

# Regulatory Impact Analysis

## Control of Hazardous Air Pollutants from Mobile Sources

### Chapter 2 Emission Inventories

Assessment and Standards Division  
Office of Transportation and Air Quality  
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## Chapter 2: Emission Inventories

This chapter describes the methods used to develop inventories for air quality modeling, estimation of emission benefits, and calculation of cost-effectiveness for this rule. The chapter also presents and discusses these inventories. MSAT inventories for air quality modeling were developed well in advance of final rule promulgation, because of the lead time required to conduct air quality, exposure, and risk analyses. Thus, these inventories do not include revised estimates of emissions using new fuel quality estimates developed for the Renewable Fuel Standard Program, as discussed below. Therefore, the chapter has separate sections discussing MSAT inventories used for modeling, and revised inventories used to estimate emission benefits of the rule and cost-effectiveness.

### 2.1 Criteria Pollutants

#### 2.1.1 Methods

For the final rule, we have revised the emission inventories to reflect conditions anticipated under the Renewable Fuel Standard (RFS) program. The RFS program was mandated by the Energy Policy Act of 2005 in order to increase national consumption of renewable fuels. In September 2006, EPA issued a proposed rule to implement the RFS program for 2007 and beyond.<sup>1</sup> The RFS proposal analyzed several different scenarios of increased ethanol use and developed county-level fuel properties specific to each scenario.

In one particular RFS scenario, we estimated county-level fuel properties by allocating the Energy Information Agency's forecast of 9.6 billion gallons of national ethanol consumption in 2012, attributing as much as possible for use as an oxygenate in reformulated gasoline. For purposes of this rule, we have selected this scenario as the most likely ethanol volume and distribution in 2012, and have therefore adopted those fuel properties as the new baseline fuel for MSAT inventories used to evaluate the cost-effectiveness of the standards being finalized in this rule. In the discussion that follows, the new MSAT baseline fuel is referred to as the "RFS fuel". The RFS Draft Regulatory Impact Assessment (DRIA) contains a detailed discussion of the effects of ethanol fuel on gasoline properties and the methods by which we derived RFS county-level fuel properties.<sup>2</sup>

Though cost-effectiveness inventories in both the RFS proposal and the MSAT final rule reflect RFS fuels, there are slight differences in other methodologies used to estimate the emissions inventories. However, the differences are minor and have little impact on emission reductions used to evaluate cost-effectiveness.

### 2.1.1.1 Highway Vehicles

Highway vehicle hydrocarbon (HC) emission inventories were calculated by using vehicle emission rates produced from the emission model MOBILE6.2 multiplied by vehicle miles traveled (VMT) using the National Mobile Inventory Model (NMIM).<sup>3</sup> MOBILE6.2 uses emission factors obtained through the analysis of emissions data collected from vehicle emission research.<sup>4</sup> The emission factors reflect impacts of vehicle standards as well as current and planned inspection and maintenance programs. They also reflect impacts of changes in properties of gasoline and diesel fuels. Impacts of alternative fueled vehicles and engines (e.g. liquid propane, compressed natural gas, methanol) are negligible in NMIM. The VMT used by NMIM was estimated for base years using historical data from the Federal Highway Administration, allocated to counties using the methodology documented for the National Emissions Inventory, and projected to future years using the Energy Information Administration's National Energy Modeling System (NEMS) Transportation Model. NEMS projects VMT for personal travel based on demographic effects and economic influences such as estimated fuel costs and disposable income, and projects commercial truck travel based on economic factors such as industrial output and demand. This is the same approach used in the Clean Air Interstate Air Quality (CAIR) rule.<sup>5</sup> As mentioned above, county-level fuel properties contained in the public release version of NMIM were revised to RFS fuel.

Analysis of vehicle emission certification data submitted by vehicle manufacturers to EPA as part of requirements to comply with requirements for cold temperature carbon monoxide (CO) standards, as well as surveillance testing data from the California Air Resources Board, indicated that MOBILE6.2 was substantially underestimating start emissions at cold temperatures for Tier 1 and later vehicles. This data was supplemented with test data collected by EPA at Southwest Research Institute (SwRI)<sup>6</sup> and was then used to adjust the temperature and engine start emission factors in MOBILE6.2 to provide inputs to NMIM, which calculates county-level national inventories.<sup>7</sup>

EPA cold CO certification data was paired as 20 °F versus 75 °F tests per engine family to calculate the additional hydrocarbon (HC) emissions due to lower temperature. Available bag emission data indicated that at 20 °F, as in the standard Federal Test Procedure (FTP) at 75 °F, the majority of HC emissions occur during vehicle start and that lower vehicle soak and start temperatures result in higher HC emissions. Table 2.1.-1 indicates the trends found in the EPA Cold CO program certification data.

The state of California has a 50 °F emission standard requirement and that data, also supplied by manufacturers, reflects the same trend over the smaller temperature difference (Table 2.1.-2).

The EPA testing at SwRI was performed on four Tier 2 vehicles to confirm the effects seen in the certification data and to extend the range of soak temperature to 0 °F. A summary of the hydrocarbon data is found in Table 2.1.-3.

<b>Table 2.1.-1. FTP HC Data From Federal Certified Vehicles (grams per mile)</b>					
		75°		20°	
Emission Standard	Sample Size	Mean	Std. Dev.	Mean	Std. Dev.
Tier 1	410	0.1190	0.0553	0.8630	0.7269
TLEV	64	0.0804	0.0286	0.6996	0.2778
LEV	695	0.0501	0.0209	0.6402	0.3723
ULEV	132	0.0335	0.0214	0.4675	0.2727
LEV2	119	0.0296	0.0123	0.5035	0.2549
2004 Tier 2	172	0.0406	0.0169	0.5641	0.3269
2005 Tier 2	190	0.0415	0.0203	0.5651	0.3247
2006 Tier 2	90	0.0408	0.0239	0.5502	0.3107

<b>Table 2.1.-2. FTP HC Emissions Data from California Certified Vehicles (grams per mile)</b>						
		75°		50°		
Emission Standard	Sample Size	Mean	Std. Dev.	Mean	Std. Dev.	Ratio of Averages
LEV	53	0.0397	0.0259	0.0988	0.0631	2.49
ULEV	14	0.0162	0.0043	0.0403	0.0176	2.48
LEV2	21	0.0346	0.0097	0.0843	0.0310	2.44

Temperature in °F	75	20	0
Number of Observations	4	8	4
Average THC (gm/mile)	0.115	1.658	3.752
Standard deviation	0.072	0.780	2.117
Ratio to 75 °F	1	14.446	32.699

MOBILE6.2 currently has engine start emission factors based on 75° emission test data on 1981 and newer vehicles. These engine start emissions are the difference, in grams, between the emissions from phase 1 of the FTP after a 12-hour engine soak and the emissions of the same driving fully warm and without the engine start. Temperature effects on HC emissions are estimated using a multiplier that depends on ambient temperature. This process is described in the MOBILE6.2 documentation.<sup>8</sup> The current engine start adjustments in MOBILE6.2 are not as large for Tier 1 and later vehicles as what is indicated in the certification and SwRI test data. A method of correcting the emission factors was developed using the test data. Those methods are covered in detail in EPA technical report no. EPA420-D-06-001, “Cold Temperature Effects on Vehicle HC Emissions.”

Based on our analysis from Tier 1 and newer vehicles, it was decided that additive values would be applied to 75 °F start emission factors based on temperature and vehicle technology (i.e., Tier 1, NLEV, Tier 2, etc). Additive values can more closely approximate the additional hydrocarbon emissions caused strictly by the start and warm-up of the engine and/or the exhaust aftertreatment at the different temperatures than multiplicative values. These values were obtained from subtracting the FTP emissions at 0, 20, and 50 °F from the FTP emissions at 75 °F using the certification and SwRI test data. For emissions at temperature points where data was not available (i.e., 50 °F for Tier 2 vehicles), linear interpolation between the 0°, 20° and 75 °F test data was used. All of the difference in emissions is attributed to the increase in engine start emissions. The values used for inputs for start adjustments are found in Table 2.1.-4.

It is not clear what impact this phenomenon has on HC emissions in malfunctioning or deteriorated vehicles. Emissions could go up proportionally to properly operating vehicles or could go up at a lower rate. Properly operating vehicles are very clean due to their emissions technology. Vehicle starts represent a period of operation where the vehicle’s emissions equipment is not fully operational and the oxidation of fuel to carbon dioxide and water is not optimal. This situation is similar to the conditions found in a deteriorated or improperly maintained vehicle except that the condition is temporary in a normal vehicle. While MOBILE currently uses a multiplier to account for temperature effects, doing so in the case of Tier 2 high emitting vehicles results in extremely high and unrealistic emission rates. Therefore we have used the MOBILE6.2 estimate of FTP emissions at 20 °F for model year 2005 high-emitting vehicles in calendar year 2005 to develop the additive factor for all Tier 2 high-emitting

vehicles. Those values are found in Table 2.1.-5. We are not changing high-emitting vehicle emission factors for Tier 1 and older vehicles.

<b>Table 2.1.-4. Increase in Engine Start Hydrocarbon Emissions Over the 75 °F Baseline at Low Temperatures (grams per engine start after a 12 hour soak)</b>				
<b>Index</b>	<b>Description</b>	<b>°F</b>		
		<b>0</b>	<b>20</b>	<b>50</b>
1	Tier 0 (not used)	25.96	12.98	3.09
2	Intermediate Tier 1	25.96	12.98	3.09
3	Tier 1	25.96	12.98	3.09
4	Tier 2 (not used)	18.26	9.13	3.27
5	Intermediate Transitional Low Emission Vehicle	21.60	10.80	2.09
6	Transitional Low Emission Vehicle	21.60	10.80	2.09
7	Intermediate Low Emission Vehicle	20.59	10.29	1.30
8	Low Emission Vehicle (LEV)	20.59	10.29	1.30
9	Transitional Ultra Low Emission Vehicle	15.14	7.57	0.87
10	Ultra Low Emission Vehicle (ULEV)	15.14	7.57	0.87
11	Zero Emission Vehicle (ZEV) (not used)	0.00	0.00	0.00
<b>Index</b>	<b>Tier 2 (All Cars &amp; Trucks) By Model Year</b>	<b>0</b>	<b>20</b>	<b>50</b>
1	2004	18.26	9.13	3.27
2	2005	18.27	9.13	3.27
3	2006	17.77	8.88	3.27
4	2007	17.77	8.88	3.27
5	2008	17.77	8.88	3.27
6	2009	17.77	8.88	3.27
7	2010	17.77	8.88	3.27
8	2011	17.77	8.88	3.27
9	2012	17.77	8.88	3.27
10	2013	17.77	8.88	3.27
11	2014	17.77	8.88	3.27
12	2015	17.77	8.88	3.27

<b>Table 2.1.-5. Tier 2 High Emitter HC Adjustment Based on 2005 Model Year MOBILE6.2 Results in Calendar Year 2005</b>				
Temperature °F	0	20	50	75
Engine start grams without adjustment	63.335	41.360	21.821	12.813
Additional grams	50.522	28.547	9.008	N/A



The above tables and the new emission standard were used to determine the effects of the cold temperature emission standard on start emission factors. The predicted reductions were applied to Tier 2 vehicles over the phase-in period of the standards. Those values are found in Table 2.1.-6. No reductions beyond those found for normally-emitting Tier 2 vehicles are applied for Tier 2 high-emitting vehicles.

With the appropriate HC start emission temperature adjustment factors, we can provide the necessary emission factors required as inputs to NMIM to project pre-control and control inventories for this rule. With the exception of using RFS fuel, no modification to any other components of NMIM is needed to calculate these inventories. The inventories are presented in Chapter 2.1.2.

**Table 2.1.-6. Adjustments to Engine Start Hydrocarbon Emissions  
Over the 75 °F Baseline at Low Temperatures  
For MSAT Rule  
(grams per engine start after a 12 hour soak)**

Index	Tier 2 Cars & Light Trucks <6,000 lbs GVWR By Model Year	°F			Phase In Fraction
		0	20	50	
1	2004	18.26	9.13	3.27	0
2	2005	18.27	9.13	3.27	0
3	2006	17.77	8.88	3.27	0
4	2007	17.77	8.88	3.27	0
5	2008	17.77	8.88	3.27	0
6	2009	17.77	8.88	3.27	0
7	2010	6.66	3.3	1.215	0.25
8	2011	6.66	3.3	1.215	0.50
9	2012	6.66	3.3	1.215	0.75
10	2013	6.66	3.3	1.215	1.00
11	2014	6.66	3.3	1.215	1.00
12	2015	6.66	3.3	1.215	1.00
Index	Tier 2 Light Trucks >6,000 lbs GVWR By Model Year	°F			Phase In Fraction
		0	20	50	
1	2004	18.26	9.13	3.27	0
2	2005	18.27	9.13	3.27	0
3	2006	17.77	8.88	3.27	0
4	2007	17.77	8.88	3.27	0
5	2008	17.77	8.88	3.27	0
6	2009	17.77	8.88	3.27	0
7	2010	17.77	8.88	3.27	0
8	2011	17.77	8.88	3.27	0
9	2012	11.0	5.5	2.025	0.25
10	2013	11.0	5.5	2.025	0.50
11	2014	11.0	5.5	2.025	0.75
12	2015	11.0	5.5	2.025	1.00

### 2.1.1.2 Portable Fuel Containers

In 1999, California's Air Resources Board (ARB) proposed a methodology to estimate annual VOC emissions from portable fuel containers (PFCs) within California. Their approach relied on survey data to first estimate the number of PFCs, and then to combine those estimates with results from testing PFCs to develop a statewide annual inventory.

EPA has modified California's approach. We first used our NONROAD2005 emissions model to estimate (for each month of the year and for each state) the quantity of gasoline dispensed from PFCs that was used to fuel nonroad equipment. Then using some of the California survey data on the amount of gasoline stored in each PFC, EPA estimated the number of PFCs in use (each season) with gasoline in each state. These estimated counts of PFCs were similar (but not identical) to the California estimates. EPA also adjusted the California emission estimates to account for daily temperature variations and seasonal RVP variations. (The estimated RVPs for future years include the effects of the Renewable Fuels Standard.) EPA then combined its state-by-state estimates of PFC usage with its adjusted emission rates to obtain seasonal VOC inventory estimates for each state.<sup>9</sup> This analysis does not consider usage of PFCs with diesel or kerosene fuels, as these fuels contribute minimally to evaporation emissions due to the very low volatilities of these fuels.

For each of the 50 states plus the District of Columbia, this EPA approach produced the estimates for calendar year 1990 given in Table 2.1.-7. Assuming no changes (i.e., no controls), each of these estimates will increase by approximately 1.21 percent annually due to the increase in gasoline consumption predicted by the NONROAD model.

Twelve states plus the District of Columbia (California, Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Texas, Virginia, and Washington DC) already have or will implement controls on the design of PFCs that will reduce HC emissions. Additionally, three other states (Massachusetts, Rhode Island, and Vermont) are also planning to adopt the California PFC program. Inventories include the impacts of these programs, as described in a technical support document (EPA, 2006, Report No. EPA420-R-07-001).

Additionally, California has begun to adopt more stringent emission standards that will require each PFC to emit (permeation plus evaporation) no more than 0.3 grams of VOC per day for each gallon of capacity. This requirement will be effective July 1, 2007. Assuming that PFCs have a typical life of about five years on average, the "new" versions of the PFCs should replace virtually all of the earlier versions by 2013. As these state programs result in replacing the existing PFCs with lower-emitting PFCs, the estimated national inventory of VOCs associated with PFCs will drop by about 20 percent.

To estimate the VOC emissions from PFCs upon implementation of the final rule, we made the following three changes to our inventory estimates:

1. Since the final rule makes it unlikely for a newly designed PFC to be left in the "open" position, we altered the distribution of the cans (from the California survey) to 100 percent "closed." This change reduced the VOC emissions from both evaporation as well as spillage during transport. (Note, the 15 states plus the District of Columbia that are adopting the California PFC rules already had this change applied. So, this affected the VOC emissions from only PFCs in the other 35 states.)
2. This final rule also produces changes to the design of the individual PFCs that are expected to reduce the spillage by 50 percent when these PFCs are used to refuel individual pieces of equipment. Again, this emission reduction was already included in the base case for those states that are adopting the California rules. Therefore, only the PFCs in the remaining 35 states contributed to our estimated reductions of spillage.
3. Finally, the final rule includes a maximum emission rate of 0.3 grams per gallon per day for the new PFCs. We used this emission standard to estimate the total permeation plus evaporative emissions from each newly designed PFC. Only California has adopted this requirement. Thus, the effect of this final national requirement applies to the remaining 49 states.

The change in VOC emissions was then calculated by subtracting the emissions (on a state-by-state basis) estimated using these preceding three changes from our base estimates. The national estimate was simply the sum of the 50 individual state (plus DC) estimates. The national pre- and post-control inventories are presented in Chapter 2.1.2 below.

## **2.1.2 Emission Reductions of Criteria Pollutants Resulting From Controls**

### **2.1.2.1 Light-Duty Gasoline Vehicles**

We are finalizing as proposed a 20° F FTP emission standard for non-methane hydrocarbon (NMHC) emissions from spark ignition vehicles of 0.3 grams per mile for light-duty vehicles and trucks that weigh 6000 pounds or less and a 0.5 gram per mile standard for vehicles that weigh more than 6000 pounds (including medium-duty passenger vehicles; i.e., "MDPVs"). The standard will be applied to a manufacturer on a sales-weighted fleet-wide basis. Furthermore, the standards will be phased in over a period of time following the schedule found in Table 2.1.-8.

The resulting reductions were modeled based upon the above standard and the phase-in period. This was done as outlined in Section 2.1.1.1 with an external data file provided as input to MOBILE6.2 that altered MOBILE6.2 start emission factors for Tier

2 vehicles only. MOBILE6.2 was then used with NMIM (using fuel properties which reflect RFS, as described in Section 2.1.1) to generate county and nationwide inventories for the control case. When the standard is fully phased in we expect a 60% reduction in start emissions in gasoline-fueled vehicles that have a gross vehicle weight rating (GVWR) of less than or equal to 6000 lbs and a 30% reduction for gasoline-fueled vehicles that have a GVWR greater than 6000 lbs. The impact on future nationwide VOC inventories is found in Table 2.1.-9. Table 2.1.-10 shows the impacts on a state-by-state basis in year 2030.

**Table 2.1-7. PFC Emissions (Tons VOC per Year) by Source Type (for 1990)**

<u>State</u>	<u>Refilling PFC at Pump</u>		<u>Spillage During Transport</u>	<u>Refueling Equipment</u>		<u>Permeation Plus Evaporation</u>	<u>Totals by State</u>
	<u>Vapor Displ</u>	<u>Spillage</u>		<u>Vapor Displ</u>	<u>Spillage</u>		
AK	224.8	15.0	447.1	224.8	1,010.8	4,286.7	6,209.2
AL	24.8	1.9	60.1	24.8	103.2	776.6	991.3
AR	279.1	22.9	647.9	279.1	1,630.1	3,936.1	6,795.1
AZ	105.7	8.5	262.7	105.7	533.4	2,813.4	3,829.4
CA	1,532.1	133.9	3,760.8	1,532.1	9,284.9	19,682.1	35,925.8
CO	202.7	18.9	536.5	202.7	1,319.4	2,137.2	4,417.5
CT	123.2	12.0	342.7	123.2	837.2	1,422.5	2,860.8
DC	36.6	3.1	89.1	36.6	217.9	514.9	898.2
DE	7.6	0.7	25.0	7.6	56.6	235.1	332.7
FL	933.1	72.5	2,055.5	933.1	5,050.7	14,664.5	23,709.5
GA	390.9	32.4	930.8	390.9	2,234.7	5,918.5	9,898.3
HI	58.1	4.0	112.9	58.1	285.3	1,208.2	1,726.6
IA	50.6	4.9	146.3	50.6	316.0	780.1	1,348.5
ID	405.1	36.3	1,058.5	405.1	2,458.1	5,764.9	10,127.9
IL	241.4	19.8	578.2	241.4	1,353.8	3,914.8	6,349.3
IN	99.6	8.3	248.5	99.6	541.9	1,886.4	2,884.3
KS	93.5	8.5	247.9	93.5	567.2	1,457.6	2,468.2
KY	129.1	11.1	340.2	129.1	727.8	2,914.7	4,252.1
LA	168.9	12.1	370.7	168.9	771.4	5,178.9	6,670.9
MA	40.7	4.3	130.7	40.7	297.7	620.4	1,134.5
MD	226.0	21.1	597.8	226.0	1,520.6	2,528.1	5,119.6
ME	199.0	19.1	556.1	199.0	1,322.3	2,561.3	4,856.7
MI	316.9	29.6	886.3	316.9	1,966.1	5,253.7	8,769.4
MN	181.4	15.5	463.1	181.4	992.3	3,281.1	5,114.9
MO	97.0	7.4	230.6	97.0	476.0	2,997.4	3,905.5
MS	212.6	19.0	560.9	212.6	1,271.6	3,427.2	5,704.1
MT	26.4	2.6	81.9	26.4	160.5	506.1	803.9
NC	55.0	5.2	154.0	55.0	336.4	911.4	1,516.8
ND	123.4	10.6	295.8	123.4	759.6	1,362.6	2,675.3
NE	44.1	4.5	131.0	44.1	299.6	572.4	1,095.5
NH	332.9	30.0	857.4	332.9	2,041.2	4,049.9	7,644.2
NJ	58.0	5.2	155.6	58.0	358.7	1,050.8	1,686.2
NM	517.1	47.5	1,414.3	517.1	3,095.2	8,473.6	14,064.8
NV	407.9	31.5	911.8	407.9	2,179.0	6,950.0	10,888.3
NY	17.2	1.8	54.1	17.2	103.9	302.1	496.2
OH	507.3	41.1	1,188.5	507.3	2,843.0	7,500.9	12,588.0
OK	139.6	12.1	352.5	139.6	824.4	2,322.6	3,790.6
OR	133.8	12.8	373.6	133.8	864.5	1,889.7	3,408.1
PA	419.5	38.5	1,132.0	419.5	2,644.5	6,498.5	11,152.6
RI	28.3	2.7	80.8	28.3	188.9	422.5	751.5
SC	207.8	15.1	438.3	207.8	1,066.9	3,981.0	5,916.9
SD	20.9	2.0	62.1	20.9	124.8	398.1	628.9
TN	237.0	18.6	553.4	237.0	1,245.3	4,944.1	7,235.5
TX	875.0	67.6	1,954.5	875.0	4,645.6	15,730.9	24,148.7
UT	70.8	6.7	201.4	70.8	418.4	1,208.1	1,976.3
VA	18.7	1.9	57.6	18.7	127.6	296.3	520.9
VT	309.8	27.6	786.6	309.8	1,986.7	3,853.6	7,274.1
WA	225.6	20.5	595.1	225.6	1,399.7	3,174.0	5,640.6
WI	65.4	5.4	170.6	65.4	345.8	1,700.5	2,353.1
WV	166.3	16.4	488.5	166.3	1,089.3	2,512.5	4,439.2
WY	14.8	1.5	48.1	14.8	92.7	265.7	437.7
50-State	11,403.3	972.1	28,226.3	11,403.3	66,389.1	181,040.0	299,434.1

