small Tanks w/o Flares	kg/tank	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6
Malfunctioning Separator Dump Valves	kg/large tank	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Pneumatic Devices, High Bleed	kg/device	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7
Pneumatic Devices, Low Bleed	kg/device	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6
Pneumatic Devices, Int Bleed	kg/device	NA	NA	NA	NA	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7
Chemical Injection Pumps	kg/pump	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3
Vessel Blowdowns	kg/vessel	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Compressor Blowdowns	kg/compressor	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7
Compressor Starts	kg/compressor	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6
Associated Gas Flaring	kg/well	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8
Associated Gas Venting	kg/well	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5
Well Completion Venting (less HF Completions)	kg/event	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Well Workovers	kg/event	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
HF Well Completions, Uncontrolled	kg/event	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1
HF Well Completions, Controlled	kg/event	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pipeline Pigging	kg/station	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	kg/platform	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	kg/platform	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7
<i>Fugitive</i>														
Oil Wellheads (heavy crude)	kg/well	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Oil Wellheads (light crude)	kg/well	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9
Separators (heavy crude)	kg/sep	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Separators (light crude)	kg/sep	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4
Heater/Treaters (light crude)	kg/HT	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9
Headers (heavy crude)	kg/hdr	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Headers (light crude)	kg/hdr	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3
Floating Roof Tanks	kg/tank	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8
Compressors	kg/compressor	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0
Large Compressors	kg/compressor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sales Areas	kg/loading	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Pipelines	kg/mile	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Well Drilling	kg/well	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Pumps	kg/pump	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
<i>Combustion</i>														
Gas Engines	kg/MMHP-hr	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4
Heaters	kg/MMbbl	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5
Well Drilling	kg/well	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2

Petroleum Systems Emission Factors

Segment/Source	Emission Factor Units	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
<i>Process Upset</i>														
Pressure Relief Valves	kg/valve	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Well Blowouts Onshore	kg/event	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0
Transportation														
<i>Vented</i>														
Tanks	kg/MMbbl	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8
Truck Loading	kg/MMbbl	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4
Marine Loading	kg/1000 gal	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rail Loading	kg/MMbbl	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4
Pump Station Maintenance	kg/station	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Pipeling Piggging	kg/station	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2
<i>Fugitive</i>														
Pump Stations	kg/mile	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pipelines	kg/MMbbl	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Floating Roof Tanks	kg/tank	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7
<i>Combustion</i>														
Pump Engine Drivers	kg/hp-hr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heaters	kg/bbl	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Refining														
<i>Vented</i>														
Uncontrolled Blowdowns	kg/Mbbl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Asphalt Blowing	kg/Mbbl	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Process Vents	kg/Mbbl	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
CEMS	kg/Mbbl	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
<i>Fugitive</i>														
Equipment Leaks	kg/Mbbl	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Storage Tanks	kg/Mbbl	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wastewater Treating	kg/Mbbl	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cooling Towers	kg/Mbbl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Loading Operations	kg/Mbbl	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
<i>Combustion</i>														
Catalytic Cracking, Coking, Reforming	kg/Mbbl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Flares	kg/Mbbl	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Delay Cokers	kg/Mbbl	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Coke Calcining	kg/Mbbl	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Petroleum Systems Emission Factors