**Table 2.1.-8. Phase-in Schedule for 20°F Standard by Model Year**

Vehicle GVWR (Category)	2010	2011	2012	2013	2014	2015
≤ 6000 lbs (LDV/LLDT)	25%	50%	75%	100%		
> 6000lbs HLDT (and MDPV)			25%	50%	75%	100%

**Table 2.1.-9. Impact on Nationwide VOC Emissions from Light Duty Vehicles and Trucks of a 20 °F FTP Emission Standard for Non-Methane Hydrocarbons.**

Year	Tons Without Standard	Tons With Standard	Reduction
1999	4,899,891	N. A.	N.A.
2010	2,990,760	2,839,012	151,748
2015	2,614,987	2,293,703	321,284
2020	2,538,664	2,009,301	529,363
2030	2,878,836	1,996,074	882,762

**Table 2.1.-10. Impacts on State Light Duty Vehicle and Truck VOC Emissions of 20 °F FTP Emission Standard for Non-Methane Hydrocarbons in 2030.**

State	Reference Case Tons	Control Case Tons	Reduction in Tons <sup>(a)</sup>	Percent Reduction
AL	52,985	41,636	11,349	21
AK	11,605	6,299	5,306	46
AZ	50,655	39,988	10,667	21
AR	30,893	23,185	7,708	25
CA	259,253	185,702	73,551	28
CO	61,855	40,187	21,667	35
CT	28,766	17,706	11,059	38
DE	7,213	4,639	2,574	36
DC	3,229	2,146	1,082	34
FL	123,002	110,498	12,504	10
GA	100,284	75,270	25,014	25
HI	7,835	7,626	209	3
ID	21,439	13,588	7,851	37
IL	107,467	67,221	40,245	37
IN	85,144	57,529	27,615	32
IA	38,982	25,254	13,729	35
KS	31,740	22,190	9,550	30
KY	48,011	32,867	15,144	32
LA	36,806	30,134	6,672	18
ME	16,942	10,247	6,695	40
MD	45,754	29,230	16,525	36
MA	44,407	25,717	18,690	42
MI	133,830	86,171	47,659	36
MN	86,476	51,148	35,328	41
MS	25,290	19,642	5,648	22
MO	71,439	49,467	21,972	31
MT	16,326	10,015	6,311	39
NE	22,897	15,077	7,819	34
NV	28,102	20,771	7,330	26
NH	15,434	9,413	6,022	39
NJ	54,869	35,834	19,035	35
NM	31,625	22,152	9,473	30
NY	112,589	67,387	45,202	40
NC	94,614	69,429	25,185	27
ND	11,222	6,752	4,470	40
OH	115,095	73,824	41,271	36
OK	46,290	34,712	11,578	25
OR	66,957	46,226	20,731	31
PA	105,046	67,864	37,183	35
RI	9,036	5,641	3,395	38
SC	47,950	36,058	11,892	25
SD	11,920	7,443	4,476	38
TN	70,526	51,999	18,528	26
TX	159,952	126,799	33,154	21
UT	36,024	24,050	11,974	33
VT	9,873	5,906	3,967	40
VI	80,579	53,729	26,850	33
WA	108,386	74,481	33,905	31
WV	16,993	10,833	6,160	36
WI	64,663	37,816	26,847	42
WY	10,566	6,574	3,992	38

(a) Values calculated prior to rounding reference and control values.

Test data show that the controls on cold temperature hydrocarbon emissions will have the ancillary benefit of reducing PM emissions as well. Emissions generated during cold temperature starts tend to be elevated due to a combination of a cold catalyst and excess fuel in the combustion chamber. These factors increase emissions of benzene and other hydrocarbons, and at the same time allow for unburned or pyrolyzed fuel to be emitted.

A number of source apportionment studies have indicated previously that emissions from vehicles starting at cold temperatures contribute disproportionately to ambient PM<sub>2.5</sub>. For instance, the Northern Front Range Air Quality study conducted in the Denver, CO area during the winter of 1997 estimated that, on average, 12% of ambient PM<sub>2.5</sub> could be attributed to cold start light-duty gasoline vehicle emissions.<sup>10</sup>

At this point, the PM emission factors in MOBILE6.2 for PM from light-duty gasoline vehicles are not sensitive to temperatures. However, as outlined above, the emission factors for hydrocarbons and gaseous toxics are temperature-dependent.

In order to estimate the expected emission reductions in PM as a result of the cold temperature standards, we evaluated the relationship between PM and NMHC in Tier 2 vehicles operating at different temperatures. All emissions benefits of the cold temperature standard are expected to affect only the cold temperature starting emissions. As such, all analyses were restricted to Bag 1. However, similar results were obtained when using full weighted FTP results.

First, data from the only extant testing program of Tier 2 vehicles at multiple temperatures was obtained from Southwest Research Institute.<sup>11</sup> Figure 2.1.-1 shows the PM emission factors as a function of temperature. Like NMHC, PM emission factors increase exponentially with lower temperatures through the entire range of testing.



**Figure 2.1.-1. FTP Bag 1 PM Emissions vs. Temperature, Tier 2 Vehicles**

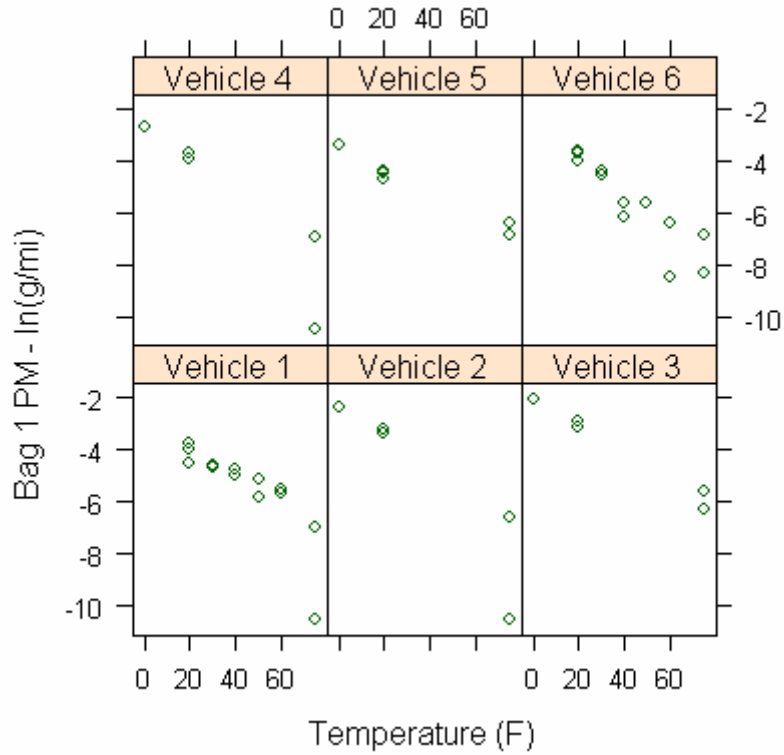
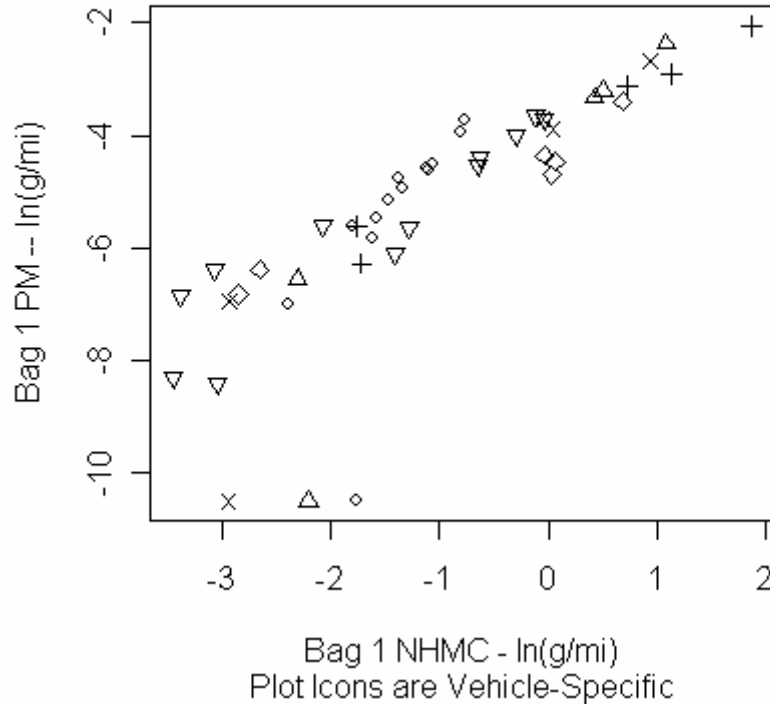


Figure 2.1.-2 illustrates the relationship between FTP Bag 1 NMHC and PM emission factors in this test program. Lower temperature tests are found to the upper right corner, corresponding to elevated emissions of both NMHC and PM. The symbol used for each data point represents the different vehicles in the test program. As shown, there is a clear, linear association. Thus, we concluded that estimated reductions in PM as a result of the hydrocarbon emission controls in this rule could be estimated by applying a PM to NMHC ratio to the estimated reduction in NMHC.

**Figure 2.1.-2. FTP Bag 1 PM and FTP Bag 1 NMHC for Various Tier 2 Vehicles**



In order to determine an appropriate PM/NMHC ratio for calculating PM reductions from NMHC reductions during cold start conditions, we employed mixed models with random vehicle terms.<sup>12</sup> We fit several models to the data, treating the PM/NMHC ratio as a dependent variable. In summary, the model fit to the data was:

$$\mathbf{Y} = \boldsymbol{\mu} + \boldsymbol{\tau} + \mathbf{b} + \mathbf{e}$$

Here,  $\mathbf{Y}$  is a matrix of dependent variables (emission factors);

$\boldsymbol{\mu}$  is the intercept term or “grand mean”;

$\mathbf{b}$  is the change in emission factor associated with discrete testing temperatures;

$\boldsymbol{\tau}$  is the vehicle effect, normally distributed around zero;

$\mathbf{e}$  is the random error term (normally distributed).

Tests in which temperature was treated as a continuous variable were also employed. Overall, the  $\mathbf{b}$  term was found to be significant only at 75° testing, and this may have been due to random measurement errors in the PM/NMHC ratio as a result of very low emissions at 75°. The  $\mathbf{b}$  term became insignificant when it was allowed to vary randomly by vehicle. In addition, because the standards apply only to cold starting conditions, the effect on the ratio at 75° is not relevant to changes in overall emissions. Therefore, we used the mean PM/NMHC ratio of 0.022 to calculate the expected ancillary reductions in PM. The 95% confidence interval for the mean was 0.020 – 0.024.

Using this number, the expected reductions in PM from this rule are estimated to be 7,068 tons in 2015, 11,646 tons in 2020 and 19,421 tons in 2030. These calculations provide initial evidence that the potential public health impacts of this final rule are substantial.

In subsequent test programs demonstrating the feasibility of the NMHC standards in this final rule, the test vehicles exhibited substantial reductions in PM emissions as well. The test results from the two feasibility vehicles fall within the range of those derived from the SwRI test program. These PM emission reductions at 20° F were of similar magnitude as those predicted by the above calculation. Furthermore, examining the feasibility demonstration results, the PM/NMHC ratio of the emission reductions were both close to the value of 0.022 used in the above calculation, spanning either side of the original number (0.010-0.025).<sup>A</sup> In the first feasibility test program, the vehicle reflected a unique control technology that requires careful coordination among the engine air-fuel ratio and secondary air injection timing and air volume to provide the maximum emission benefits. That feasibility program was a "proof of concept" study that did not have the ability to fully explore ideal control coordination and sizing of the emission control system. In the second feasibility study, the vehicle only received recalibration to achieve emission reductions, which is likely to be more representative of the emission control technologies that will be employed for the majority of vehicles. Despite different technologies being used in the feasibility tests, the six current unmodified production vehicles tested in the SwRI test program are considered to be more representative of emission control technologies found throughout the fleet.

Several factors are not accounted for in the emission reduction estimation procedures, which adds uncertainty to the level of emission reductions reported here. First, if manufacturers employ control technologies that differ substantially from those in the two feasibility test programs, actual emission reductions could differ from the estimates here. Second, actual PM reductions may be affected by the extent to which different vehicle or engine technologies penetrate into the vehicle market (such as hybrid electric drivetrains and direct injection gasoline engines).

#### **2.1.2.2 Portable Fuel Containers**

The PFC controls in this final rule will also reduce emissions of hydrocarbons. As noted in Section 2.1.1.2, fifteen states plus the District of Columbia have adopted controls on PFCs independent of the controls being finalized in this rule. In Figure 2.1.-3, we have graphed the estimated annual national VOC emissions (in tons) associated with PFCs for the following three scenarios:

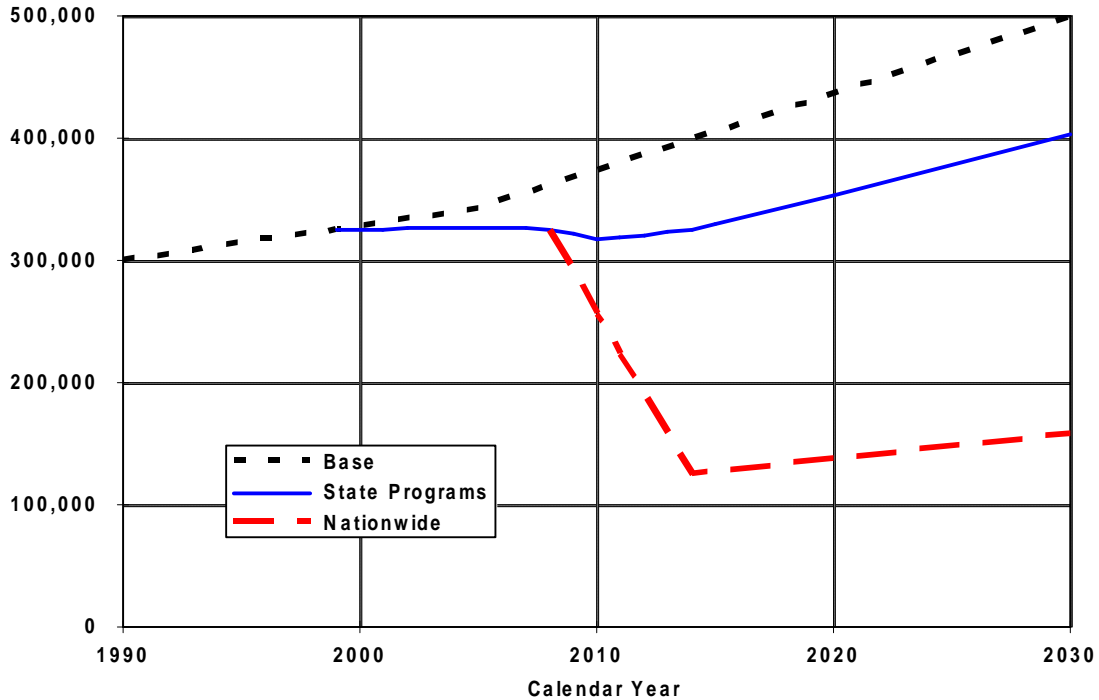
- a base scenario in which no PFC controls are used illustrated with the dotted (black) line,

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<sup>A</sup> This range derives from the feasibility tests with the lowest measured NMHC emissions.

- a scenario in which only those 15 states plus DC have implemented PFC controls illustrated with the solid (blue) line, and
- a scenario in which the PFC controls are implemented nationwide illustrated with the dashed (red) line

**Figure 2.1-3. Comparison of PFC Control Scenarios  
Annual Nationwide VOC Emissions (Tons) from PFCs by Calendar Year**



As noted in Section 2.1.1.2, the estimates of the VOC inventory in the basic scenario are increasing (annually) at a rate of about 1.21 percent. The scenario containing just the state programs has the estimated VOC inventory increasing at an annual rate of about 1.33 percent once all of the programs are phased in. Similarly, the scenario in which nationwide requirements (of this RIA) are phased in exhibit an annual increase in the VOC inventory of about 1.44 percent after phase-in.

Table 2.1.-11 compares the estimated national (annual) inventory of PFC-related VOC with the control program to a reference case scenario that includes only State level controls.

**Table 2.1.-11. Nationwide Annual PFC VOC Emissions (tons)**

<b><u>Calendar Year</u></b>	<b><u>With NO EPA PFC Controls</u></b>	<b><u>With EPA PFC Controls</u></b>	<b><u>Reduction</u></b>
1999	325,030	NA	NA
2007	327,320	NA	NA
2010	316,756	256,175	60,580
2015	329,504	127,157	202,347
2020	353,470	137,175	216,294
2030	402,916	157,661	245,255

### 2.1.3 Strengths and Limitations of Criteria Pollutant Inventories

As previously discussed, the MSAT final rule inventories were estimated using fuel properties developed for the RFS proposed rule. Because the RFS and MSAT inventories were developed in relatively close proximity, we highlight in this section some minor differences in methodologies, as well as uncertainties related to the RFS fuel. Though these methodologies contribute to different baseline RFS and MSAT inventories, they have little impact on our estimates of emission reduction benefits associated with this MSAT final rule.

*Future Volume of Renewable Fuel* – Under the RFS mandate, a minimum volume of ethanol must be blended in gasoline. However, the Energy Information Agency (EIA) has forecasted that market forces alone will push ethanol use well beyond the minimum volume required by the RFS mandate<sup>13</sup>. The volume of renewable fuel forecasted by EIA, and not the RFS program mandate, was used as the baseline for developing RFS fuel properties used in MSAT inventories. Though there are uncertainties related to the future volume of renewable fuel use (and regional allocation), the effects on the emission reduction benefits achieved by the MSAT final rule are likely minimal. Furthermore, as presented in the RFS Draft RIA (DRIA)<sup>2</sup>, inventories for criteria pollutants never differ by more than a few percent between the RFS mandate volume scenario (7.2 billion gallons of national ethanol use) and the EIA-predicted scenario (9.6 billion gallons of national ethanol use).

*Ethanol Effects on Gasoline Properties* – The MSAT rule inventories are based on fuel properties estimated under the RFS program. In the RFS draft regulatory impact analysis, we based our assessment of the effects of ethanol on gasoline fuel properties on annual fuel survey data provided by the Alliance of Automobile Manufacturers. We limited the analysis to cities for which data from both ethanol-blend and non-ethanol gasoline samples were available. These criteria reduced the data to samples from four cities, limiting the national geographic representation of the fuel effects. In addition, there was no distinction to indicate whether the fuel came from multiple refineries within any given city, which eliminates refinery-specific effects. However, we checked the results against the AAM data from all U.S. cities, comparing all conventional gasoline

non-ethanol blends to all conventional gasoline ethanol blends. The results were very similar to those from the four cities.

*Seasonal and Permeation Effects*– For MSAT inventories, we interpolated summer and winter fuel properties to all 12 months and ran each month in NMIM individually. Due to time constraints during development of RFS proposal inventories, we ran NMIM for only January and July, using fuel survey data collected in summer and winter, and assumed that emissions for those two months could be extrapolated to represent the entire year. We estimated RFS annual emissions inventories by summing the two monthly inventories and multiplying by six. For RFS, we also added the effect of ethanol on permeation from onroad non-exhaust emissions. Again, these different methodologies have minimal effect on the emissions benefits associated with this final rule.

*Light-Duty Gasoline Vehicles* – Emission factors for hydrocarbons in the MOBILE model are based on tens of thousands of tests under a wide variety of conditions, and account for leaking fuel systems, aggressive driving, air conditioner use and a variety of other parameters. These data are supported by over 50 technical reports, and many of them received extensive scientific peer review. The strengths and limitations of the MOBILE model have been evaluated by the Coordinating Research Council and the National Research Council.<sup>14,15</sup>

There are significant uncertainties in emission inventories resulting from the use of national default data rather than local inputs, as well as “top-down” allocation schemes in estimating toxic emissions. Examples include use of national default vehicle registration distributions, default average speed distributions, and use of county level population data to allocate State or urban level VMT. Furthermore, emission rates were modeled for only a subset of the total number of counties. Therefore, we do not fully capture all local conditions, introducing additional uncertainty into the inventories.

Also, it should be noted that there are greater uncertainties in projection year estimates. Estimates of emissions from advanced technology vehicles and engines that will comply with planned future emission standards include assumptions regarding levels of emission deterioration and performance under various conditions. Also, vehicle miles traveled are estimated using economic projections with similar inherent limitations.

The revised estimates of cold start VOC emissions are based on a robust dataset at temperatures of 20°F and above. At lower temperatures, however, data are more limited and the magnitude of cold temperature effects is not as certain. Similarly, the estimate of PM reductions from NMHC cold temperature controls are based on limited data, although PM shows a very strong correlation with NMHC. Future control strategies may also employ mechanisms that result in different PM/NMHC ratios than found in existing vehicles.

Finally, the MSAT inventories used the fuel effects contained in MOBILE6.2. In the RFS proposal, we accounted for uncertainties in MOBILE6.2 fuel effects by adjusting

the model output for exhaust VOC and NO<sub>x</sub> emissions by applying EPA Predictive Model fuel effects instead. The MSAT inventories do not use the Predictive Model effects since the use of the Predictive Model would have little impact on estimates of emission benefits of this rule.

*Portable Fuel Containers* – To estimate PFC inventories we were able to build on survey and test data collected by the California Air Resources Board. We also developed inventories using a "bottom-up" approach which provides flexibility and permits very detailed fine-tuning of the various scenarios. However, the inventory involved many assumptions, including refueling activity and temperature effects. Spillage occurring when non-road equipment is refueled is a significant source of VOC emissions. We are assuming (from EPA's NONROAD model) that spillage is a constant 17 grams for each refueling event. We are also assuming that each refueling event occurs when the fuel tank on that piece of equipment is empty. However, if the user "tops off" the fuel tank prior to each use, then we are underestimating the total VOC emissions.

Another assumption relates to whether inactive PFCs are stored with fuel. For example, we assumed that a residence that uses a PFC to only fuel a lawn mower (perhaps six months of the year) will have that PFC empty the remainder of the year (i.e., no permeation or evaporative emissions). However, if that PFC were to contain a small amount of gasoline for those non-mowing months, then we are underestimating the total inventory.

Uncertainty in the characterization of the population of PFCs (i.e., commercial versus residential usage, open versus closed, metal versus plastic) is the major source of uncertainty in our estimates of the inventory of VOCs from PFCs. Our characterization of the population of PFCs is based on surveys performed by the Air Resources Board (ARB) of California. We used the same distribution of open versus closed PFCs determined by ARB. Since the PFC population in the rest of the country might not be exactly like California's, we performed a sensitivity analysis to determine the effects of varying that distribution. We found that even relatively large changes in that distribution produced changes in estimated total VOC of less than 13 percent.<sup>16</sup> Other source of uncertainty include estimates of the frequency of refilling of containers, estimates of effects of ambient temperature on vapor displacement and spillage, estimates of effects of RVP on vapor displacement, impacts of temperature of the fuel itself on emissions, and estimates of the amount of spillage during refilling.

## **2.2 Air Toxics**

### **2.2.1 Emission Inventories Used in Air Quality Modeling**

The data and methods employed to develop the county-level air toxics inventories used for air quality, exposure and risk modeling to support this final rule are discussed in detail in the EPA Technical Report, "National Scale Modeling of Air Toxics for the Final Mobile Source Air Toxics Rule; Technical Support Document," Report Number EPA-454/R-07-002. All underlying data and summary statistics are included in the docket for

this rule. Major revisions have been made to the inventories used for air quality, exposure, and risk modeling since proposal. These revisions include:

- Revisions to cold temperature start emissions for gaseous air toxics in Tier 1 and later highway gasoline vehicles
- Estimation of air toxic emissions for nonroad equipment using NMIM2005 rather than NMIM2004
- Inclusion of air toxic emissions from portable fuel containers
- Revision of the benzene and naphthalene inventories for gasoline distribution based on recent analysis of benzene in gasoline vapor emitted during the distribution process

While cold temperature emissions and portable fuel container emissions were included in analyses of emission benefits and cost-effectiveness for the proposal, the proposal did not use NMIM2005 for nonroad equipment or include changes to the gasoline distribution emissions estimates based on recent analyses. While the air quality modeling inventories for the final rule included the above improvements, it did not include impacts of the renewable fuel standard, as the inventories were developed well in advance of the proposal for that standard. Furthermore, the modeling accounted only for the 0.62 percent standard, but not the 1.3 vol% maximum average. Thus, the emission reductions from highway vehicles and other sources attributable to the fuel benzene standard are underestimated in many areas of the country, particularly in areas where fuel benzene levels were highest without control, such as the Northwest. It should be noted that the inventories used in the proposal were presented in a peer reviewed journal article.<sup>17</sup>

The following sections summarize the methods used to develop the air quality modeling inventories, including details of the major revisions listed above, and also present inventory results. While air quality, exposure, and risk modeling was done for years 1999, 2015, 2020, and 2030 (with modeling for 1999 done as the National Scale Air Toxics Assessment), reference case inventories were also developed for 2010 in order to better assess emission trends over time. Control case modeling which included cumulative impacts of the controls being finalized in this rule was done for 2015, 2020 and 2030. For the reference case, we modeled all air toxic compounds listed in section 112 of the Clean Air Act for which we had adequate data to estimate emissions. Table 2.2.-1 lists the pollutants included in these inventories which were used in subsequent modeling of air quality, exposure, and risk. For the control case, we modeled a smaller subset of pollutants as discussed below. Emission inventories included stationary sources, highway vehicles, and nonroad equipment.

### **2.2.1.1 Methods Used to Develop Air Toxics Inventories for Air Quality Modeling**

#### **2.2.1.1.1 Highway Vehicles**

Highway gasoline vehicle inventories for all emission types except refueling were developed using a modified version of NMIM2005.<sup>18, 19, 20</sup> NMIM develops inventories using EPA's MOBILE6.2 emission factor model for highway vehicles, EPA's



NONROAD emissions inventory model for nonroad equipment, and model inputs stored in data files. Model inputs include data such as temperatures, fuel properties, vehicle registration distributions, inspection and maintenance programs, vehicle miles traveled, and toxics inputs in the form of toxic to volatile organic compound (VOC) ratios, toxic to particulate matter (PM) ratios, or toxic emission factors. The toxics inputs were developed from a variety of emissions testing programs conducted by EPA, States, and industry over many years (see Section 2.2.1.1.6 for more information). Details on data sources can be found in the documentation for the National Emissions Inventory. Refueling emission estimates for 2015 and later years were carried over from the inventories used for air quality modeling in the proposal. For 1999 and 2010, benzene refueling emission estimates were not available, so benzene refueling emissions were backcast from 2015, using ratios of VOC refueling emissions in 1999 or 2010 to 2015 VOC. The approach used to do this is discussed in detail in the technical support document.

NMIM was modified to include the hydrocarbon start emission adjustment factors discussed in Section 2.1.1.1. Since the algorithms used to calculate toxic to hydrocarbon emission ratios in MOBILE6.2 do not vary with temperature, reductions in hydrocarbon emissions result in proportional reductions in air toxic emissions.

The assumption in MOBILE6.2 that reductions in air toxic emissions are proportional to hydrocarbon emission reductions was based on testing done at temperatures ranging from -20 to 75 °F in EPA's Office of Research and Development in the late 1980's.<sup>21, 22</sup> These studies found that, overall, the composition of hydrocarbon emissions did not vary appreciably with temperature, although fractions of formaldehyde increased somewhat with lower temperature in port fuel injected vehicles. The validity of the assumption was re-evaluated for later model vehicles.

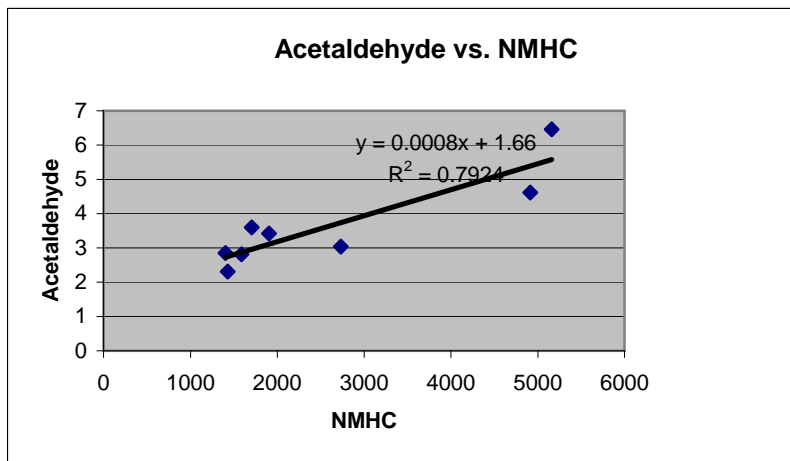
EPA's Office of Research and Development recently tested several late model vehicles at the same temperature ranges cited above.<sup>23,24,25</sup> These results can be used to reevaluate the validity of the assumption discussed above. The results of the test program are unpublished, but are included in the docket for the rule. Vehicles included in the test program were a 1993 Chevrolet Cavalier, a 1987 and 1993 Ford Taurus, a 1996 Chrysler Concord, a 2001 Ford Focus, a 1993 Buick Regal, and a 2001 Dodge Intrepid. This test program found increasing emissions of individual air toxics at lower temperatures. Benzene and 1,3-butadiene emissions increased proportionally with hydrocarbon emissions, with a very strong correlation. However, correlations were not as strong with aldehydes. Results from the 1993 Cavalier and 1993 Taurus found a statistically significant correlation for acetaldehyde but not for formaldehyde, whereas analysis of data from the other vehicles found a correlation for formaldehyde but not acetaldehyde.

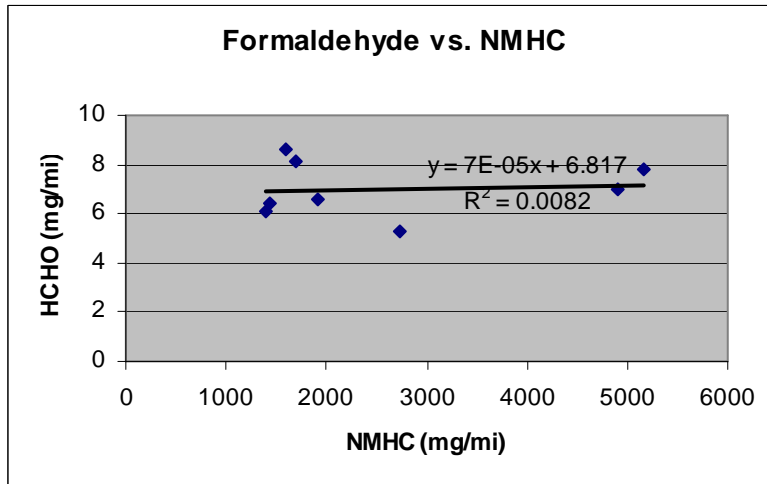
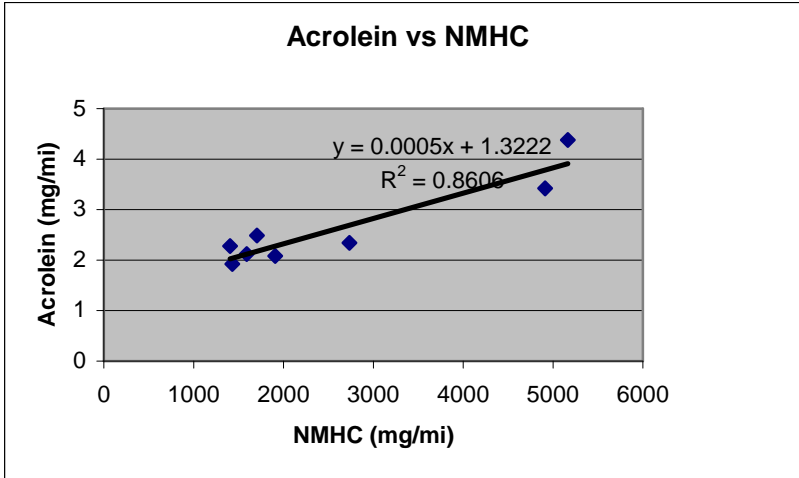
A major vehicle manufacturer also recently tested two Tier 2 compliant vehicles at 75 and 20 °F. Although the data are confidential, they show emission of air toxics increase at the same rate as hydrocarbons, with a very high correlation.

A third source of data is testing done by Southwest Research Institute for EPA on four model year 2005 vehicles – a Ford F-150, a Mazda 3, a Honda Odyssey and a Chevrolet Equinox.<sup>26</sup> The four vehicles were tested at 0, 20 and 75 °F. Benzene and 1,3-butadiene correlated very strongly with hydrocarbon emissions, with r-square values above 0.9. Benzene accounted for about 3.6 percent of exhaust non-methane hydrocarbon emissions at all temperatures, while 1,3-butadiene accounted for about 0.3%. However, formaldehyde and acetaldehyde fractions appeared to decrease with decreasing temperature. When data for the largest vehicle, the Ford F-150, were removed, there seemed to be a stronger correlation between aldehyde emissions and non-methane hydrocarbons. This could be because this larger engine is running richer during cold starts than the other vehicles, and not enough oxygen is available for aldehyde formation.

Recent EPA testing of a Chevrolet Trailblazer, with its engine recalibrated to meet the cold temperature standard, showed reductions in acetaldehyde and acrolein proportional to the reduction in VOC. Formaldehyde was also reduced, but was not reduced as much as acetaldehyde and acrolein. Other air toxic compounds, including benzene, were not included in this testing. Figure 2.2.-1 depicts the relationship between carbonyl compounds and NMHC.

**Figure 2.2.-1. Regressions of Carbonyl Emissions Versus NMHC for Chevrolet Trailblazer Recalibrated to Meet Cold Temperature Standard.**





Given available data, we have concluded it is reasonable to retain the assumption that ratios of toxic emissions to hydrocarbon emission do not vary with temperature. However, as more data become available, this assumption should be reevaluated, particularly for aldehydes.

Within the MOBILE6.2 model, six MSATs (benzene, formaldehyde, acetaldehyde, 1,3 butadiene, acrolein, and methyl tertiary butyl ether [MTBE]) can be calculated directly by including detailed fuel parameters. These parameters are stored in the NMIM database. The fuel parameters are: sulfur content, olefins content, aromatics content, benzene content, E200 value, E300 value, oxygenate content by type, and oxygenate sales fraction by type.<sup>B</sup> Since these fuel parameters are area-specific, EPA developed county-level inputs for each of these parameters. Fuel parameters were collected for winter and summer seasons using a number of different data sources. These sources include the Alliance of Automobile Manufacturers, Northrop Grumman Mission Systems (formerly TRW Petroleum Technologies), and EPA reformulated gasoline

<sup>B</sup> E200 and E300, represent the percentage of vapor that gasoline produces at 200 and 300 °F, respectively.

surveys. Documentation for the National Emissions Inventory (NEI)<sup>27</sup> describes the development of the fuel parameter database used with MOBILE6.2 in detail. The fuel parameter data through 1999 are posted at the following website:

<ftp://ftp.epa.gov/EmisInventory/finalnei99ver3/haps/datafiles/onroad/auxiliary/>

Although fuel parameter data were prepared for only two seasons (summer and winter), NMIM uses monthly rather than seasonal fuel parameters, and parameters for spring and fall months are estimated by interpolating from summer and winter data. In addition, documentation of the fuel parameters used in NMIM was compiled in 2003 (Eastern Research Group, 2003), and subsequently, a number of changes were made, based on comments from States. These changes are documented in the change log for NMIM, dated May 14, 2004. This change log is included in the docket for this rule, along with the original documentation. In general, multiplicative adjustment factors were used to calculate future year gasoline parameters (i.e., future year parameter = base year parameter x adjustment factor). However, additive adjustment factors were used to calculate future year parameters for E200, E300, and oxygenate market shares (i.e., future year parameter = base year parameter + adjustment factor). These adjustment factors were developed using results of several refinery modeling analyses conducted to assess impacts of fuel control programs on fuel properties.<sup>28, 29, 30</sup> The database used for this assessment assumes no Federal ban on MTBE, but does include State bans. Also, it did not account for recent increases in the use of ethanol oxygenated gasoline, the renewable fuels mandate in the recent Energy Policy Act, or the 1.3 vol% maximum average fuel benzene level.

MOBILE6.2 also has a command (ADDITIONAL HAPS) which allows the user to enter emission factors or air toxic ratios for additional air toxic pollutants. Emission factors for the other HAPs in Table 2.2.-1 were calculated by MOBILE6.2 through the use of external data stored in the NMIM database, specifying emission factors for these pollutants in one of three ways: as fractions of volatile organic compounds (VOC), fractions of PM, or by supplying the basic emission factors. The ratios used with this command must be expressed as milligrams of HAP per gram of VOC or PM. Gaseous hydrocarbons were estimated as fractions of VOC. Polycyclic aromatics hydrocarbons (PAHs) were calculated as fractions of PM, although the data used to calculate mass ratios included both gas and particle phase PAH emissions. Metals were estimated using basic emission factors. Evaporative emissions (e.g., toluene, xylenes) can only be estimated as fractions of VOC. Because toxic to VOC ratios for several gaseous HAPs vary between baseline (i.e., non-oxygenated) gasoline and gasoline oxygenated with MTBE or ethanol, separate ADDITIONAL HAPS input data were developed for: 1) baseline gasoline; 2) gasoline oxygenated with 2% MTBE by weight (e.g., Federal reformulated gasoline); 3) gasoline oxygenated with 2.7% MTBE by weight (e.g., winter oxygenated gasoline); and 4) gasoline oxygenated with 3.5% ethanol by weight (gasohol).

**Table 2.2.-1. Air Toxics Included in Emission Inventories and Used for Air Quality, Exposure, and Risk Modeling.**

1,3-Butadiene	Ethyl Benzene
2,2,4-Trimethylpentane	Fluoranthene
Acenaphthene	Fluorene
Acenaphthylene	Formaldehyde
Acetaldehyde	n-Hexane
Acrolein	Indeno(1,2,3,c,d)-pyrene
Anthracene	Manganese
Benzene	Methyl tert-butyl ether (MTBE)
Benz(a)anthracene	Naphthalene
Benzo(a)pyrene	Nickel
Benzo(b)fluoranthene	Phenanthrene
Benzo(g,h,i)perylene	Propionaldehyde
Benzo(k)fluoranthene	Pyrene
Chromium	Styrene
Chrysene	Toluene
Dibenzo(a,h)anthracene	Xylenes

Vehicle miles traveled used in this assessment were those developed for the Clean Air Interstate Air Quality Rule (CAIR).<sup>31</sup>

For years 2015, 2020, and 2030, inventories were developed that reflected the cumulative impacts of the controls being finalized in this rule. These control case inventories included all the pollutants in Table 2.2-1.

To develop these inventories, NMIM was rerun with revised gasoline fuel parameter inputs for fuel benzene and aromatics levels, as well as estimated emission reductions from new start emission standards for hydrocarbons. The fuel parameter inputs were revised based on refinery modeling done for the proposed rule, rather than the final rule refinery modeling discussed in Chapter 6 of the this document. As part of the refinery modeling, average fuel properties under a 0.62% fuel benzene standard, with no maximum average level, were estimated for each Petroleum Administration for Defense District (PADD). Average fuel benzene levels for conventional gasoline and reformulated gasoline in each PADD before and after implementation of the standards were used to develop multiplicative factors which were applied to the reference case fuel benzene levels for each county in the NMIM database. These multiplicative factors are summarized in Table 2.2.-2. Although California is part of PADD5, it was treated separately, since California has its own reformulated gasoline program. Table 2.2.-3 compares average fuel benzene levels for each PADD used in the air quality modeling

inventories, compared to levels predicted by refinery modeling for the final rule, which assumes a 1.3 vol% maximum average. If the refinery modeling data had been available to be used in the air quality modeling inventories, benzene emission reductions from the fuel standard would have been significantly greater in PADDs 2 and 5, but slightly lower in PADDs 1 and 3.

The refinery modeling also indicated that the reduction in fuel benzene levels would result in small proportional decreases in aromatics levels as well.<sup>32</sup> Thus aromatics levels were adjusted using the additive factors calculated as follows:

$$\text{Additive Factor} = 0.77 (\text{BZ}(\text{control}) - \text{BZ}(\text{ref})) \quad (1)$$

Where BZ = benzene

An Excel workbook, designated “fuel changes.xls”, summarizes the control and reference case fuel benzene and aromatics levels used for 2015, 2020, and 2030. This file is included in the docket for the rule. We also checked the control case fuel benzene levels to make sure the nationwide average level was close to the standard. We did this by weighting county fuel benzene level by VMT as a surrogate for fuel sales. The resulting nationwide average level was a little under 0.63%, very close to the standard. The refinery modeling methodology is discussed in Chapter 9 of the Regulatory Impact Analysis. Since the reduction in fuel benzene changes well below one percent of the gasoline, the level of uncertainty in the impacts on other fuel parameters and emissions is quite small.

Once fuel parameters were developed for the control case, NMIM was rerun with data files that included new start emission standards for hydrocarbons. Output included exhaust emissions, non-refueling evaporative emissions, and refueling evaporative emissions.

It should be noted that the inventory used for air quality modeling included an error in contractor-supplied input files for 13 Northeastern states. This error had a small impact on reference case inventories, but the impact on estimates of emission reductions with controls was insignificant. In addition, the control case inventory for 2015 assumes that the fuel program is fully phased in, which is a simplification of the actual phase-in. For more information about fuel program phase-in, refer to Chapter 6 of the Regulatory Impact Analysis.