Segment/Source	Emission Factor Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Production														
<i>Vented</i>														
Large Tanks w/Flares	kg/tank	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3	72.3
Large Tanks w/VRU	kg/tank	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1	209.1
Large Tanks w/o Control	kg/tank	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0	986.0
Small Tanks w/Flares	kg/tank	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8	3.8
Small Tanks w/o Flares	kg/tank	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6	81.6
Malfunctioning Separator Dump Valves	kg/large tank	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
Pneumatic Devices, High Bleed	kg/device	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7	4,370.7
Pneumatic Devices, Low Bleed	kg/device	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6	160.6
Pneumatic Devices, Int Bleed	kg/device	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7	1,534.7
Chemical Injection Pumps	kg/pump	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3	1,515.3
Vessel Blowdowns	kg/vessel	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Compressor Blowdowns	kg/compressor	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7	72.7
Compressor Starts	kg/compressor	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6	162.6
Associated Gas Flaring	kg/well	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	2,902.8	3,419.0	3,811.5	3,382.2	1,838.8
Associated Gas Venting	kg/well	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	14,730.5	13,403.4	7,115.4	3,386.9	3,709.1
Well Completion Venting (less HF Completions)	kg/event	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	NA	NA	NA	14.1
Well Workovers	kg/event	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
HF Well Completions, Uncontrolled	kg/event	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1	6,763.1
HF Well Completions, Controlled	kg/event	NA	NA	NA	NA	NA	338.2	338.2	338.2	338.2	338.2	338.2	338.2	338.2
Pipeline Pigging	kg/station	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	kg/platform	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9	116,358.9
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	kg/platform	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7	659,657.7
<i>Fugitive</i>														
Oil Wellheads (heavy crude)	kg/well	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Oil Wellheads (light crude)	kg/well	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9	116.9
Separators (heavy crude)	kg/sep	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Separators (light crude)	kg/sep	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4	97.4
Heater/Treaters (light crude)	kg/HT	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9	134.9
Headers (heavy crude)	kg/hdr	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Headers (light crude)	kg/hdr	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3	76.3
Floating Roof Tanks	kg/tank	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8	6,515.8
Compressors	kg/compressor	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0	703.0
Large Compressors	kg/compressor	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sales Areas	kg/loading	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Pipelines	kg/mile	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Well Drilling	kg/well	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Battery Pumps	kg/pump	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
<i>Combustion</i>														
Gas Engines	kg/MMHP-hr	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4	4,622.4
Heaters	kg/MMbbl	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5	10,036.5
Well Drilling	kg/well	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2	47.2

Petroleum Systems Emission Factors

Segment/Source	Emission Factor Units	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<i>Process Upset</i>														
Pressure Relief Valves	kg/valve	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Well Blowouts Onshore	kg/event	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0	48,150.0
Transportation														
<i>Vented</i>														
Tanks	kg/MMbbl	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8	396.8
Truck Loading	kg/MMbbl	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4
Marine Loading	kg/1000 gal	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Rail Loading	kg/MMbbl	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4	10,017.4
Pump Station Maintenance	kg/station	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Pipelining Piggling	kg/station	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2	274.2
<i>Fugitive</i>														
Pump Stations	kg/mile	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Pipelines	kg/MMbbl	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Floating Roof Tanks	kg/tank	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7	1,135.7
<i>Combustion</i>														
Pump Engine Drivers	kg/hp-hr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Heaters	kg/bbl	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Refining														
<i>Vented</i>														
Uncontrolled Blowdowns	kg/Mbbl	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.9	1.0	0.9	0.9
Asphalt Blowing	kg/Mbbl	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.05	0.1	0.1	0.05	0.04
Process Vents	kg/Mbbl	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6	0.9	0.8	0.6	0.3	0.5
CEMS	kg/Mbbl	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.003	0.01	0.003	0.01	0.01
<i>Fugitive</i>														
Equipment Leaks	kg/Mbbl	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Storage Tanks	kg/Mbbl	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.2	0.2	0.1
Wastewater Treating	kg/Mbbl	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Cooling Towers	kg/Mbbl	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Loading Operations	kg/Mbbl	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.003	0.01	0.004	0.004	0.002	0.002
<i>Combustion</i>														
Catalytic Cracking, Coking, Reforming	kg/Mbbl	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2
Flares	kg/Mbbl	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9	2.0	1.7	1.7	1.6	1.8
Delay Cokers	kg/Mbbl	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
Coke Calcining	kg/Mbbl	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.005	0.004	0.004	0.004	0.002