**Table 2.2.-2. Average Fuel Benzene Level (Volume Percent) by PADD with Implementation of Fuel Benzene Standard (CG – Conventional Gasoline; RFG – Reformulated Gasoline)**

		<b>PADD 1</b>	<b>PADD 2</b>	<b>PADD 3</b>	<b>PADD 4</b>	<b>PADD 5</b>	<b>Calif.</b>
<b>Reference Case</b>	CG	0.91 %	1.26%	0.95%	1.47%	1.42%	0.62%
	RFG	0.59%	0.80%	0.57%	1.05%	0.65%	0.62%
<b>Control Case</b>	CG	0.55%	0.68%	0.54%	0.93%	0.85%	0.61%
	RFG	0.54%	0.71%	0.55%	0.62%	0.60%	0.61%
<b>Multiplicative Factor</b>	CG	0.60	0.54	0.57	0.63	0.60	0.98
	RFG	0.92	0.89	0.96	0.59	0.92	0.98

**Table 2.2-3. Comparison of Average Fuel Benzene Level (Volume Percent) by PADD In Inventories Versus Final Rule Refinery Modeling..**

		<b>PADD 1</b>	<b>PADD 2</b>	<b>PADD 3</b>	<b>PADD 4</b>	<b>PADD 5</b>	<b>Calif.</b>
<b>Average Fuel Benzene Level Assumed in Inventories (0.62% standard)</b>	CG	0.55 %	0.68%	0.54%	0.93%	0.85%	0.61%
	RFG	0.54%	0.71%	0.55%	0.62%	0.60%	0.61%
<b>Average Fuel Benzene Level, Final Rule Refinery Modeling, with 0.62% Standard and 1.3 vol% Maximum Average</b>	CG	0.61%	0.62%	0.63%	0.85%	0.65%	0.61%
	RFG	0.54%	0.60%	0.55%	0.62%	0.60%	0.61%

For highway diesel vehicles, we used a different approach than we used for gasoline vehicles. NMIM2004 outputs for 1999, 2007, 2010, 2015 and 2020 were used to develop ratios of future year to 1999 air toxic inventories. These were then applied to 1999 NEI inventory estimates by SCC, county and HAP:

$$PF_{20XX} = \frac{E_{NMIM,20XX}}{E_{NMIM,1999}} \quad (2)$$

where  $PF_{20XX}$  is the projection factor for 2007, 2010, 2015, 2020, or 2030,  $E_{20XX}$  is the emissions for the corresponding year and  $E_{1999}$  is the 1999 emissions. Highway diesel vehicle air toxic emission estimates remained unchanged from the proposal.

#### 2.2.1.1.2 Nonroad Equipment in the Nonroad Model

Nonroad equipment in the NONROAD model includes such sources as recreational, construction, industrial, lawn and garden, farm, light commercial, logging, airport service, railway maintenance, recreational marine vessels. For final rule modeling, we used 1999 and future year inventories developed using NMIM2005, which includes NONROAD2005. NONROAD2005 includes a number of improvements over NONROAD 2004, which was used in the proposed rule. These improvements include new evaporative categories for tank permeation, hose permeation, hot soak, and running loss emissions, a revised methodology for calculating diurnal emissions, and improvements to allocation of emissions from recreational marine and construction equipment.

As with highway vehicles, exhaust gaseous hydrocarbons were estimated as fractions of VOC, PAHs were calculated as fractions of PM, and metals were estimated using basic emission factors. Evaporative emissions were estimated as fractions of VOC.

Changes in fuel benzene and aromatics levels are expected to result in similar emission changes for nonroad gasoline equipment as for gasoline highway vehicles. However, NMIM does not have the capability to model impacts of these fuel changes on nonroad equipment emissions. Thus, we assumed that changes in county-level exhaust and evaporative emissions of nonroad gasoline equipment were proportional to changes in highway light-duty gasoline vehicle emissions.

$$PF_{nonroad\ exhaust}_{20XX} = \frac{ELDG_{Vexhaust\ NMIM\ Control\ 20XX}}{ELDG_{VExhaust\ NMIM\ Reference\ 20XX}} \quad (3)$$

$$PF_{nonroad\ evap}_{20XX} = \frac{ELDG_{Vevap\ NMIM\ Control\ 20XX}}{ELDG_{VEvap\ NMIM\ Reference\ 20XX}} \quad (4)$$

The nonroad refueling associated with PFCs was subtracted from the nonroad inventory prior to air quality modeling, and the inventory summaries presented in Section 2.2.1.2.1 include this subtraction.



### 2.2.1.1.3 Commercial Marine Vessels, Locomotives and Aircraft

These source sectors will not be impacted by the fuel benzene standards being finalized in this rule. Final rule inventories are unchanged from those used to model the proposal.

Emissions for these source sectors in 1999 were obtained from the 1999 National Emissions Inventory, Final Version 3. Gaseous air toxic and PAH emissions for turbine engine aircraft were estimated by applying toxic to VOC ratios obtained from detailed characterization of turbine engine emissions. Since no emissions data were available for piston engine aircraft, a speciation profile from a non-catalyst light-duty gasoline vehicle was used as a surrogate. Metal emissions were not estimated for aircraft. No speciated emissions data were available for commercial marine vessels. For diesel marine vessels, profiles from heavy-duty diesel highway vehicles were used; for steamships, a profile for stationary and industrial boilers was used. Locomotive air toxic emissions were estimated using speciation data from a year 2000 study done by the California Air Resources Board.<sup>33</sup> More detailed information on methods used to develop air toxic inventories for these sectors can be found in the documentation for the 1999 NEI.<sup>34</sup> This documentation also describes methods used to develop inventories for 1990 and 1996.

The following approaches were used to project emissions for these source categories:

Locomotives and commercial marine vessels – For gaseous HAPs, inventories were developed by applying ratios of future year to 1999 national level 50 state VOC inventory estimates (from the recent Clean Air Nonroad Diesel rule) by SCC code. For polycyclic aromatic hydrocarbons, PM ratios were used. Metal inventory estimates were projected to future years based on activity. Locomotive activity was projected using fuel consumption data from the Energy Information Administration, as discussed in the Regulatory Impact Analysis for Clean Air Nonroad Diesel Rule. For commercial marine vessels, projected equipment populations from 1998 Power Systems Research (PSR) data were used to develop factors. The future year inventories do not account for potential reductions of additional locomotive or commercial marine vessel emission controls currently under consideration.

Aircraft – To project emissions from aircraft and from aviation gas distribution emissions, we developed and applied growth factors (in EMS-HAP) to 1999 emissions based on landing and take off data. The Federal Aviation Administration's Terminal Area Forecast System provided landing and take off data for future years up to 2020, associated with commercial aircraft, general aviation, air taxi and military aircraft.<sup>35</sup> These four categories map directly to the inventory categories for aircraft emissions. The landing and take off data were summed across airports to create growth factors at the national level. The general aviation growth factors were used for aviation gas distribution emissions. After 2020, activity was assumed to increase at the same rate as the increase from 2015 to 2020.

#### 2.2.1.1.4. Portable Fuel Containers

Any MSATs contained in the liquid gasoline will be present as a component of the VOCs. Specifically, the VOC emissions (estimated in Sections 2.1.1.2 and 2.1.3) will contain the following eight MSATs:

- benzene,
- MTBE,
- n-hexane,
- toluene,
- xylenes,
- ethylbenzene,
- naphthalene, and
- 2,2,4-trimethylpentane.

While MSAT inventories for portable fuel containers (PFCs) were developed at the State level (benzene) or national level (other MSATs above) to estimate emission benefits and cost-effectiveness of the proposed rule, county-level inventories for portable fuel containers were not developed for use in air quality modeling for the proposal. In this section, we describe the methodology used to develop such inventories for 1999, 2010, 2015, 2020, and 2030, for the final rule.

As discussed in Section 2.1.1., VOC inventories were developed at the State level for the following years – 1990, 2005, 2010, 2015, 2020, and 2030. Thus an inventory had to be developed for 1999. This was done by linear interpolation of the 1990 and 2005 inventories. Permeation and evaporative emissions had to be separated as well, since they were combined in the State-level VOC inventories. Based on analyses done by the California Air Resources Board, 33.87 percent of combined permeation plus evaporative emissions was assumed to be permeation (see Section 2.1.1.2). This percentage was applied to all the State inventory estimates.

Statewide total annual VOC inventories were allocated to counties using county level fuel consumption ratios for calendar year 2002, obtained from the public release version of NONROAD2005:

$$PFC\ VOC\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ County\ Z} = PFC\ VOC\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ StateZ} \times \frac{County\ Fuel\ Consumption_{Nonroad\ 2005}}{State\ Fuel\ Consumption_{Nonroad\ 2005}} \quad (5)$$

For all compounds except benzene and naphthalene, the fraction of total PFC emissions that is composed of each of those HAPs was assumed to be directly proportional to the ratio of each of those HAPs at the county level in total evaporative emissions from light-duty gasoline vehicles (Equation 8).

$$PFC\ MSAT\ evap_{20XX} = \frac{MSAT\ Emissions_{LDG\ Evap_{20XX}}}{VOC\ Emissions_{LDG\ Evap_{20XX}}} \times PFC\ VOC\ Emissions \quad (6)$$

These ratios were obtained from the database of toxic to VOC ratios in the NMIM model, discussed in previous sections. NMIM has ratios that vary by fuel type (conventional or baseline gasoline, ethanol oxygenated gasoline, and MTBE oxygenated gasoline).

Another approach was used to estimate emissions of benzene with and without PFC control, and also with and without the fuel benzene standard. First, we divided county-level benzene refueling emissions by county-level VOC refueling emissions estimated by NMIM, for both reference and control case scenarios. The resultant ratios were multiplied by VOC emissions from evaporation, vapor displacement, and spillage. These ratios were then adjusted based on a recent analysis of average nationwide percentage of benzene in gasoline vapor from gasoline distribution with an RVP of 10 psi at 60 degrees Fahrenheit.<sup>36</sup> That analysis shows that the percentage of benzene in gasoline vapor from gasoline distribution is 0.27%, in contrast to 0.74% benzene on average nationwide in vehicle refueling emissions from highway vehicles. The reason for this difference is that the refueling algorithm in MOBILE6.2 is based on a temperature of 90 degrees, whereas temperatures for gasoline marketing emissions will typically be lower. Thus a ratio of 0.36 was applied to the gasoline vehicle refueling ratios. For all emission types except permeation, the equation used was:

$$PFC\ Benzene\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ County\ Z} = PFC\ VOC\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ County\ Z} \times \left( \frac{Re\ fueling\ Benzene_{LDGV,\ County\ Z}}{Re\ fueling\ VOC_{LDGV,\ County\ Z}} \right) \times 0.36 \quad (7)$$

A separate ratio was used for permeation emissions since recent research suggests that the ratio of benzene from permeation is higher than for evaporation, vapor displacement or spillage. A recent study<sup>37</sup> suggests that the ratio of benzene from permeation to total VOC from permeation is about 1.7727 times higher than the ratio associated with evaporation. Thus, we multiplied the benzene refueling ratios for each state by 1.7727 to obtain the benzene to VOC ratios for permeation:

$$PFC\ Benzene\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ County\ Z} = PFC\ VOC\ Emissions_{Emission\ Type\ X,\ SCC\ YYY,\ County\ Z} \times \left( \frac{Re\ fueling\ Benzene_{LDGV,\ County\ Z}}{Re\ fueling\ VOC_{LDGV,\ County\ Z}} \right) \times 0.36 \times 1.77 \quad (8)$$

A similar adjustment was applied to naphthalene emissions with and without fuel benzene control, based on a recent analysis of average nationwide percentage of naphthalene in gasoline vapor from gasoline distribution with an RVP of 10 psi at 60

degrees Fahrenheit.<sup>38, 39</sup> The percentage is 0.00027, in contrast to 0.05% naphthalene on average nationwide in vehicle refueling emissions from highway vehicles. Thus a ratio of 0.0054 was applied to the gasoline vehicle refueling ratios:

$$\begin{aligned}
 &PFC \text{ Naphthalene Emissions}_{\text{Emission Type X, SCC YYY, County Z}} = \\
 &PFC \text{ VOC Emissions}_{\text{Emission Type X, SCC YYY, County Z}} \times \qquad \qquad \qquad (9) \\
 &\left( \frac{\text{Re fueling Naphthalene}_{LDGV, \text{County Z}}}{\text{Re fueling VOC}_{LDGV, \text{County Z}}} \right) \times 0.0054
 \end{aligned}$$

#### 2.2.1.1.5. Gasoline Distribution

EPA’s estimates of gasoline distribution emissions reflect improvements in its methodology developed for the 2002 National Emissions Inventory (NEI). The key changes are:

- 1) Vehicle refueling emissions are estimated as part of the highway vehicle inventory using NMIM2004, as discussed previously, and included in the highway vehicle inventory. Details of how the modeling was done can be found in the documentation for the mobile source 2002 NEI.<sup>40</sup> The previous methodology is described in the nonpoint 1999 NEI documentation.<sup>41</sup> In this older method, national VOC emissions were calculated using fuel sales data and estimates of emissions per fuel volume in areas with and without Stage 2 vapor recovery systems. Air toxic emissions were estimated from VOC by applying speciation profiles for different fuel types, such as baseline gasoline, MTBE oxygenated gasoline, and ethanol oxygenated gasoline. Total emissions for each combination of vapor recovery system and fuel type were allocated to individual counties using vehicle miles traveled.
- 2) For all other source categories in the gasoline distribution sector, EPA is using an improved set of methods. These improvements include: (a) for source categories where activity-based emission factors were available (all except bulk terminals and pipelines), EPA established methods that maintain mass balance for storage and transfer activities, such that there is agreement with the activity estimates used for each of the different distribution sectors; (b) EPA developed criteria pollutant and air toxic emission estimates using the same activity data and a consistent set of speciation profiles; and (c) EPA accounted for local differences in fuel properties for downstream emissions (e.g. bulk plants, transit, unloading, storage, Stage 1 evaporative losses). More details on these improvements can be found in a technical memorandum on the website for the 2002 NEI.<sup>42</sup>

The results of these changes were a significant increase in the air toxic inventory estimates for vehicle refueling and a small increase nationwide for other sources of gasoline distribution emissions. County-level estimates for some gasoline distribution sources changed considerably since local differences in fuel properties were accounted for. Table 2.2.-4 compares benzene estimates in the 1999 NEI, final version 3, and the final 2002 NEI.

**Table 2.2.-4. Vehicle Refueling and Gasoline Distribution Benzene Emissions (Tons), 1999 and 2002 NEI.**

	1999 NEI	2002 NEI	% Difference
Vehicle Refueling	1558	2129	+36
Gasoline Distribution	4978	5119	+3

In order to develop better estimates of the emission benefits of the fuel benzene control being finalized in this rule, EPA developed updated air toxic inventories for vehicle refueling and gasoline distribution to reflect the changes made in the 2002 NEI. In addition, the same adjustment factors for benzene and naphthalene described above for PFC emissions were also applied to gasoline distribution emissions.

Inventories were developed as follows:

- 1) Vehicle refueling emissions were estimated using NMIM2004. Refueling emissions were estimated for reference case inventories in 1999, 2010, 2015, 2020 and 2030. Control case inventories were estimated for 2015, 2020 and 2030.

- 2) For other gasoline distribution emissions, for each air toxic pollutant, EPA estimated a national-scale adjustment factor as follows:

Adjustment factor = 2002 NEI national emissions/2002 national emissions estimated from interpolation of the 1999 NEI and a 2007 projection for the proposed rule.

- 3) EPA developed new county-level reference case inventories for these pollutants by applying these adjustment factors to county-level gasoline distribution emissions for 1999 and future years. The gasoline distribution projections were based on projection information (growth factors, closures, reductions, etc.) from the 1999 NEI.<sup>43</sup> Revised inventories were developed for years 1999, 2015, and 2020. 2030 was assumed to be the same as 2020.
- 4) Additional nationwide adjustments of 0.36 and 0.0054, respectively, were applied to emissions of benzene and naphthalene. The basis for these adjustments is discussed in the Section 2.2.1.1.4.
- 5) EPA developed new control case inventories for gasoline distribution, for benzene, for years 2015, 2020, and 2030. These revised county-level inventories were estimated by applying the following ratios:

emissions proposed rule control scenario/emissions proposed rule reference case

These ratios reflect reductions estimated based on the assumption that reductions are proportional to reductions in vehicle refueling emissions.

2.2.1.1.6. Other Stationary Sources

Stationary source estimates for 1999, for all source categories except gasoline distribution, were obtained from the National Emissions Inventory.<sup>44, 45</sup>

For nearly all stationary sources (point and non-point source inventories), we used the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP), Version 3.0 to apply growth and control factors to the 1999 NEI, source type by source type.<sup>46</sup> EMS-HAP has the capability of projecting emissions to 2020. After 2020, stationary source emissions were assumed to remain constant.

The general methodology for projecting stationary source emissions using EMS-HAP is as follows:

$$\text{Future Year Emissions} = \text{Base Year Emissions} * \text{Growth Factor} * (100\% - \% \text{Reduction})/100 \quad (10)$$

The actual equations used by EMS-HAP also allow the application of a “new source” reduction to a fraction of the emissions to allow for a different level of emission reduction to be applied to a portion of the emissions. In addition, if the source is already controlled, and the value of the overall control efficiency is provided in the emission inventory, EMS-HAP adjusts the percent reduction (% Reduction) based on the overall control efficiency value provided in the inventory. The actual projection equations are provided in Chapter 6 (PtGrowCntl) of the EMS-HAP User’s Guide (U. S. EPA, 2004b, pp. 6-15 – 6-17).

*Stationary source growth* -- EMS-HAP allows growth factors to be applied to the inventory on either a national, state or county level basis, based on one of the following inventory codes that describe the source: (1) MACT, which identifies an emission source as a belonging to a particular regulatory category or subcategory; (2) Standard Industrial Classification (SIC), which classifies establishments by their primary type of activity, as defined by the U.S. Census Bureau; (3) Source Category Code (SCC), which defines the source using EPA’s coding system for the NEI. The MACT and SCC code definitions are contained in the code tables supplied with the NEI. Note that even though the code is called “MACT”, it is also used for other regulations besides MACT such as section 129 rules. The hierarchy built into EMS-HAP is to use a MACT-based growth factor first, followed by an SIC-based and lastly, an SCC-based growth factor. The most detailed geographic level is used first (e.g., a state-specific growth factor replaces a national growth factor). EMS-HAP does not have the capability to apply growth factors to specific point source facilities, nor can they be applied differently for the different pollutants for a particular source category.

For stationary sources, growth factors were developed using three primary sources of information:

- Regional Economic Models, Inc. (REMI) Policy Insight<sup>®</sup> model, version 5.5;<sup>47, 48</sup>
- Regional and National fuel-use forecast data from the Energy Information Administration, U.S. Department of Energy, Annual Energy Outlook (AEO)<sup>49</sup>

- Rule development leads or economists who had obtained economic information in the process of rule development.

The first two sources of information were also used in projecting criteria pollutant emissions for EPA's 2005 Clean Air Interstate Rule.<sup>50</sup>

More details on how these sources were used can be found in the EPA technical report, "National Scale Modeling of Mobile Source Air Toxic Emissions, Air Quality, Exposure and Risk for the Mobile Source Air Toxics Rule," cited previously.

*Stationary source reductions* -- Emission reductions were applied to the grown emissions to account for regulatory efforts which are expected to reduce HAPs from 1999 levels. The percent reductions we determined were primarily based on estimates of national average reductions for specific HAPs or for groups of HAPs from a source category or subcategory as a result of regulatory efforts. These efforts are primarily the MACT and section 129 standards, mandated in Title III of the 1990 Clean Air Act Amendments. We determined percent reductions, and whether they apply to major only or both major and area sources, for the various rules from rule preambles, fact sheets and through the project leads (questionnaire and phone calls). A major source is defined as any stationary source or group of stationary sources located within a contiguous area and under common control that has the potential to emit considering controls, in the aggregate, 10 tons per year or more of any hazardous air pollutant or 25 tons per year or more of any combination of hazardous air pollutants. For some rules, percent reductions were provided for specific HAPs or groups of HAPs (e.g., all metals, or all volatiles) rather than a single number for all HAPs in the categories. After 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics.

#### 2.2.1.1.7 Precursor Emissions

In addition to the air toxics in Table 2.2.-1, emissions of a number of other compounds were estimated because they are precursor emissions which are atmospherically transformed into air toxics. These pollutants are listed in Table 2.2.-5, along with air toxic pollutants included in the inventory which can be transformed into other air toxics. Precursor emissions in 1999 were estimated by applying speciation profiles from SPECIATE to VOC estimates from version 2 of the 1999 NEI.<sup>51</sup> Stationary source precursor emissions were assumed to remain at 1999 levels in future year modeling since the impact of growth and control is unknown. However, mobile source precursor emissions are expected to increase along with VOCs. To account for this in modeling done to support the final rule, we estimated secondary concentrations from mobile sources in future years by assuming they increased proportionally with primary concentrations. For the proposed rule, we had projected precursor emissions for 1999 to future years using ratios of VOCs for future years versus 1999, then used these projected emissions to model secondary concentrations. A comparison of the two approaches,

using modeling data from the proposal, yielded very similar results. A more detailed discussion of the comparison can be found in EPA Technical Report Number EPA-454/R-07-002

#### 2.2.1.1.8 Strengths and Limitations

*Highway Vehicles* – Limitations in the VOC and PM emission estimates which are the basis for calculating air toxic emissions are discussed in Section 2.1.3. MOBILE6.2 toxic to VOC ratios for key toxics from gasoline vehicles, such as benzene, 1,3-butadiene, formaldehyde and acetaldehyde, are based on almost 900 vehicle tests on a wide variety of fuels. These data account for impacts of emissions control technology, normal vs. high emitters, and impacts of a variety of fuel properties, including benzene level, aromatics levels, olefin level, sulfur level, RVP, E200, E300, and oxygenate content.

However, there are a number of significant uncertainties in our highway vehicle air toxic inventories for air quality modeling. Among the uncertainties are:

- The Agency has limited emissions data for advanced technology highway vehicles, including hybrid and alternative technology vehicles. The toxic to VOC ratios in MOBILE6.2 are all based on Tier 0 and earlier vehicles. EPA has recently evaluated data on more recent technology vehicles and what might be the potential impacts of these data on inventories. The result of this analysis is discussed in Section 2.3.1.
- MOBILE6.2 uses the same toxic to VOC ratios for cold starts and hot running operation even though these ratios for benzene and 1,3-butadiene are higher during cold starts than hot running. We have a limited understanding of the impact of off-cycle operation on highway vehicle air toxic emissions.
- Data are limited for certain sources and pollutants not significant to this rule. For heavy-duty highway vehicles (both gasoline and diesel engines) the toxic to VOC ratios used in MOBILE6.2 to develop inventory estimates are based on very limited data. Moreover, we lack data on how diesel fuel properties impact air toxic emissions, and we have very little data on mobile source metal emissions.

There are also significant uncertainties resulting from the use of national default data rather than local inputs, as well as “top-down” allocation schemes in estimating toxic emissions. Examples include use of national default vehicle registration distributions, default average speed distributions, and use of county level population data to allocate State or urban level VMT. A recent paper evaluated the impacts of these default inputs and allocation schemes on local level inventories.<sup>52</sup>

Finally, as discussed in Section 2.1.3, there are greater uncertainties in projection year estimates.



**Table 2.2.-5. Precursor Pollutants.**

<b>Pollutant</b>	<b>Precursor for</b>	<b>Pollutant</b>	<b>Precursor for</b>
Acetaldehyde	Formaldehyde (reactive and inert)	Isoprene	Formaldehyde (reactive and inert)
1,3-Butadiene	Formaldehyde (reactive and inert), Acrolein (reactive and inert)	MTBE	Formaldehyde (reactive and inert)
1-Butene	Formaldehyde (reactive and inert), Propionaldehyde (reactive and inert)	Methanol	Formaldehyde (reactive and inert)
1-2,3-Dimethyl butene	Formaldehyde (reactive and inert)	1-Nonene	Formaldehyde (reactive and inert)
1-2-Ethyl butene	Formaldehyde (reactive and inert)	2-Nonene	Acetaldehyde (reactive and inert)
1-2-Methyl butene	Formaldehyde (reactive and inert)	1-Octene	Formaldehyde (reactive and inert)
1-3-Methyl butene	Formaldehyde (reactive and inert)	2-Octene	Acetaldehyde (reactive and inert)
2-Butene	Acetaldehyde (reactive and inert)	1-Pentene	Formaldehyde (reactive and inert)
2-2-Methyl butene	Acetaldehyde (reactive and inert)	1-2,4,4-Trimethyl pentene	Formaldehyde (reactive and inert)
1-Decene	Formaldehyde (reactive and inert)	1-2-Methyl pentene	Formaldehyde (reactive and inert)
Ethanol	Acetaldehyde (reactive and inert)	1-3-Methyl pentene	Formaldehyde (reactive and inert)
Ethene	Formaldehyde (reactive and inert)	1-4-Methyl pentene	Formaldehyde (reactive and inert)
1-Heptene	Formaldehyde (reactive and inert)	2-Pentene	Acetaldehyde (reactive and inert), Propionaldehyde (reactive and inert)
2-Heptene	Acetaldehyde (reactive and inert)	2-3-Methyl pentene	Acetaldehyde (reactive and inert)
1-Hexene	Formaldehyde (reactive and inert)	2-4-Methyl pentene	Acetaldehyde (reactive and inert)
2-Hexene	Acetaldehyde (reactive and inert)	Propene	Acetaldehyde (reactive), Acetaldehyde (inert), Formaldehyde (reactive and inert)
3-Hexene	Propionaldehyde (reactive and inert)	2-Methylpropene	Formaldehyde (reactive and inert)

*Nonroad Equipment* – The toxic to VOC ratios in NMIM for lawn and garden equipment, which makes the single largest contribution of any nonroad sector to the air toxics inventory, is supported by a large amount of test data. The VOC estimates for uncontrolled engines in the NONROAD model are based on a large amount of in-use test data and peer reviewed methodologies. Estimates for controlled engines are based on certification test data and emission standards. However, for a number of source categories—in particular heavy-duty diesel engines and aircraft engines--the toxic to VOC ratios used to develop inventory estimates are based on very limited data. In addition, the Agency has limited emissions data for nonroad equipment with emission controls. The Agency has been doing test data to address some of the limitations. This work is discussed in Sections 2.3.3 and 2.3.4. There are also significant uncertainties associated with allocating nonroad equipment emissions from the national to the local level. As with highway sources, future year inventories are more uncertain. Finally, the relationship between fuel parameters and emission rates for gasoline nonroad equipment is much more poorly understood than the relationship for highway gasoline vehicles. In our modeling, we assumed that the impacts of fuel control on emissions from nonroad equipment would be proportional to the impact on highway vehicle emissions, as discussed above.

*Portable Fuel Containers* -- Since no direct measurements of air toxic emissions from evaporation of gasoline in portable fuel containers were available, they were estimated based on toxic to VOC ratios obtained from evaporative emissions measurements taken from light-duty gasoline vehicles. However, since evaporation of fuel occurs at higher temperatures in vehicles than in PFCs, speciation profiles are different. An effort to account for these differences was made for benzene and naphthalene based on recent analyses done for the gasoline distribution sector.

*Stationary Sources* -- For the 1999 NEI, there are a number of known or suspected issues for stationary source emissions listed on the emission inventory website (U. S. EPA, 2004a). The issues listed are generally limited to specific geographic areas and are not expected to influence national-level results. Of these, it is expected that issues related to acrolein are most likely to affect the results for assessment of noncancer effects. Another uncertainty concerning the base year inventory is the proper identification of sources using the inventory codes. These codes are utilized for applying growth and reduction factors.

There are several uncertainties associated with the growth and reduction information. The growth information is uncertain for a number of reasons. For most sources, activity growth is used as a surrogate for emissions growth, which may not be appropriate for some industry sectors. In addition the growth information available is from economic models, is typically specific to broad industry categories, and is not resolved geographically for all categories. The stationary source reductions are uncertain because they are generally based on national-average reductions (although we have used facility-specific reductions where available). We do not expect this uncertainty to have an impact on national-level results.

As previously mentioned, after 2010, stationary source emissions are based only on economic growth. They do not account for reductions from ongoing toxics programs such as the urban air toxics program, residual risk standards and area source program, which are expected to further reduce toxics. Furthermore, the 2030 stationary source inventory estimates are equal to the 2020 estimates, because of additional uncertainties in the available growth data past 2020 and the lack of knowledge of the effect of stationary source control programs that far into the future.

### **2.2.1.2 Trends in Air Toxic Emissions**

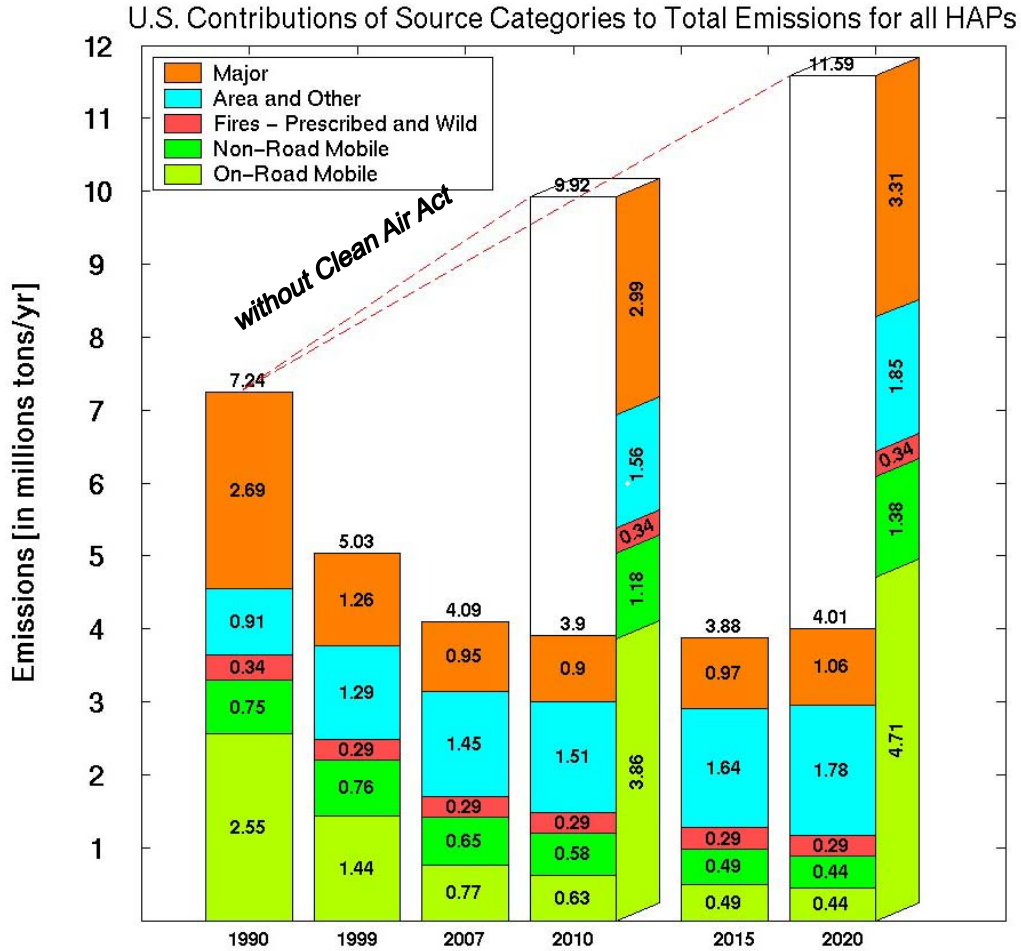
#### **2.2.1.2.1 Emission Trends Without Controls**

In 1999, based on the National Emissions Inventory (NEI), mobile sources accounted for 44% of total emissions of 188 hazardous air pollutants (see Figure 2.2.-2). Diesel particulate matter is not included in this list of 188 pollutants. Sixty-five percent of the mobile source tons in this inventory were attributable to highway mobile sources, and the remainder to nonroad sources. Furthermore, over 90% of mobile source air toxic emissions are attributable to gasoline vehicles and equipment

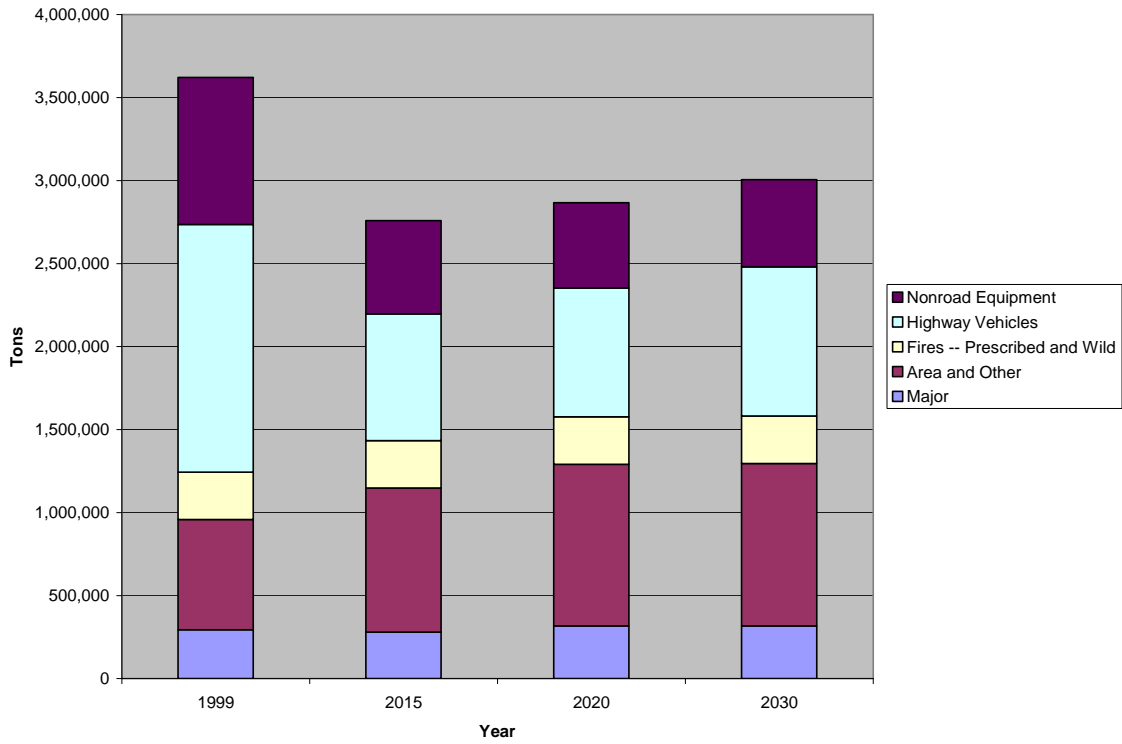
Overall, emissions from all air toxics are projected to decrease from 5,030,000 tons in 1999 to 4,010,000 tons in 2020, as a result of existing and planned emission controls on major, area, and mobile sources. In the absence of Clean Air Act emission controls currently in place, EPA estimates air toxic emissions would total 11,590,000 tons in 2020 (Figure 2.2-2). It should be noted that these estimates do not account for higher estimates of cold temperature hydrocarbon emissions in vehicles, PFC emissions, or categories of nonroad gasoline evaporative emissions included in NONROAD2005 and discussed in Section 2.2.1.1.2.

If higher estimates of cold temperature hydrocarbon emissions and vehicles and evaporative emissions from nonroad gasoline equipment are accounted for, air toxic emissions emitted from mobile sources will be reduced 46% between 1999 and 2020 without the controls in this proposal, from 2.38 million to 1.29 million tons (Figure 2.2-3). This reduction will occur despite a projected 57% increase in vehicle miles traveled, and a 47% projected increase in nonroad activity (See Figures 2.2.-4 and 2.2.-5). It should be noted, however, that EPA anticipates mobile source air toxic emissions will begin to increase after 2020, from about 1.29 million tons in 2020 to 1.42 million tons in 2030. Benzene emissions from all sources decrease from about 366,000 tons in 1999 to 279,000 tons in 2020, and as is the case with total air toxic emissions, begin to increase between 2020 and 2030 (Figure 2.2.-5).

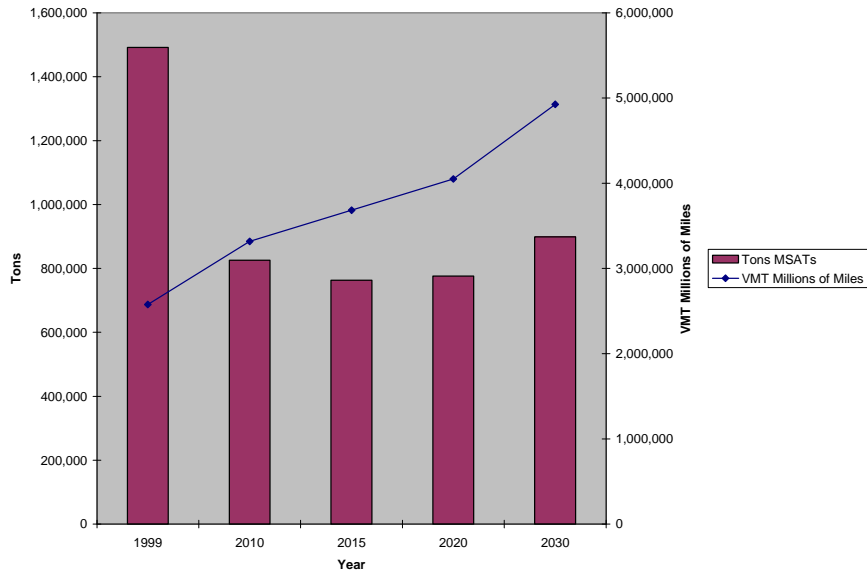
**Figure 2.2.-2. Contribution of Source Categories to Air Toxic Emissions, 1990 to 2020 (not Including Diesel Particulate Matter). Dashed Line Represents Projected Emissions without Clean Air Act Controls. Does not Account for Higher Estimates of Cold Temperature Hydrocarbon Emissions in Vehicles, PFC Emissions, or Categories of Nonroad Gasoline Evaporative Emissions Included in NONROAD2005.**



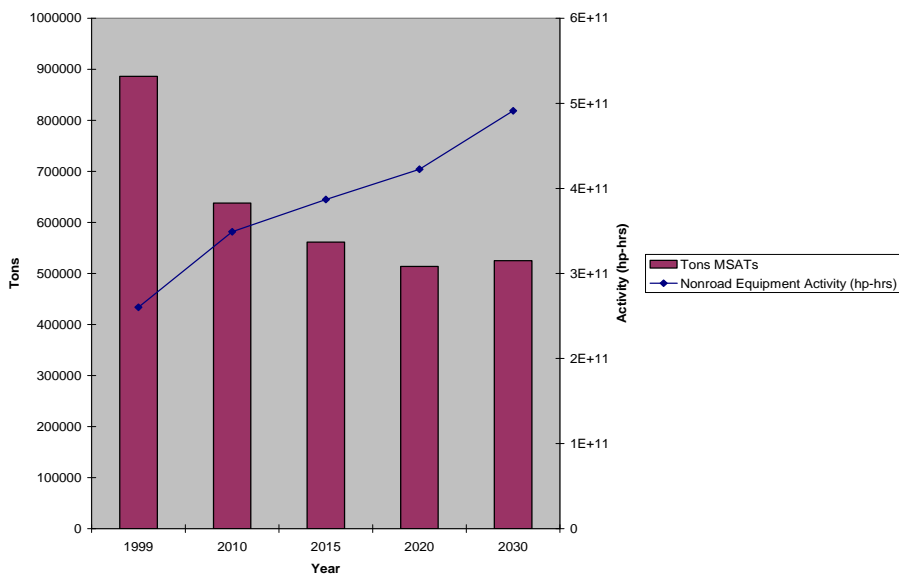
**Figure 2.2.-3. Contribution of Source Categories to Mobile Source Air Toxic Emissions, 1999 to 2030 (Not Including Diesel Particulate Matter). Includes Higher Estimates of Cold Temperature Hydrocarbon Emissions and Vehicles, Evaporative Emissions from Nonroad Gasoline Equipment, and PFC Emissions as Part of Area Source Inventory.**



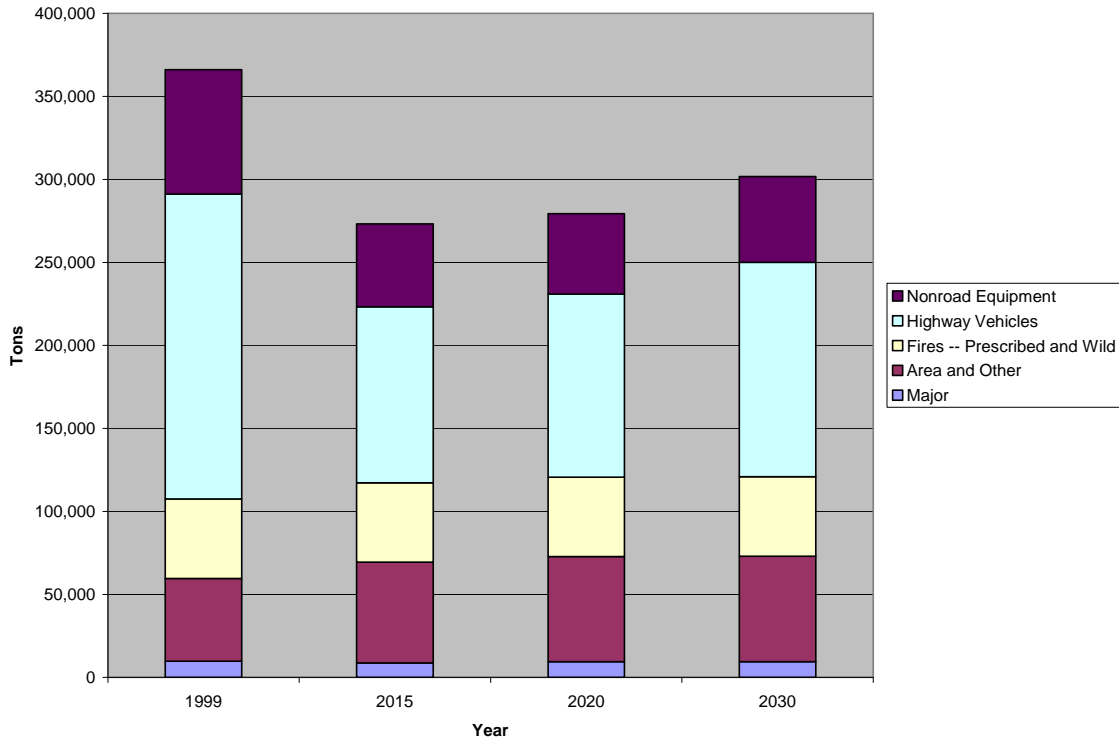
**Figure 2.2.-4. Trend in Highway Vehicle Air Toxic Emissions Versus VMT, 1999 to 2030.**



**Figure 2.2.-5. Trend in Emissions of Nonroad Equipment Air Toxic Emissions (Excluding Commercial Marine Vessels, Locomotives and Aircraft) versus Activity, 1999 to 2030.**



**Figure 2.2.-6. Trend in Benzene Emissions, 1999 to 2030.**



*Highway Vehicle Trends* – Table 2.2.-6 summarizes nationwide emissions of individual air toxics from highway vehicles from 1999 to 2030. Fifteen POM compounds listed in Table 2.2.-1 (except for naphthalene) are grouped together as POM. For mobile sources, forty percent of the chromium from highway vehicles and eighteen percent of the chromium from nonroad sources was assumed to be the highly toxic hexavalent form. The estimate for highway vehicles is based on data from utility boilers,<sup>53</sup> and the estimate for nonroad equipment is based on combustion data from stationary combustion turbines that burn diesel fuel.<sup>54</sup>

**Table 2.2.-6. Nationwide Emissions (Tons) of Individual Air Toxic Pollutants from Highway Vehicles.**

<b>Pollutant</b>	<b>1999</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2030</b>
1,3-Butadiene	23,876	11,473	10,763	11,355	13,378
2,2,4-Trimethylpentane	182,120	101,880	94,469	96,315	111,783
Acetaldehyde	29,821	17,169	16,149	16,893	19,879
Acrolein	3,845	1,824	1,650	1,704	1,981
Benzene	183,661	110,526	105,956	110,317	129,290
Chromium III	8	10	11	12	15
Chromium VI	5	7	8	8	10
Ethyl Benzene	73,439	40,732	37,528	38,080	44,055
Formaldehyde	80,458	38,885	35,857	37,153	43,404
Hexane	66,267	39,801	33,481	30,727	33,468
MTBE	57,801	29,886	23,089	18,372	17,957
Manganese	5	6	6	7	9
Naphthalene	4,056	2,261	2,022	1,986	2,259
Nickel	10	13	14	16	19
POM	497	255	234	239	278
Propionaldehyde	4,288	2,327	2,154	2,222	2,574
Styrene	14,284	7,652	7,368	7,814	9,253
Toluene	489,873	268,871	250,646	257,367	299,677
Xylenes	277,285	152,046	141,710	145,473	169,369

Table 2.2.-7 summarizes total tons of air toxic emissions from highway vehicles by vehicle class in 1999, 2007, 2010, 2015, 2020, and 2030. Table 2.2.-8 provides the percentage of total highway vehicle emissions associated with each vehicle class. In 1999, 55% of air toxic emissions from highway vehicles were emitted by light-duty gasoline vehicles (LDGVs) and 37% by light-duty trucks (LDGTs). EPA projects that in 2020, only 34% of highway vehicle HAP emissions will be from LDGVs and 60% will be from LDGTs. More detailed summaries of emissions by individual pollutant, by State, and for urban versus rural area can be found in Excel workbooks included in the docket for this rule.