Petroleum Systems Activity Data Sources

Segment/Source	Activity Units	Data Source/Method
Production		
<i>Vented</i>		
Large Tanks w/Flares	No. of tanks	2011-2015: Count per well based on RY2015 GHGRP subpart W data. 1990-2010: Interpolation between zero controls assumed in 1990, to the activity factor assigned in 2011.
Large Tanks w/VRU	No. of tanks	2011-2015: Count per well based on RY2015 GHGRP subpart W data. 1990-2010: Interpolation between zero controls assumed in 1990, to the activity factor assigned in 2011.
Large Tanks w/o Control	No. of tanks	2011-2015: Count per well based on RY2015 GHGRP subpart W data. 1990-2010: Interpolation between zero controls assumed in 1990, to the activity factor assigned in 2011.
Small Tanks w/Flares	No. of tanks	2011-2015: Count per well based on RY2015 GHGRP subpart W data. 1990-2010: Interpolation between zero controls assumed in 1990, to the activity factor assigned in 2011.
Small Tanks w/o Flares	No. of tanks	2011-2015: Count per well based on RY2015 GHGRP subpart W data. 1990-2010: Interpolation between zero controls assumed in 1990, to the activity factor assigned in 2011.
Malfunctioning Separator Dump Valves	No. of large tanks	Sum of Large Tanks w/Flares, Large Tanks w/VRU, Large Tanks w/o Control.
Pneumatic Devices, High Bleed	No. of high-bleed devices	1990-1993: Consensus of Industry Review Panel. 2011-2015: Pneumatic controllers per well developed from 2015 GHGRP data; bleed rate fraction developed from year-specific GHGRP data. 1994-2010: Linear interpolation.
Pneumatic Devices, Low Bleed	No. of low-bleed devices	1990-1993: Consensus of Industry Review Panel. 2011-2015: Pneumatic controllers per well developed from 2015 GHGRP data; bleed rate fraction developed from year-specific GHGRP data. 1994-2010: Linear interpolation.
Pneumatic Devices, Int Bleed	No. of int-bleed devices	1990-1993: Consensus of Industry Review Panel. 2011-2015: Pneumatic controllers per well developed from 2015 GHGRP data; bleed rate fraction developed from year-specific GHGRP data. 1994-2010: Linear interpolation.
Chemical Injection Pumps	No. of pumps	1990-1993: Radian (1999). 2011-2015: CIPs per well developed from 2015 GHGRP data; bleed rate fraction developed from year-specific GHGRP data. 1994-2010: Linear interpolation.
Vessel Blowdowns	No. of vessels	Number of vessels = Sum of separators and heater/treaters.
Compressor Blowdowns	No. of compressors	1993: Radian (1999). 1990-1992,1994-2015: Scaled base year estimate using annual domestic production (Energy Information Administration (EIA) Monthly Energy Review) and total producing oil wells (DrillingInfo)
Compressor Starts	No. of compressors	1993: Radian (1999). 1990-1992,1994-2015: Scaled base year estimate using annual domestic production (Energy Information Administration (EIA) Monthly Energy Review) and total producing oil wells (DrillingInfo)
Associated Gas Flaring	No. of wells	2011-2015: Percent of total producing oil wells (DrillingInfo) with venting or flaring is assigned based on RY2015 GHGRP subpart W data; year-specific split between venting and flaring is from subpart W. 1990-2010: Assumed to be same as 2010 proportions.
Associated Gas Venting	No. of wells	2011-2015: Percent of total producing oil wells (DrillingInfo) with venting or flaring is assigned based on RY2015 GHGRP subpart W data; year-specific split between venting and flaring is from subpart W. 1990-2010: Assumed to be same as 2010 proportions.
Well Completion Venting (less HF Completions)	Oil well completions	1990-2010: Counts from Energy Information Administration (EIA) Monthly Energy Review minus HF well completion count (uncontrolled and controlled) (DrillingInfo); 2011-2015: Use year 2014 EIA counts and year-specific DrillingInfo-based estimates
Well Workovers	Oil well workovers	Radian (1999) assumed workover rate of 7.5% and total producing oil wells (DrillingInfo)
HF Well Completions, Uncontrolled	HF oil well completions	DrillingInfo-based estimate of total HF oil well completions. Assumed 7% control fraction from 2008 forward (CO and WY REC regulations).
HF Well Completions, Controlled	HF oil well completions	DrillingInfo-based estimate of total HF oil well completions. Assumed 7% control fraction from 2008 forward (CO and WY REC regulations).
Pipeline Pigging	No. of crude pig stations	Consensus of Industry Review Panel.
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	No. of shallow water oil platforms	Bureau of Ocean Energy Management (BOEM). Percentage of platforms that are oil producing is a straightline projection between estimates developed specific to years 1992 and 2003.
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	No. of deepwater oil platforms	Bureau of Ocean Energy Management (BOEM). Percentage of platforms that are oil producing is a straightline projection between estimates developed specific to years 1992 and 2003.
<i>Fugitive</i>		
Total Oil Wells	No. of oil wells	Total producing oil wells (DrillingInfo). See 2015 Well counts memo (https://www.epa.gov/sites/production/files/2015-12/documents/revision-data-source-well-counts-4-10-2015.pdf) and 2017 Production Segment memo (https://www.epa.gov/sites/production/files/2017-01/documents/2017_ghgi_ngpetro_revunderconsid-production_and_gb_1.10.17.pdf).