**Table 2.2.-7. Tons of Air Toxic Emissions from Highway Vehicle Classes, 1999 to 2030 (Not Including Diesel Particulate Matter).**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	36,958	22,622	19,605	19,469	22,172
HDGV	66,672	21,323	14,812	11,638	10,188
LDDT	1,215	589	528	470	389
LDDV	688	41	23	16	16
LDGT1	353,671	279,674	287,644	319,974	375,603
LDGT2	188,134	144,254	141,165	144,247	159,682
LDGV	836,995	349,220	290,746	270,956	319,395
MC	7,267	7,899	8,595	9,291	11,213
<b>Total Highway</b>	<b>1,491,600</b>	<b>825,624</b>	<b>763,117</b>	<b>776,062</b>	<b>898,659</b>
HDDV: Heavy Duty Diesel Vehicles HDGV: Heavy Duty Gasoline Vehicles LDDT: Light Duty Diesel Trucks LDDV: Light Duty Diesel Vehicles LDGT1: Light Duty Gasoline Trucks 1 LDGT2: Light Duty Gasoline Trucks 2 LDGV: Light Duty Gasoline Vehicles MC: Motorcycles					

**Table 2.2.-8. Percent Contribution of Vehicle Classes to Highway Vehicle Air Toxic Emissions, 1999 to 2030 (Not Including Diesel Particulate Matter).**

Vehicle	1999	2010	2015	2020	2030
LDGV	56%	42%	38%	35%	35%
LDGT1 and 2	36%	51%	56%	60%	60%
HDGV	5%	3%	2%	1%	1%
HDDV	2%	3%	2%	2%	2%
Other (motorcycles and light-duty diesel vehicles and trucks)	1%	1%	2%	2%	2%

Tables 2.2.-9 through 2.2.-14 summarize total tons of emissions nationwide for benzene, 1,3-butadiene, formaldehyde, acetaldehyde, naphthalene, and acrolein from highway vehicles. About 90% of benzene emissions from gasoline vehicles were in exhaust, with the remainder in evaporative and refueling emissions. Benzene emissions from diesel vehicles were all exhaust. There are no evaporative emissions of 1,3-butadiene, formaldehyde, acetaldehyde, and acrolein.

**Table 2.2.-9. Tons of Benzene Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	2,564	1,574	1,366	1,358	1,547
HDGV	6,665	2,383	1,715	1,399	1,213
LDDT	200	97	87	78	64
LDDV	112	7	4	3	3
LDGT1	46,358	39,456	41,796	47,352	56,290
LDGT2	21,392	19,742	20,074	21,083	23,737
LDGV	105,724	46,598	40,186	38,257	45,489
MC	646	669	728	787	947
<b>Total Highway</b>	<b>183,661</b>	<b>110,526</b>	<b>105,956</b>	<b>110,317</b>	<b>129,290</b>

**Table 2.2.-10. Tons of 1,3-Butadiene Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	1,489	915	794	789	899
HDGV	1,177	197	99	78	63
LDDT	90	44	39	35	29
LDDV	50	3	2	1	1
LDGT1	5,307	3,820	3,929	4,520	5,411
LDGT2	3,526	1,991	1,913	2,064	2,344
LDGV	12,034	4,280	3,743	3,605	4,312
MC	202	224	243	263	318
<b>Total Highway</b>	<b>23,876</b>	<b>11,473</b>	<b>10,763</b>	<b>11,355</b>	<b>13,378</b>

**Table 2.2.-11. Tons of Formaldehyde Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	19,094	11,724	10,176	10,114	11,522
HDGV	6,142	1,213	688	556	460
LDDT	386	188	168	150	124
LDDV	217	13	7	5	5
LDGT1	15,666	9,702	10,030	11,487	13,790
LDGT2	9,916	4,851	4,656	4,961	5,652
LDGV	28,522	10,627	9,515	9,213	11,044
MC	516	567	617	667	806
<b>Total Highway</b>	<b>80,458</b>	<b>38,885</b>	<b>35,857</b>	<b>37,153</b>	<b>43,404</b>

**Table 2.2.-12. Tons of Acetaldehyde Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	7,032	4,318	3,748	3,725	4,243
HDGV	1,411	390	248	204	173
LDDT	123	60	54	48	40
LDDV	69	4	2	2	2
LDGT1	6,050	4,808	5,068	5,836	7,039
LDGT2	3,429	2,367	2,329	2,502	2,880
LDGV	11,555	5,043	4,504	4,364	5,246
MC	152	180	196	213	258
<b>Total Highway</b>	<b>29,821</b>	<b>17,169</b>	<b>16,149</b>	<b>16,893</b>	<b>19,879</b>

**Table 2.2.-13. Tons of Acrolein Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	855	525	455	453	516
HDGV	689	76	24	17	12
LDDT	35	17	15	14	11
LDDV	20	1	1	0	0
LDGT1	623	457	472	538	644
LDGT2	326	231	226	240	271
LDGV	1,286	503	442	425	508
MC	13	14	15	16	20
<b>Total Highway</b>	<b>3,845</b>	<b>1,824</b>	<b>1,650</b>	<b>1,704</b>	<b>1,981</b>

**Table 2.2.-14. Tons of Naphthalene Emissions from Highway Vehicle Classes, 1999 to 2030.**

Vehicle Type	Emissions (tons/yr)				
	1999	2010	2015	2020	2030
HDDV	167	65	32	19	16
HDGV	773	400	248	195	176
LDDT	7	2	1	1	1
LDDV	7	0	0	0	0
LDGT1	760	640	697	769	900
LDGT2	489	267	273	281	315
LDGV	1,830	861	743	693	817
MC	23	25	27	29	35
<b>Total Highway</b>	<b>4,056</b>	<b>2,261</b>	<b>2,022</b>	<b>1,986</b>	<b>2,259</b>

*Nonroad Equipment Trends* -- Table 2.2.-15 summarizes nationwide emissions of individual air toxics from nonroad equipment, from 1999 to 2030. The lead emissions in the table are from piston engine aircraft, which use leaded gasoline. Table 2.2.-16 summarizes total tons of air toxic emissions from categories of nonroad equipment by equipment type in 1999, 2010, 2015, 2020, and 2030. Table 2.2.-17 provides the percentage of total nonroad equipment emissions associated with each equipment type. Air toxic emissions from nonroad equipment are dominated by lawn and garden equipment, recreational equipment, and pleasure craft, which collectively account for about 80% of nonroad HAP emissions in all years. More detailed summaries of emissions by individual pollutant, by State, and for urban versus rural area can be found in Excel workbooks included in the docket for this rule.

**Table 2.2.-15. Nationwide Emissions of Individual Air Toxics from Nonroad Equipment, from 1999 to 2030.**

Pollutant	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
1,3-Butadiene	10,333	7,136	6,586	6,518	7,004
2,2,4-Trimethylpentane	109,793	83,546	71,362	62,991	62,250
Acetaldehyde	21,952	16,208	14,459	13,663	14,153
Acrolein	2,754	2,264	2,179	2,168	2,340
Benzene	74,902	54,763	49,985	48,453	51,647
Chromium III	15	15	16	16	16
Chromium VI	3	4	4	4	4
Ethyl Benzene	46,072	33,435	29,489	27,057	28,033
Formaldehyde	52,083	38,213	34,406	32,678	33,994
Hexane	36,925	29,758	27,430	26,083	27,439
Manganese	2	2	2	2	2
MTBE	78,585	28,464	27,238	27,245	29,865
Naphthalene	1,212	1,182	1,228	1,291	1,440
Nickel	31	34	36	37	41
POM	347	305	287	275	287
Propionaldehyde	4,968	3,462	3,036	2,824	2,865
Styrene	3,055	2,297	2,003	1,807	1,835
Toluene	234,558	189,605	164,871	146,220	145,330
Xylenes	208,728	147,242	126,825	114,252	116,764

**Table 2.2.-16. Tons of Air Toxic Emissions from Nonroad Equipment Types, 1999 to 2030 (Not Including Diesel Particulate Matter).**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	21,397	12,512	9,686	7,875	6,567
Aircraft	14,276	14,965	16,081	17,256	19,603
Airport Support	325	198	157	141	152
Commercial	59,302	33,977	35,994	39,207	46,503
Commercial Marine Vessel	8,736	9,742	10,213	10,973	13,354
Construction	42,496	22,280	18,688	16,439	15,207
Industrial	11,422	4,247	2,793	2,239	2,093
Lawn/Garden	261,635	129,932	130,157	139,762	160,669
Logging	3,578	2,094	2,228	2,452	2,960
Pleasure Craft	332,631	202,760	163,953	148,746	147,720
Railroad	4,412	3,972	3,886	3,752	3,533
Recreational	125,933	201,118	167,488	124,640	106,845
Underground Mining	177	138	114	101	102
Total Nonroad	886,318	637,934	561,439	513,583	525,309

**Table 2.2.-17. Contribution of Equipment Types to Nonroad Air Toxic Emissions, 1999 to 2030 (not Including Diesel Particulate Matter).**

Equipment Type	1999	2010	2015	2020	2030
Lawn and Garden	30%	20%	23%	27%	31%
Pleasure Craft	38%	32%	29%	29%	28%
Recreational	14%	32%	30%	24%	20%
All Others	18%	16%	18%	19%	21%

Over 90% of nonroad toxic emissions are from 2-stroke and 4-stroke gasoline engines, with the remainder from diesel engines and turbine engine aircraft. Similarly, over 90% of benzene emissions from nonroad equipment are from gasoline engines, and these emissions would be reduced by a fuel benzene standard.

Tables 2.2.-18 through 2.2.-23 summarize total tons of emissions nationwide for benzene, 1,3-butadiene, formaldehyde, acetaldehyde, naphthalene, and acrolein from nonroad equipment types.

**Table 2.2.-18. Tons of Benzene Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	2,105	1,283	1,020	855	736
Aircraft	1,102	1,163	1,247	1,335	1,511
Airport Support	33	19	15	14	15
Commercial	7,931	5,140	5,478	6,010	7,178
Commercial Marine Vessel	644	719	753	809	982
Construction	3,945	2,111	1,786	1,595	1,494
Industrial	1,498	524	335	263	233
Lawn/Garden	25,753	15,996	15,540	16,644	19,133
Logging	202	131	130	140	168
Pleasure Craft	24,963	16,698	14,101	13,145	13,264
Railroad	162	143	139	134	126
Recreational	6,548	10,825	9,430	7,502	6,798
Underground Mining	15	12	10	9	9
Total Nonroad	74,902	54,763	49,985	48,453	51,647

**Table 2.2.-19. Tons of 1,3-Butadiene Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	236	145	116	98	85
Aircraft	824	859	924	993	1,131
Airport Support	4	2	2	2	
Commercial	1,324	774	820	901	1,080
Commercial Marine Vessel	6	6	6	6	
Construction	455	231	198	180	171
Industrial	242	76	47	37	31
Lawn/Garden	4,034	2,240	2,085	2,225	2,558
Logging	35	21	21	23	28
Pleasure Craft	2,069	1,291	1,034	928	909
Railroad	114	104	102	99	94
Recreational	990	1,385	1,230	1,025	907
Underground Mining	1	1	1	1	
Total Nonroad	10,333	7,136	6,586	6,518	7,004

**Table 2.2.-20. Tons of Formaldehyde Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	8,890	5,051	3,759	2,915	2,296
Aircraft	6,549	6,809	7,333	7,885	8,990
Airport Support	123	83	66	58	63
Commercial	3,516	2,331	2,122	2,019	2,080
Commercial Marine Vessel	4,715	5,252	5,499	5,899	7,152
Construction	12,103	7,352	5,662	4,541	3,858
Industrial	2,487	1,212	837	697	718
Lawn/Garden	7,050	3,902	3,633	3,816	4,328
Logging	334	153	117	109	116
Pleasure Craft	2,345	1,548	1,274	1,160	1,147
Railroad	1,895	1,721	1,683	1,624	1,527
Recreational	1,990	2,731	2,365	1,904	1,669
Underground Mining	87	68	56	50	50
Total Nonroad	52,083	38,213	34,406	32,678	33,994

**Table 2.2.-21. Tons of Acetaldehyde Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	3,986	2,265	1,685	1,306	1,028
Aircraft	2,019	2,098	2,259	2,430	2,770
Airport Support	55	37	30	26	28
Commercial	1,390	999	902	850	866
Commercial Marine Vessel	2,364	2,639	2,768	2,974	3,619
Construction	5,433	3,308	2,550	2,046	1,739
Industrial	1,087	539	372	310	320
Lawn/Garden	2,381	1,522	1,410	1,476	1,670
Logging	133	59	41	37	37
Pleasure Craft	1,615	1,098	920	844	834
Railroad	850	772	755	728	685
Recreational	599	843	743	613	533
Underground Mining	39	30	25	22	23
Total Nonroad	21,952	16,208	14,459	13,663	14,153



**Table 2.2.-22. Tons of Acrolein Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	232	132	99	77	61
Aircraft	968	1,005	1,083	1,165	1,329
Airport Support	3	2	2	2	2
Commercial	143	89	85	86	94
Commercial Marine Vessel	98	112	118	129	161
Construction	326	195	151	123	105
Industrial	72	33	23	19	19
Lawn/Garden	398	206	195	207	236
Logging	11	5	5	5	5
Pleasure Craft	218	134	106	95	93
Railroad	130	119	117	113	107
Recreational	151	231	194	148	128
Underground Mining	2	2	1	1	1
Total Nonroad	2,754	2,264	2,179	2,168	2,340

**Table 2.2.-23. Tons of Naphthalene Emissions from Nonroad Equipment Types, 1999 to 2030.**

Equipment Type	Annual Total Nonroad Emissions (Tons)				
	1999	2010	2015	2020	2030
Agriculture	42	26	21	17	12
Aircraft	456	496	530	566	638
Airport Support	1	1	0	0	0
Commercial	104	103	113	125	149
Commercial Marine Vessel	65	68	72	79	102
Construction	56	37	30	22	17
Industrial	26	13	9	6	4
Lawn/Garden	305	245	246	264	303
Logging	2	2	2	1	2
Pleasure Craft	34	36	37	39	42
Railroad	61	44	42	40	35
Recreational	59	112	127	132	136
Underground Mining	0	0	0	0	0
Total Nonroad	1,212	1,182	1,228	1,291	1,440

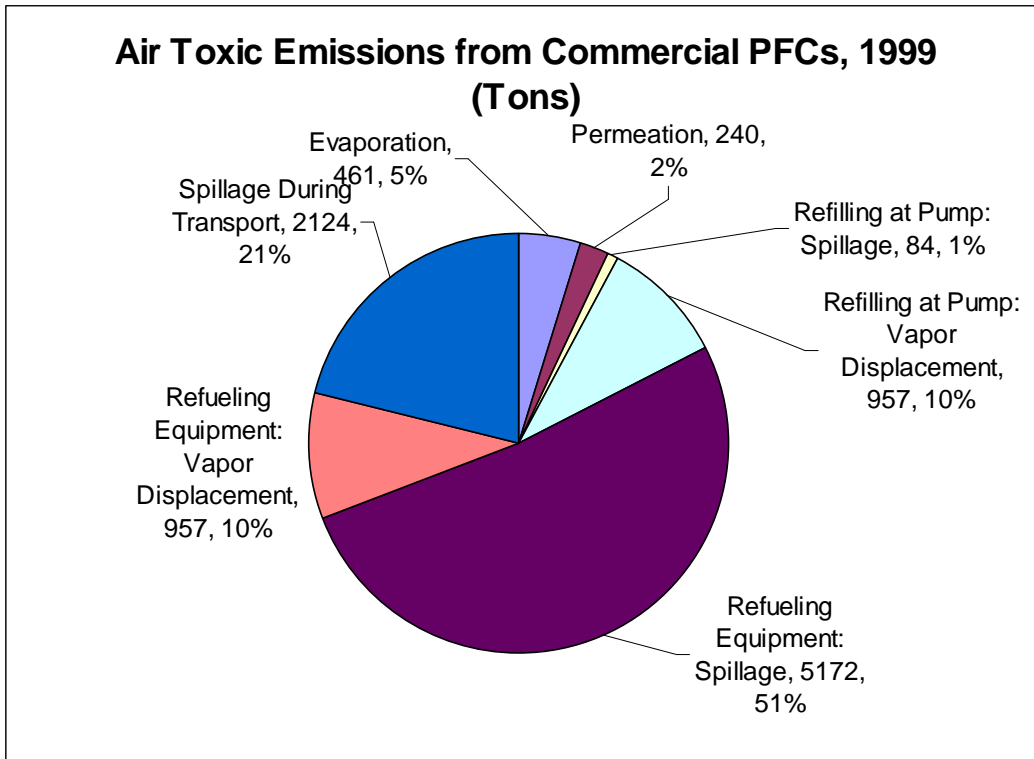
*Portable Fuel Containers* – Table 2.2.-24 summarizes nationwide emissions of individual air toxics from gasoline in portable fuel containers (PFCs), from 1999 to 2030.

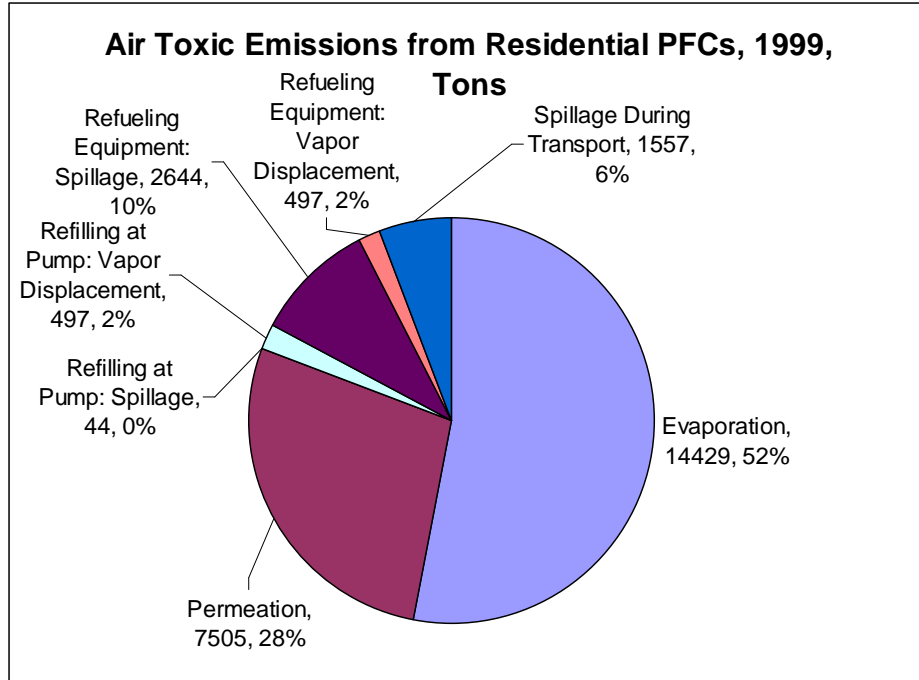
**Table 2.2.-24.** Tons of Air Toxic Emissions from Portable Fuel Containers, 1999 to 2030.

Pollutant	1999	2010	2015	2020	2030
2,2,4-Trimethylpentane	4,870	4,461	4,741	5,088	5,805
Benzene	853	833	889	953	1,086
Ethyl Benzene	2,135	1,900	2,027	2,175	2,480
Hexane	5,417	5,176	5,532	5,935	6,766
MTBE	6,969	4,763	4,987	5,007	5,503
Naphthalene	1	1	1	1	1
Toluene	10,733	9,668	10,329	11,082	12,636
Xylenes	6,189	5,432	5,800	6,223	7,096
Total	37,166	32,232	34,306	36,464	41,374

About 75% of all HAP emissions and benzene emissions from PFCs are associated with residential use, and the rest are from commercial use. As can be seen in Figure 2.2.-7, most commercial PFC air toxic emissions are associated with equipment refueling, and most residential emissions are associated with evaporation and permeation.