Petroleum Systems Activity Data Sources

Segment/Source	Activity Units	Data Source/Method
Oil Wellheads (heavy crude)	No. of hvy. crude wells	Total producing oil wells (DrillingInfo) and Radian (1999) assumed fraction of 7.05% heavy crude.
Oil Wellheads (light crude)	No. of lt. crude wells	Total producing oil wells (DrillingInfo) and Radian (1999) assumed fraction of 7.05% heavy crude.
Separators (heavy crude)	No. of hvy. crude seps.	1990-1993: Mean of two Radian (1999) approaches based on year 1993 estimates [# wells for year N * 217,804 separators for year 1993] / [# wells for year 1993] and [Production for year N * 26,562 separators for year 1993] / [Production for year 1993]; expert judgment assigns 90.1% light crude, 9.9% heavy crude equipment split. 2011-2015: Separators per well developed from 2015 GHGRP data; light heavy split per existing assumption. 1994-2010: Linear interpolation.
Separators (light crude)	No. of lt. crude seps.	1990-1993: Mean of two Radian (1999) approaches based on year 1993 estimates [# wells for year N * 217,804 separators for year 1993] / [# wells for year 1993] and [Production for year N * 26,562 separators for year 1993] / [Production for year 1993]; expert judgment assigns 90.1% light crude, 9.9% heavy crude equipment split. 2011-2015: Separators per well developed from 2015 GHGRP data; light heavy split per existing assumption. 1994-2010: Linear interpolation.
Heater/Treaters (light crude)	No. of heater treaters	1990-1993: Mean of two Radian (1999) approaches based on year 1993 estimates [# wells for year N * 143,491 H-Ts estimated for year 1993] / [# wells for year 1993] and [Production for year N * 23,873 H-Ts for year 1993] / [Production for year 1993]. 2011-2015: H-Ts per well developed from 2015 GHGRP data. 1994-2010: Linear interpolation.
Headers (heavy crude)	No. of hvy. crude hdrs.	Total producing oil wells (DrillingInfo); Radian (1999) assumed fraction of 7.05% heavy crude; Radian factor of 0.37 headers per heavy crude well and 0.087 headers per light crude well.
Headers (light crude)	No. of lt. crude hdrs.	Total producing oil wells (DrillingInfo); Radian (1999) assumed fraction of 7.05% heavy crude; Radian factor of 0.37 headers per heavy crude well and 0.087 headers per light crude well.
Floating Roof Tanks	No. of floating roof tanks	1995: Industry panel & Entropy tank survey. 1990-1994,1996-2015: Assumed to be same as 1995 value.
Compressors	No. of compressors	1993: Radian (1999). 1990-1992,1994-2015: Scaled base year estimate using annual domestic production (Energy Information Administration (EIA) Monthly Energy Review) and total producing oil wells (DrillingInfo)
Large Compressors	No. of large comprs.	1995: Consensus of Industry Review Panel. 1990-1994,1996-2015: Assumed to be same as 1995 value.
Sales Areas	Loadings/year	1995: Consensus of Industry Review Panel. 1990-1994,1996-2015: Scaled base year estimate using annual domestic production (Energy Information Administration (EIA) Monthly Energy Review)
Pipelines	Miles of gathering line	1990-2003: API Basic Petroleum Data Book. 2004-2015: Oil and Gas Journal, year-specific Pipeline Economics issue
Well Drilling	No. of oil wells drilled	1990-2010: Energy Information Administration (EIA) Monthly Energy Review. 2011-2015: Assumed to be same as 2010 value (data source no longer maintained).
Battery Pumps	No. of battery pumps	1990-2015: Consensus of Industry Review Panel (1 pump/battery with LACT unit and 75% batteries have LACT unit, 2.5 wells per battery) and total producing oil wells (DrillingInfo)
Combustion		
Gas Engines	MMHP-hr	Radian (1999) assumed 6.3 MMhp/hr/compressor
Heaters	MMbbl/yr	Energy Information Administration (EIA) Monthly Energy Review, Total Domestic Crude Oil Production
Well Drilling	Oil wells drilled	1990-2010: Energy Information Administration (EIA) Monthly Energy Review, Crude Oil and Natural Gas Exploratory and Development Wells. 2011-2015: Assumed to be same as 2010 value (data source no longer maintained).
Process Upset		
Pressure Relief Valves	No. of PR valves	Factor developed by Industry Review Panel multiplied by annual domestic production (Energy Information Administration (EIA) Monthly Energy Review).
Well Blowouts Onshore	No. of blowouts/yr	Industry Review Panel assumed 1 blowout per 300 wells drilled.
Transportation		
Vented		
Tanks	MMbbl crude feed/yr	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Truck Loading	MMbbl crude transported by truck	1990-2004: DOE Petroleum Supply Annual. 2005-2015: DOE Refinery Capacity Report, Refinery Receipts of Crude Oil, Trucks Domestic
Marine Loading	1000 gal./yr loaded	Crude Oil Exports from EIA Monthly Energy Review; Domestic Barge and Tanker Traffic from U.S. Army Corps of Engineers Waterborne Commerce of the U.S.

Petroleum Systems Activity Data Sources

Segment/Source	Activity Units	Data Source/Method
Rail Loading	MMbbl.crude by rail/yr	1990-2004: DOE Petroleum Supply Annual. 2005-2015: DOE Refinery Capacity Report, Refinery Receipts of Crude Oil by Tank Cars (Rail) Domestic
Pump Station Maintenance	No. of pump stations	Total miles of crude pipeline from Oil and Gas Journal, year-specific Pipeline Economics issue; divided by 100
Pipelining Pigging	No. of pig stations	Two pig stations per pump station
<i>Fugitive</i>		
Pump Stations	No. of miles of crude p/l	Total miles of crude pipeline from Oil and Gas Journal, year-specific Pipeline Economics issue
Pipelines	MM bbl crude piped	Total crude deliveries from Oil and Gas Journal, year-specific Pipeline Economics issue
Floating Roof Tanks	No. of floating roof tanks	1995: Industry panel & Entropy tank survey. 1990-1994,1996-2015: Assumed to be same as 1995 value.
<i>Combustion</i>		
Pump Engine Drivers	No. of hp-hrs	Not Estimated
Heaters	No. of bbl. burned	Not Estimated
Refining		
<i>Vented</i>		
Uncontrolled Blowdowns	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Asphalt Blowing	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Process Vents	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
CEMS	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
<i>Fugitive</i>		
Equipment Leaks	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Storage Tanks	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Wastewater Treating	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Cooling Towers	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Loading Operations	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
<i>Combustion</i>		
Catalytic Cracking, Coking, Reforming	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Flares	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Delay Cokers	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil
Coke Calcining	Mbbl Refinery Feed	DOE Petroleum Supply Annual, Refinery Net Output, Total U.S. Crude Oil

Petroleum Systems Emission Factor Sources

Segment/Source	Emission Factor Units	Data Source/Method
Production		
<i>Vented</i>		
Large Tanks w/Flares	kg/tank	Developed from RY2015 GHGRP subpart W data.
Large Tanks w/VRU	kg/tank	Developed from RY2015 GHGRP subpart W data.
Large Tanks w/o Control	kg/tank	Developed from RY2015 GHGRP subpart W data.
Small Tanks w/Flares	kg/tank	Developed from RY2015 GHGRP subpart W data.
Small Tanks w/o Flares	kg/tank	Developed from RY2015 GHGRP subpart W data.
Malfunctioning Separator Dump Valves	kg/large tank	Developed from RY2015 GHGRP subpart W data.
Pneumatic Devices, High Bleed	kg/device	Developed from RY2014 GHGRP subpart W data.
Pneumatic Devices, Low Bleed	kg/device	Developed from RY2014 GHGRP subpart W data.
Pneumatic Devices, Int Bleed	kg/device	Developed from RY2014 GHGRP subpart W data.
Chemical Injection Pumps	kg/pump	Developed from RY2014 GHGRP subpart W data.
Vessel Blowdowns	kg/vessel	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Compressor Blowdowns	kg/compressor	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Compressor Starts	kg/compressor	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Associated Gas Flaring	kg/well	2011-2015: Emissions per well based on year-specific GHGRP subpart W data. 1990-2010: Use year 2011 EFs.
Associated Gas Venting	kg/well	2011-2015: Emissions per well based on year-specific GHGRP subpart W data. 1990-2010: Use year 2011 EFs.
Well Completion Venting (less HF Completions)	kg/event	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Well Workovers	kg/event	EPA/Radian, Methane Emissions from the U.S. Petroleum Industry (1999)
HF Well Completions, Uncontrolled	kg/event	Developed from NSPS OOOOa rulemaking data analysis
HF Well Completions, Controlled	kg/event	Developed from NSPS OOOOa rulemaking data analysis
Pipeline Pigging	kg/station	Canadian Association of Petroleum Producers (CAPP), A Detailed Inventory of CH ₄ and VOC Emissions from Upstream Oil & Gas Operations in Alberta (1992)
OCS Offshore Platforms, Shallow water oil, fugitive vented, and combusted	kg/platform	Adapted from BOEM GOADS 2011 study
OCS Offshore Platforms, Deep water oil, fugitive, vented, and combusted	kg/platform	Adapted from BOEM GOADS 2011 study
<i>Fugitive</i>		
Oil Wellheads (heavy crude)	kg/well	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 5 valves, 10 flanges, 1 polished rod & 4 connectors/well
Oil Wellheads (light crude)	kg/well	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 5 valves, 10 flanges, 1 polished rod & 4 connectors/well
Separators (heavy crude)	kg/sep	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 6 valves, 12 flanges and 10 connector/separator.
Separators (light crude)	kg/sep	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 6 valves, 12 flanges and 10 connector/separator.
Heater/Treaters (light crude)	kg/HT	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 8 valves, 12 flanges and 20 connectors/heater treater.
Headers (heavy crude)	kg/hdr	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 5 valves, 10 flanges and 4 connectors/header.
Headers (light crude)	kg/hdr	Consensus of Industry Review Panel; EFs from API Workbook 4638 (1996); Assume 5 valves, 10 flanges and 4 connectors/header.
Floating Roof Tanks	kg/tank	EPA, AP-42 Compilation of Air Pollutant Emission Factors and API Workbook 4638 (1996) for % CH ₄ .
Compressors	kg/compressor	Consensus of Industry Review Panel
Large Compressors	kg/compressor	Consensus of Industry Review Panel
Sales Areas	kg/loading	Consensus of Industry Review Panel
Pipelines	kg/mile	Assumed to be 0 until further data becomes available.
Well Drilling	kg/well	Assumed to be 0 until further data becomes available.
Battery Pumps	kg/pump	API Pub. 4615.
<i>Combustion</i>		
Gas Engines	kg/MMHP-hr	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Heaters	kg/MMbbl	EPA, AP-42 Compilation of Air Pollutant Emission Factors
Well Drilling	kg/well	Radian/API, Global Emissions of Methane from Petroleum Sources (1992)