**Figure 2.2.-7.** Distribution of air toxic emissions (tons) among emission types for commercial versus residential PFCs, 1999.





*Diesel Particulate Matter* – The inventory estimates presented above for mobile source air toxics do not include diesel particulate matter. Table 2.2.-25 summarizes the trend in diesel particulate matter between 1999 and 2030, by source category. These inventory estimates were obtained from EPA’s recently proposed national ambient air quality standard for particulate matter.<sup>55</sup> Diesel particulate matter emissions will be reduced by 75% between 2001 and 2030. As controls on highway diesel engines and nonroad diesel engines phase in, diesel-powered locomotives and commercial marine vessels increase from 13% of the inventory in 2001 to 55% in 2030.

**Table 2.2.-25. Percent Contribution of Mobile Source Categories to Diesel Particulate Matter (PM<sub>10</sub>) Emissions, 2001 to 2030 in Tons Per Year (Percent of Total).**

Source	2001	2015	2020	2030
Highway Vehicles	125,162 (36.7%)	37,463 (24.8%)	26,471 (24.4%)	18,135 (21.6%)
Commercial Marine Vessels	20,541 (6%)	17,085 (11.3%)	16,984 (15.7%)	21,388 (25.5%)
Locomotives	25,173 (7.4%)	17,521 (11.6%)	16,535 (15.3%)	25,086 (29.9%)
Other Nonroad Equipment	170,357 (49.9%)	78,930 (52.3%)	48,284 (44.6%)	19,285 (23.0%)

2.2.1.2.2 Impact on Inventory of Controls

The controls being finalized in this rule would reduce air toxic emissions from highway gasoline vehicles, nonroad gasoline equipment, gasoline distribution and

portable fuel containers. The total air toxic emissions reduced in the 2030 inventories used for air quality modeling for these sectors are 335,000 tons, and the total benzene emissions reduced are 65,000 tons. It should be emphasized that the air quality, exposure and risk modeling inventory does not account for recent increases in the use of ethanol oxygenated gasoline or implementation of the renewable fuels standard. For inventories which include these emissions, see Section 2.2.2.2.

Table 2.2.-26 summarizes the nationwide impact of the controls on emissions of key air toxics from highway vehicles in 2015, 2020, and 2030. The reductions in highway vehicle air toxic emissions by 2030 are dramatic, about 35%. Benzene reductions are over 40%. Nonroad equipment emissions are impacted by fuel benzene control, which result in reductions of about 14% for that pollutant (Table 2.2.-27). Emissions from PFCs will be impacted by both controls on the containers themselves as well as the fuel benzene standard (Table 2.2-28), with reductions in total air toxic emissions of over 60% in 2030, and reductions in benzene of about 80%. In addition, fuel benzene controls would reduce emissions within the gasoline distribution sector. Table 2.2.-29 presents estimated reductions for this source in 2015 and 2020, which total over 30%, due to the fuel benzene standard. Figures 2.2.-8 and 2.2.-9 depict the trend in total MSAT and benzene emissions for all sources with the controls being finalized in this rule. More detailed summaries of emissions by individual pollutant, by State, and for urban versus rural areas can be found in Excel workbooks included in the docket for this rule.

**Table 2.2.-26. Nationwide Impact of Controls on Emissions of Gaseous Air Toxics from Highway Vehicles in 2015, 2020, and 2030.**

Pollutant	Annual Emissions (tons) by Vehicle Type								
	2015 Reference Case	2015 Control Case	2015 Reduction	2020 Reference Case	2020 Control Case	2020 Reduction	2030 Reference Case	2030 Control Case	2030 Reduction
1,3-Butadiene	10,763	9,160	1,602	11,355	8,655	2,700	13,378	8,707	4,670
2,2,4-Trimethylpentane	94,469	80,630	13,840	96,315	73,103	23,212	110,895	72,262	38,634
Acetaldehyde	16,149	13,970	2,180	16,893	13,222	3,671	19,879	13,677	6,202
Acrolein	1,650	1,458	192	1,704	1,382	322	1,981	1,434	548
Benzene	105,956	79,034	26,922	110,317	73,141	37,176	129,290	72,673	56,617
Ethyl Benzene	37,528	32,189	5,339	38,080	29,117	8,962	43,676	28,770	14,906
Formaldehyde	35,857	31,475	4,382	37,153	29,877	7,276	43,404	31,196	12,207
Hexane	33,481	30,802	2,679	30,727	26,241	4,486	32,435	25,832	6,602
MTBE	23,089	22,363	725	18,372	17,226	1,146	17,109	16,080	1,029
Propionaldehyde	2,154	1,925	230	2,222	1,837	385	2,574	1,919	655
Styrene	7,368	6,134	1,234	7,814	5,743	2,071	9,253	5,720	3,533
Toluene	250,646	212,901	37,745	257,367	194,002	63,365	297,748	191,607	106,141
Xylenes	141,710	120,444	21,266	145,473	109,772	35,701	168,285	108,480	59,805
<b>Total</b>	<b>760,821</b>	<b>642,486</b>	<b>118,336</b>	<b>773,793</b>	<b>583,319</b>	<b>190,474</b>	<b>889,908</b>	<b>578,358</b>	<b>311,549</b>

**Table 2.2.-27. Nationwide Impact of Controls on Emissions of Key Air Toxics from all Nonroad Equipment in 2015, 2020, and 2030.**

Pollutant	Annual Emissions (tons)								
	2015 Reference Case	2015 Control Case	2015 Reduction	2020 Reference Case	2020 Control Case	2020 Reduction	2030 Reference Case	2030 Control Case	2030 Reduction
1,3-Butadiene	6586	6599	-13	6518	6530	-12	7004	7017	-13
Acetaldehyde	14459	14468	-9	13663	13671	-8	14153	14162	-9
Acrolein	2179	2179	0	2168	2168	0	2340	2340	0
Benzene	49985	43220	6265	48453	41736	6717	51647	44427	7220
Formaldehyde	34406	34433	-27	32678	32703	-25	33994	34020	-26
<b>5 MSAT Total</b>	<b>107615</b>	<b>101418</b>	<b>6197</b>	<b>103480</b>	<b>97339</b>	<b>6141</b>	<b>109138</b>	<b>102528</b>	<b>6610</b>

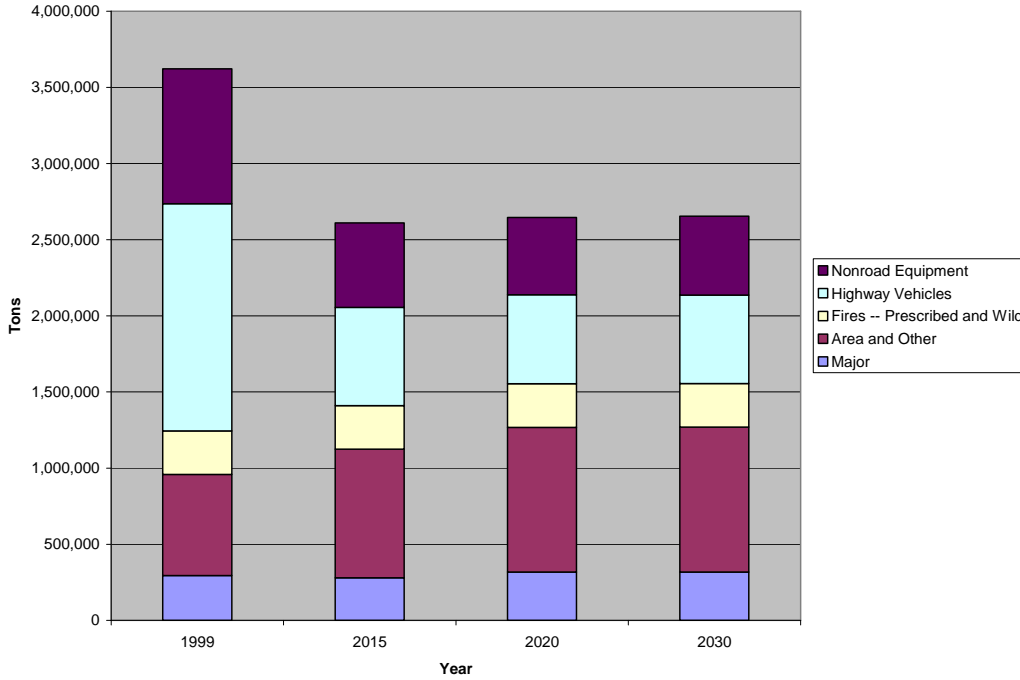
**Table 2.2.-28. Nationwide Impact of Controls on Emissions of Air Toxics from Portable Fuel Containers in 2010, 2015, 2020, and 2030.**

Pollutant	Annual Emissions (tons)							
	2010 Reference Case	2010 Control Case	2015 Reference Case	2015 Control Case	2020 Reference Case	2020 Control Case	2030 Reference Case	2030 Control Case
2,2,4-Trimethylpentane	4,461	4,003	4,741	1,864	5,088	2,012	5,805	2,315
Benzene	833	752	889	179	953	193	1,086	222
Ethyl Benzene	1,900	1,700	2,027	756	2,175	816	2,480	939
Hexane	5,176	4,622	5,532	1,932	5,935	2,085	6,766	2,399
MTBE	4,763	4,295	4,987	2,360	5,007	2,382	5,503	2,638
Naphthalene	1	1	1	0	1	0	1	0
Toluene	9,668	8,646	10,329	3,752	11,082	4,050	12,636	4,658
Xylenes	5,432	4,862	5,800	2,157	6,223	2,328	7,096	2,678
Total	32,232	28,880	34,306	13,000	36,464	13,867	41,374	15,849

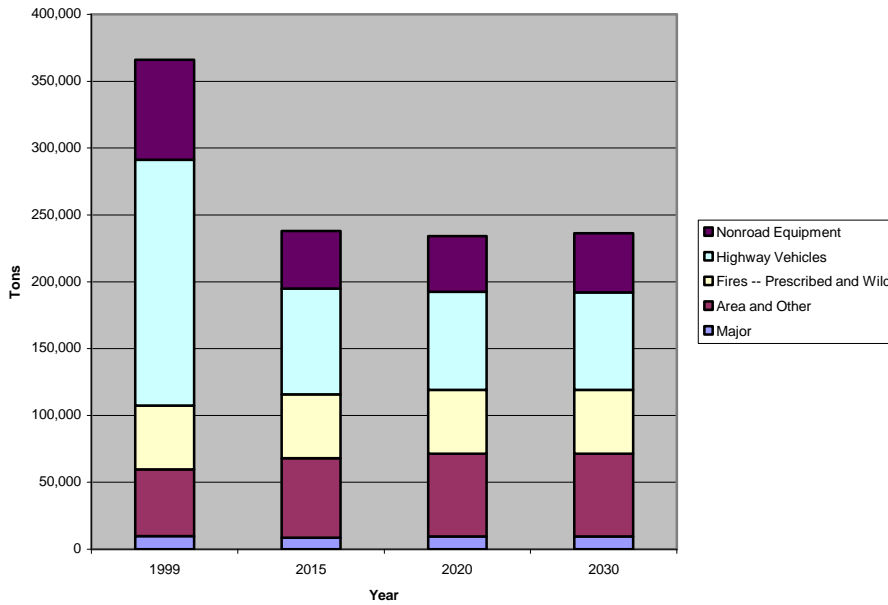
**Table 2.2.-29. Nationwide Impact of Controls Emissions of Benzene from Gasoline Distribution in 2015 and 2020 (2030 Assumed to be the Same as 2020).**

Annual Emissions (tons)					
2015 Reference Case	2015 Control Case	2015 Reduction	2020 Reference Case	2020 Control Case	2020 Reduction
2,160	1,460	700	2,234	1,516	719

**Figure 2.2.-8. Contribution of Source Categories to Mobile Source Air Toxic Emissions, 1999 to 2030, with Final Rule Standards in Place (Not Including Diesel Particulate Matter).**



**Figure 2.2.-9. Contribution of Source Categories to Mobile Source Benzene Emissions, 1999 to 2030, with Final Rule Standards in Place.**





## 2.2.2 Emission Reductions from Controls

Section 2.2.2 describes revisions made to emission inventories after we developed MSAT inventories for air quality modeling (“air quality inventories”). The primary revision is accounting for the impacts of implementing the federal Renewable Fuel Standard (RFS). The revised inventories were used to estimate emission benefits of the rule and the cost-effectiveness of the control strategies. We refer to the revised inventories as “cost-effectiveness inventories” in this section to distinguish them from the air quality inventories discussed in Section 2.2.1.

### 2.2.2.1 Methodology Changes from Air Quality Inventories

#### 2.2.2.1.1 Highway Vehicles

The fundamental difference between the air quality and cost-effectiveness inventories is the use of fuel parameters that reflect implementation of the Renewable Fuel Standard (RFS fuel), as described in Section 2.1.1. We also corrected a minor error which addresses how MOBILE6.2 calculates benzene evaporative emissions with ethanol oxygenated fuel. In addition, for the control case, aromatics levels were adjusted using a different algorithm to calculate additive adjustment factors:

$$\text{Additive Factor} = 1.0 (\text{BZ}(\text{control}) - \text{BZ}(\text{ref})) \quad (11)$$

Where BZ = benzene

We assume that with increased ethanol use, when fuel benzene is reduced there will be no increase in other aromatic levels to help compensate for octane loss. An Excel workbook with all the fuel parameters used, “MSAT Fuels Cost Effectiveness.xls,” is included in the docket for this rule. Also, we estimated vehicle refueling emissions using NMIM 2005, instead of projecting them from the 1999 NEI, as discussed in Section 2.2.1. Finally, it should be noted that inventories do not account increased permeation due to ethanol use, nor do they account for the 1.3 vol% maximum average fuel benzene level.

#### 2.2.2.1.2 Nonroad Equipment

Unlike the air quality inventories, the cost-effectiveness inventories for nonroad equipment used the RFS fuel as described in Section 2.1. As with the air quality inventories, we assumed that changes in county-level exhaust and evaporative emissions of nonroad gasoline equipment were proportional to changes in highway light-duty gasoline vehicle emissions. It should be noted that our inventories did not account for increased hose and tank permeation associated with increased ethanol use. As a result, our estimates of emission reductions from fuel benzene control may be slightly underestimated.

### 2.2.2.1.3 Portable Fuel Containers

The RFS fuel was used to develop cost-effectiveness inventories for PFCs, as described in Section 2.1. Air toxic inventories for PFCs for the reference and control cases were developed by speciating VOC, following the same approach used for the air quality modeling inventories (See Section 2.2.1.1.4). However, since the air quality modeling inventories did not account for RFS fuel, we used revised highway gasoline vehicle inventories for benzene and VOC from refueling that did account for RFS fuel to develop benzene to VOC ratios, and total evaporative emission ratios for other air toxics.

### 2.2.2.1.4 Gasoline Distribution

Gasoline distribution inventories were also revised to account for the RFS fuel. The reference case (RC) inventory was estimated for each source category (SCC code) at the county level as follows:

$$\begin{aligned}
 & \text{Gas Distr. Benzene Emissions } RC_{SCC\ YYY, County\ Z, RFS\ 9.6\ Max} = \\
 & \text{Gas Distr. Benzene RC Emissions}_{SCC\ YYY, County\ Z, Final\ Rule\ AQ\ Inventory} \times \left( \frac{\text{Nonrefueling\ evap\ Benzene } RC_{LDGV, County\ Z, RFS\ 9.6\ Max}}{\text{Nonrefueling\ evap\ Benzene } RC_{LDGV, County\ Z, AQ\ Inventory}} \right) \quad (12)
 \end{aligned}$$

Where,

Final Rule AQ Inventory = the inventory for SCC code YYY in county Z from the air quality inventory, as discussed in Section 2.2.1

RFS Max 9.6 = the inventory for SCC code YYY in county Z assuming 9.6 billion gallons of national ethanol consumption nationwide, attributing as much as possible for use as an oxygenate in reformulated gasoline.

The air quality inventory was adjusted using ratios of non-refueling evaporative emissions, because the methodology for estimating refueling emissions differed for the air quality inventory versus the final rule inventory, as discussed above.

The control case (CC) inventory was estimated using the following equation:

$$\begin{aligned}
 & \text{Gas Distr. Benzene Emissions } CC_{SCC\ YYY, County\ Z, RFS\ 9.6\ Max} = \\
 & \text{Gas Distr. Benzene RC Emissions}_{SCC\ YYY, County\ Z, RFS\ 9.6\ Max} \times \left( \frac{\text{Re\ fueling\ Benzene } CC_{LDGV, County\ Z, RFS\ 9.6\ Max}}{\text{Re\ fueling\ Benzene } RC_{LDGV, County\ Z, RFS\ 9.6\ Max}} \right) \quad (13)
 \end{aligned}$$

### 2.2.2.2 Estimated Reductions for Air Toxic Pollutants of Greatest Concern

The following sections present control case inventories and reductions for each individual control, and then cumulative reductions for all controls combined.

## 2.2.2.2.1 Fuel Benzene Standard

*Highway Gasoline Vehicles* – The fuel benzene standard will reduce emissions from light-duty gasoline vehicles and trucks, motorcycles, and heavy-duty gasoline trucks. Tables 2.2.-30, 2.2.-31, and 2.2.-32 present nationwide benzene emissions for these vehicle classes with and without the fuel standard in 2015, 2020, and 2030. Total benzene emissions from these vehicle classes were 178,000 tons in 1999. Since impacts of fuel benzene control on emissions of other MSATs are negligible (see Section 2.2.1.2), they are not presented here, although they are available in the docket for the rule.

**Table 2.2.-30. Impact of Fuel Benzene Control on Benzene Emissions from Highway Vehicles, by Class, 2015.**

Vehicle Class	Reference Case Tons	Control Case Tons	Reduction
LDGV	37,881	33,766	4,115
LDGT1	39,657	35,279	4,378
LDGT2	17,696	15,658	2,037
MC	773	663	110
HDGV	1,782	1,509	273
TOTAL	97,789	86875	10914

**Table 2.2.-31. Impact of Fuel Benzene Control on Benzene Emissions from Highway Vehicles, by Class, 2020.**

Vehicle Class	Reference Case Tons	Control Case Tons	Reduction
LDGV	35,987	32,213	3,774
LDGT1	44,611	39,849	4,762
LDGT2	18,627	16,572	2,056
MC	833	714	118
HDGV	1,456	1,240	215
TOTAL	101514	90,588	10926

**Table 2.2.-32. Impact of Fuel Benzene Control on Benzene Emissions from Highway Vehicles, by Class, 2030.**

<b>Vehicle Class</b>	<b>Reference Case Tons</b>	<b>Control Case Tons</b>	<b>Reduction</b>
LDGV	42,752	38,345	4,407
LDGT1	52,993	47,477	5,516
LDGT2	20,996	18,738	2,259
MC	1,002	861	141
HDGV	1,273	1,081	192
<b>TOTAL</b>	<b>119016</b>	<b>106502</b>	<b>12514</b>

Reductions from the fuel benzene control vary significantly across the U.S., depending on the average level of benzene in gasoline sold, as discussed in Section 2.2.1.2 on air quality modeling inventories. Table 2.2.-33 summarizes impacts of fuel benzene control on the benzene emission inventory for gasoline vehicles in each State in 2030.

**Table 2.2.-33. Impacts of Fuel Control on Gasoline Vehicle Benzene by State in 2030.**

State	2030 Reference Case Tons	2030 Control Case Tons	2030 Tons Reduced	% Change
ALABAMA	2,260.4	2,013.9	246.4	10.9
ALASKA	1,304.4	895.8	408.7	31.3
ARIZONA	1,788.9	1,631.6	157.4	8.8
ARKANSAS	1,349.2	1,197.4	151.8	11.3
CALIFORNIA	9,422.4	9,387.8	34.6	0.4
COLORADO	2,728.3	2,359.2	369.2	13.5
CONNECTICUT	1,033.1	1,019.1	14.0	1.4
DELAWARE	269.6	265.7	3.9	1.4
DISTRICT OF COLUMBIA	112.0	110.5	1.5	1.3
FLORIDA	4,175.1	3,687.3	487.8	11.7
GEORGIA	4,176.9	3,781.8	395.1	9.5
HAWAII	189.7	188.9	0.7	0.4
IDAHO	1,149.1	969.7	179.5	15.6
ILLINOIS	4,075.3	3,740.6	334.8	8.2
INDIANA	3,392.9	2,956.3	436.6	12.9
IOWA	1,580.3	1,354.9	225.4	14.3
KANSAS	1,385.9	1,154.5	231.4	16.7
KENTUCKY	1,988.4	1,749.9	238.5	12.0
LOUISIANA	1,540.8	1,356.0	184.8	12.0
MAINE	668.5	639.8	28.7	4.3
MARYLAND	1,716.1	1,667.0	49.2	2.9
MASSACHUSETTS	1,690.7	1,667.2	23.4	1.4
MICHIGAN	5,642.0	4,827.3	814.8	14.4
MINNESOTA	4,086.7	3,349.5	737.2	18.0
MISSISSIPPI	967.8	856.5	111.3	11.5
MISSOURI	2,839.5	2,471.7	367.8	13.0
MONTANA	795.0	675.0	120.0	15.1
NEBRASKA	985.5	831.7	153.8	15.6
NEVADA	1,021.5	969.3	52.2	5.1
NEW HAMPSHIRE	641.0	614.6	26.4	4.1
NEW JERSEY	1,858.8	1,833.1	25.6	1.4
NEW MEXICO	1,739.4	1,448.3	291.0	16.7
NEW YORK	4,519.9	4,278.1	241.8	5.3
NORTH CAROLINA	3,922.7	3,521.1	401.6	10.2
NORTH DAKOTA	515.0	430.1	84.9	16.5
OHIO	4,619.9	4,005.6	614.3	13.3
OKLAHOMA	1,808.7	1,609.1	199.6	11.0
OREGON	3,724.9	3,108.3	616.6	16.6
PENNSYLVANIA	4,102.3	3,821.3	281.0	6.8
RHODE ISLAND	324.4	320.0	4.4	1.4
SOUTH CAROLINA	2,038.9	1,833.7	205.2	10.1
SOUTH DAKOTA	523.5	447.6	75.8	14.5
TENNESSEE	2,545.4	2,239.0	306.3	12.0
TEXAS	6,294.5	5,651.4	643.1	10.2
UTAH	1,731.2	1,488.9	242.3	14.0
VERMONT	463.7	428.1	35.6	7.7
VIRGINIA	3,312.0	3,109.4	202.6	6.1
WASHINGTON	5,856.9	4,888.8	968.1	16.5
WEST VIRGINIA	862.5	759.9	102.6	11.9
WISCONSIN	2,693.8	2,397.2	296.6	11.0
WYOMING	581.2	491.5	89.7	15.4

*Gasoline Nonroad Equipment* – Table 2.2.-34 summarizes the nationwide impact of the fuel benzene control on benzene emissions from gasoline nonroad equipment. As with highway gasoline vehicles, emission benefits vary across the U. S. As can be seen in Table 2.2.-35, these benefits vary from 1 to 31% by State in 2030.