Petroleum Systems Emission Factor Sources

Segment/Source	Emission Factor Units	Data Source/Method
<i>Process Upset</i>		
Pressure Relief Valves	kg/valve	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Well Blowouts Onshore	kg/event	Assumes average onshore blowout EF is 50% of offshore
Transportation		
<i>Vented</i>		
Tanks	kg/MMbbl	Radian/API, Global Emissions of Methane from Petroleum Sources (1992)
Truck Loading	kg/MMbbl	EPA, AP-42 Compilation of Air Pollutant Emission Factors; and expert assumptions
Marine Loading	kg/1000 gal	EPA, AP-42 Compilation of Air Pollutant Emission Factors; and expert assumptions
Rail Loading	kg/MMbbl	EPA, AP-42 Compilation of Air Pollutant Emission Factors; and expert assumptions
Pump Station Maintenance	kg/station	EPA/Radian, Methane Emissions from the U.S. Petroleum Industry (1999)
Pipelining Pigging	kg/station	Canadian Association of Petroleum Producers (CAPP), A Detailed Inventory of CH ₄ and VOC Emissions from Upstream Oil & Gas Operations in Alberta (1992)
<i>Fugitive</i>		
Pump Stations	kg/mile	EPA/Radian, Methane Emissions from the U.S. Petroleum Industry (1999)
Pipelines	kg/MMbbl	EPA/Radian, Methane Emissions from the U.S. Petroleum Industry (1999)
Floating Roof Tanks	kg/tank	API TANK program for emissions from floating roof tanks; API Workbook 4638 (1996) for % CH ₄ .
<i>Combustion</i>		
Pump Engine Drivers	kg/hp-hr	GRI/EPA, Methane Emissions from the Natural Gas Industry (1996)
Heaters	kg/bbl	EPA/Radian, Methane Emissions from the U.S. Petroleum Industry (1999)
Refining		
<i>Vented</i>		
Uncontrolled Blowdowns	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Asphalt Blowing	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Process Vents	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
CEMS	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
<i>Fugitive</i>		
Equipment Leaks	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Storage Tanks	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Wastewater Treating	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Cooling Towers	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Loading Operations	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
<i>Combustion</i>		
Catalytic Cracking, Coking, Reforming	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Flares	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.
Delay Cokers	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.

Petroleum Systems Emission Factor Sources

Segment/Source	Emission Factor Units	Data Source/Method
Coke Calcining	kg/Mbbl	2011-2015: Process-specific emissions based on year-specific GHGRP subpart W data. 1990-2010: Use EFs developed from combined years 2010-2013 data.