**Table 2.2-34. Nationwide Impact of Fuel Benzene Control on Benzene Emissions from Nonroad Gasoline Equipment.**

	<b>Tons</b>
2015 Reference Case	41,343
2015 Control Case	35,825
2015 Reduction	5,518
2020 Reference Case	40,161
2020 Control Case	34,717
2020 Reduction	5,444
2030 Reference Case	42,994
2030 Control Case	37168
2030 Reduction	5,826

*Portable Fuel Containers* –Table 2.2.-36 summarizes MSAT emissions from PFCs with no fuel benzene or federal PFC control (but including State control programs). The fuel benzene control will reduce benzene emissions from PFCs, as summarized in Table 2.2.-37. Again, emission benefits vary across the U. S., as seen in Table 2.2.-38.

*Gasoline Distribution* –Table 2.2.-39 presents the benzene inventory from gasoline distribution (not including refueling) in 2015 and 2020 with and without the fuel benzene control. Table 2.2.-40 presents the inventory for 2020 at the State level with and without fuel benzene control. More detailed inventory estimates by county are available in the docket for the rule.

**Table 2.2.-35. Gasoline Nonroad Equipment Benzene Emission Reductions (Tons) from Fuel Control by State, 2030.**

State	2030 Reference Case Tons	2030 Control Case Tons	2030 Tons Reduced	% Change
ALABAMA	1,024.8	830.6	194.2	19.0
ALASKA	188.3	129.4	58.9	31.3
ARIZONA	715.3	615.1	100.2	14.0
ARKANSAS	637.6	514.1	123.5	19.4
CALIFORNIA	4,055.2	4,032.6	22.6	0.6
COLORADO	623.4	525.5	97.9	15.7
CONNECTICUT	412.9	403.5	9.4	2.3
DELAWARE	98.2	95.8	2.4	2.5
DISTRICT OF COLUMBIA	28.1	27.4	0.8	2.8
FLORIDA	3,752.5	3,070.6	682.0	18.2
GEORGIA	1,576.1	1,324.2	251.9	16.0
HAWAII	127.6	126.7	0.9	0.7
IDAHO	285.1	232.3	52.8	18.5
ILLINOIS	1,298.3	1,192.6	105.7	8.1
INDIANA	722.9	605.6	117.4	16.2
IOWA	489.1	404.2	84.9	17.4
KANSAS	309.2	245.4	63.7	20.6
KENTUCKY	483.1	403.6	79.5	16.4
LOUISIANA	1,133.7	896.6	237.1	20.9
MAINE	257.3	238.2	19.0	7.4
MARYLAND	789.2	737.3	52.0	6.6
MASSACHUSETTS	678.8	663.1	15.7	2.3
MICHIGAN	1,585.6	1,288.9	296.7	18.7
MINNESOTA	900.5	708.8	191.7	21.3
MISSISSIPPI	534.4	428.8	105.6	19.8
MISSOURI	778.8	654.7	124.1	15.9
MONTANA	133.6	110.3	23.3	17.5
NEBRASKA	209.1	168.4	40.8	19.5
NEVADA	310.3	279.1	31.2	10.0
NEW HAMPSHIRE	270.3	245.4	24.9	9.2
NEW JERSEY	1,053.7	1,029.4	24.3	2.3
NEW MEXICO	266.5	208.0	58.5	21.9
NEW YORK	2,366.1	2,154.0	212.1	9.0
NORTH CAROLINA	1,654.7	1,382.2	272.5	16.5
NORTH DAKOTA	107.2	86.0	21.2	19.8
OHIO	1,329.4	1,100.3	229.1	17.2
OKLAHOMA	596.0	483.6	112.4	18.9
OREGON	639.2	514.6	124.7	19.5
PENNSYLVANIA	1,516.0	1,353.4	162.6	10.7
RHODE ISLAND	110.5	108.0	2.5	2.2
SOUTH CAROLINA	907.6	749.8	157.8	17.4
SOUTH DAKOTA	109.5	89.0	20.5	18.7
TENNESSEE	739.7	606.4	133.3	18.0
TEXAS	3,156.9	2,688.5	468.5	14.8
UTAH	356.5	294.5	62.0	17.4
VERMONT	134.2	116.4	17.8	13.3
VIRGINIA	1,105.1	990.5	114.7	10.4
WASHINGTON	1,039.3	841.3	198.0	19.0
WEST VIRGINIA	326.6	269.3	57.3	17.5
WISCONSIN	962.0	815.1	146.9	15.3
WYOMING	107.4	87.8	19.6	18.2

**Table 2.2.-36. MSAT Emissions (Tons) from Uncontrolled PFCs (No Fuel Benzene Control, No Federal PFC Control, But Including State Programs)**

<b>Pollutant</b>	<b>1999</b>	<b>2010</b>	<b>2015</b>	<b>2020</b>	<b>2030</b>
2,2,4-Trimethylpentane	4,870	4,994	5,195	5,573	6,353
Benzene	853	943	992	1,063	1,210
Ethylbenzene	2,135	1,805	1,884	2,021	2,303
n-Hexane	5,417	4,679	4,895	5,250	5,981
MTBE	6,969	0	0	0	0
Naphthalene	1	1	1	1	1
Toluene	10,733	8,764	9,161	9,825	11,195
Xylenes	6,189	5,004	5,226	5,605	6,387
<b>TOTAL</b>	<b>37,167</b>	<b>21,186</b>	<b>27,354</b>	<b>29,338</b>	<b>33,430</b>

**Table 2.2.-37. Reduction in Benzene PFC Emissions (Tons) with Fuel Control (No Control on PFC Emissions).**

<b>Year</b>	<b>Reference Case</b>	<b>Control Case</b>	<b>Reduction</b>
1999	853	N.A.	N.A.
2015	992	619	373
2020	1,063	664	399
2030	1,210	756	454



**Table 2.2.-38. Reduction in Benzene PFC Emissions (Tons) with Fuel Control in 2030 by State (No Additional Control on PFC Emissions).**

State	Reference Case Tons	Control Case Tons	Reduction	% Change
ALABAMA	33.1	19.1	14.0	42.3
ALASKA	19.3	11.6	7.7	40.0
ARIZONA	25.8	15.5	10.3	40.0
ARKANSAS	23.7	13.5	10.2	43.0
CALIFORNIA	36.4	35.7	0.7	2.0
COLORADO	31.5	19.8	11.7	37.0
CONNECTICUT	3.5	3.2	0.3	8.0
DELAWARE	1.1	1.0	0.1	8.0
DISTRICT OF COLUMBIA	0.4	0.4	0.0	8.0
FLORIDA	138.2	82.9	55.3	40.0
GEORGIA	42.5	25.5	17.0	40.0
HAWAII	5.1	5.0	0.1	2.0
IDAHO	12.8	8.1	4.7	37.0
ILLINOIS	42.6	32.9	9.6	22.6
INDIANA	38.0	21.4	16.6	43.7
IOWA	20.8	11.2	9.6	46.0
KANSAS	20.8	11.2	9.6	46.0
KENTUCKY	25.3	16.1	9.2	36.4
LOUISIANA	39.2	22.4	16.9	43.0
MAINE	1.7	1.3	0.3	20.0
MARYLAND	7.0	6.2	0.9	12.5
MASSACHUSETTS	5.9	5.4	0.5	8.0
MICHIGAN	64.1	34.6	29.5	46.0
MINNESOTA	40.9	22.1	18.8	46.0
MISSISSIPPI	24.6	14.0	10.6	43.0
MISSOURI	31.7	19.9	11.8	37.2
MONTANA	8.0	5.1	3.0	37.0
NEBRASKA	12.7	6.8	5.8	46.0
NEVADA	11.9	7.8	4.1	34.5
NEW HAMPSHIRE	1.7	1.4	0.3	16.5
NEW JERSEY	8.7	8.0	0.7	8.0
NEW MEXICO	14.0	8.0	6.0	43.0
NEW YORK	17.9	14.4	3.5	19.6
NORTH CAROLINA	54.9	32.9	21.9	40.0
NORTH DAKOTA	4.5	2.4	2.1	46.0
OHIO	33.3	18.0	15.3	46.0
OKLAHOMA	20.8	11.3	9.6	46.0
OREGON	29.9	17.9	12.0	40.0
PENNSYLVANIA	16.3	11.5	4.8	29.5
RHODE ISLAND	0.9	0.9	0.1	8.0
SOUTH CAROLINA	31.5	18.9	12.6	40.0
SOUTH DAKOTA	4.8	2.6	2.2	46.0
TENNESSEE	41.8	22.6	19.2	46.0
TEXAS	42.5	30.6	12.0	28.1
UTAH	16.7	10.5	6.2	37.0
VERMONT	0.8	0.5	0.3	40.0
VIRGINIA	11.5	8.9	2.6	22.5
WASHINGTON	44.5	26.7	17.8	40.0
WEST VIRGINIA	14.3	8.6	5.7	40.0
WISCONSIN	26.0	16.9	9.1	34.9
WYOMING	4.2	2.7	1.6	37.0

**Table 2.2.-39. Nationwide Impact of Controls on Emissions of Benzene from Gasoline Distribution in 2015 and 2020.**

	<b>2015 Reference Case</b>	<b>2015 Control Case</b>	<b>2015 Reduction</b>	<b>2020 Reference Case</b>	<b>2020 Control Case</b>	<b>2020 Reduction</b>
Tons of Benzene	2,445	1,635	810	2,621	1,772	849

**Table 2.2.-40. Reduction in Gasoline Distribution Emissions of Benzene (Tons) with Fuel Benzene Control by State, 2020.**

State	Reference Case Tons	Control Case Tons	Reduction	% Change
ALABAMA	34.0	19.6	14.4	42.4
ALASKA	3.0	1.8	1.2	40.0
ARIZONA	40.9	24.6	16.4	40.0
ARKANSAS	16.5	9.4	7.1	43.0
CALIFORNIA	98.0	96.1	2.0	2.0
COLORADO	27.5	17.3	10.2	37.0
CONNECTICUT	18.6	17.1	1.5	8.0
DELAWARE	3.4	3.1	0.3	8.0
DISTRICT OF COLUMBIA	3.4	3.1	0.3	8.0
FLORIDA	88.4	53.1	35.4	40.0
GEORGIA	36.6	22.0	14.6	40.0
HAWAII	3.1	3.1	0.1	2.0
IDAHO	20.2	12.7	7.5	37.0
ILLINOIS	98.6	69.0	29.6	30.0
INDIANA	41.2	23.7	17.5	42.5
IOWA	53.6	29.0	24.7	46.0
KANSAS	70.0	37.8	32.2	46.0
KENTUCKY	48.4	28.4	20.0	41.3
LOUISIANA	108.9	62.1	46.8	43.0
MAINE	21.4	16.3	5.1	23.9
MARYLAND	34.1	28.6	5.5	16.1
MASSACHUSETTS	25.0	23.0	2.0	8.0
MICHIGAN	82.3	44.5	37.9	46.0
MINNESOTA	74.3	40.1	34.2	46.0
MISSISSIPPI	42.6	24.3	18.3	43.0
MISSOURI	26.6	16.6	9.9	37.4
MONTANA	12.0	7.5	4.4	37.0
NEBRASKA	11.1	6.0	5.1	46.0
NEVADA	7.8	5.7	2.1	27.1
NEW HAMPSHIRE	3.9	3.2	0.6	16.7
NEW JERSEY	41.7	38.3	3.3	8.0
NEW MEXICO	26.3	15.0	11.3	43.0
NEW YORK	359.7	313.4	46.3	12.9
NORTH CAROLINA	36.2	21.7	14.5	40.0
NORTH DAKOTA	9.3	5.0	4.3	46.0
OHIO	89.7	48.4	41.3	46.0
OKLAHOMA	61.0	32.9	28.1	46.0
OREGON	118.6	71.2	47.4	40.0
PENNSYLVANIA	72.7	46.1	26.6	36.6
RHODE ISLAND	4.7	4.4	0.4	8.0
SOUTH CAROLINA	19.9	11.9	8.0	40.0
SOUTH DAKOTA	6.5	3.5	3.0	46.0
TENNESSEE	57.9	31.3	26.7	46.0
TEXAS	344.2	243.6	100.6	29.2
UTAH	25.5	16.0	9.4	37.0
VERMONT	1.2	0.7	0.5	40.0
VIRGINIA	42.1	29.8	12.3	29.2
WASHINGTON	57.1	34.3	22.8	40.0
WEST VIRGINIA	55.2	33.1	22.1	40.0
WISCONSIN	23.7	15.1	8.6	36.4
WYOMING	11.8	7.4	4.4	37.0

2.2.2.2.2 Cold Temperature VOC Emission Control

Reductions in MSATs are proportional to reduced NMHC start emissions from vehicles subject to this rule. The magnitude of the reductions from these vehicles operating on a given gasoline is based entirely on the number and duration of events between engine off and engine on (vehicle soak) and the ambient conditions. The emissions reduced are those created by the engine start following the vehicle soak. These parameters are currently modeled by vehicle class and vehicle age in MOBILE6.2.<sup>56, 57, 58, 59</sup> MOBILE6.2 also provides the necessary information to adjust MSAT emission factors to account for geographic and seasonal effects on in-use fuels.

When all the affected vehicle classes meet the new emission standard we expect a 60% reduction of benzene and 1,3-butadiene from gasoline-fueled highway vehicles with GVWR ≤ 6000 lbs and 30% from gasoline-fueled highway vehicles with GVWR > 6000 lbs. This estimate does not include the effects of fuel benzene control. Effects on the trends in the inventories for the affected MSATs are shown in Table 2.2.-41 through Table 2.2.-45.

**Table 2.2.-41. Reference Case, Light-Duty Gasoline Vehicles and Trucks, 1999 MSAT Inventory.**

Pollutant	Emissions in Tons
1,3-Butadiene	20,868
2,2,4-Trimethylpentane	175,241
Acetaldehyde	21,035
Acrolein	2,234
Benzene	173,474
Ethyl Benzene	69,299
Formaldehyde	54,104
n-Hexane	61,664
MTBE	54,990
Propionaldehyde	2440
Styrene	13,070
Toluene	464,646
Xylenes	262,298
Total MSATs	1,376,002

**Table 2.2.-42. Reference and Vehicle Control Case, Light-Duty Gasoline Vehicles and Trucks, 2010 MSAT Inventories.**

<b>Pollutant</b>	<b>Reference Case Tons in Calendar Year 2010</b>	<b>Vehicle Control Case Tons in Calendar Year 2010</b>	<b>Reduction in Tons</b>	<b>Percent Reduction</b>
1,3-Butadiene	9,159	8,417	742	8
2,2,4-Trimethylpentane	95,194	88,628	6,566	7
Acetaldehyde	16,680	15,220	1,460	9
Acrolein	1,132	1,041	91	8
Benzene	99,559	91,621	7,939	8
Ethyl Benzene	36,001	33,489	2,512	7
Formaldehyde	23,466	21,371	2,095	9
n-Hexane	32,850	31,590	1,260	4
MTBE	0	0	0	0
Propionaldehyde	1254	1144	110	9
Styrene	6,688	6,107	581	9
Toluene	238,683	220,939	17,744	7
Xylenes	134,742	124,744	9,998	7
Total MSATs	695,408	644,312	51,987	7

**Table 2.2.-43. Reference and Vehicle Control Case, Light-Duty Vehicles, 2015 MSAT Inventories.**

<b>Pollutant</b>	<b>Reference Case Tons in Calendar Year 2015</b>	<b>Vehicle Control Case Tons in Calendar Year 2015</b>	<b>Reduction in Tons</b>	<b>Percent Reduction</b>
1,3-Butadiene	8,635	7,083	1,552	18
2,2,4-Trimethylpentane	87,857	73,956	13,901	16
Acetaldehyde	16,253	13,123	3,131	19
Acrolein	1,080	887	193	18
Benzene	95,234	78,664	16,570	17
Ethyl Benzene	33,276	27,970	5,305	16
Formaldehyde	22,657	18,298	4,359	19
n-Hexane	27,699	25,034	2,665	10
MTBE	0	0	0	0
Propionaldehyde	1216	985	231	19
Styrene	6,481	5,254	1,227	19
Toluene	223,510	186,031	37,480	17
Xylenes	126,114	104,997	21,117	17
Total MSATs	650,012	542,281	107,731	17

**Table 2.2.-44. Reference and Vehicle Control Case, Light-Duty Vehicles, 2020 MSAT Inventories.**

<b>Pollutant</b>	<b>Reference Case Tons in Calendar Year 2020</b>	<b>Vehicle Control Case Tons in Calendar Year 2020</b>	<b>Reduction in Tons</b>	<b>Percent Reduction</b>
1,3-Butadiene	9,131	6,592	2,539	28
2,2,4-Trimethylpentane	89,711	66,807	22,904	26
Acetaldehyde	17,345	12,143	5,203	30
Acrolein	1,139	822	317	28
Benzene	99,225	72,128	27,097	27
Ethyl Benzene	33,992	25,268	8,724	26
Formaldehyde	24,007	16,922	7,086	30
n-Hexane	25,765	21,380	4,385	17
MTBE	0	0	0	0
Propionaldehyde	1293	914	379	29
Styrene	6,898	4,880	2,018	29
Toluene	230,933	169,303	61,630	27
Xylenes	130,267	95,543	34,725	27
Total MSATs	669,707	492,700	177,007	26

**Table 2.2.-45. Reference and Vehicle Control Case, Light-Duty Vehicles, 2030 MSAT Inventories.**

<b>Pollutant</b>	<b>Reference Case Tons in Calendar Year 2030</b>	<b>Vehicle Control Case Tons in Calendar Year 2030</b>	<b>Reduction in Tons</b>	<b>Percent Reduction</b>
1,3-Butadiene	10,798	6,540	4,257	39
2,2,4-Trimethylpentane	104,511	66,317	38,194	37
Acetaldehyde	20,663	12,064	8,599	42
Acrolein	1,347	818	529	39
Benzene	116,742	71,704	45,037	39
Ethyl Benzene	39,603	25,053	14,551	37
Formaldehyde	28,529	16,897	11,632	41
n-Hexane	28,437	21,125	7,312	26
MTBE	0	0	0	0
Propionaldehyde	1540	907	633	41
Styrene	8,207	4,841	3,366	41
Toluene	270,625	167,829	102,796	38
Xylenes	152,647	94,728	57,919	38
Total MSATs	783,648	488,824	294,824	38

State-level reductions in calendar year 2030 benzene inventories are reported in Table 2.2.-46.

**Table 2.2.-46. Impacts of Vehicle Control on Light-Duty Gasoline Vehicle Benzene Emissions, by State in 2030**

State	2030 Reference Case Benzene Tons in Calendar 2030	2030 Control Case Benzene Tons in Calendar 2030	Reduction (Tons)	Percent Reduction
ALABAMA	2,199.4	1,562.7	636.6	28.9
ALASKA	1,293.1	652.7	640.4	49.5
ARIZONA	1,734.6	1,190.5	544.1	31.4
ARKANSAS	1,323.0	900.4	422.5	31.9
CALIFORNIA	9,286.2	5,634.4	3,651.7	39.3
COLORADO	2,674.7	1,560.6	1,114.1	41.7
CONNECTICUT	1,019.9	540.4	479.6	47.0
DELAWARE	264.8	148.9	115.9	43.8
DISTRICT OF COLUMBIA	109.9	62.1	47.7	43.5
FLORIDA	4,032.2	3,374.8	657.4	16.3
GEORGIA	4,076.8	2,698.4	1,378.4	33.8
HAWAII	183.7	174.7	9.0	4.9
IDAHO	1,132.6	653.4	479.3	42.3
ILLINOIS	4,004.2	2,255.1	1,749.0	43.7
INDIANA	3,335.4	2,035.6	1,299.8	39.0
IOWA	1,564.5	927.2	637.3	40.7
KANSAS	1,362.3	859.7	502.6	36.9
KENTUCKY	1,952.6	1,197.3	755.3	38.7
LOUISIANA	1,502.6	1,122.2	380.4	25.3
MAINE	657.6	358.9	298.7	45.4
MARYLAND	1,689.2	943.6	745.6	44.1
MASSACHUSETTS	1,649.1	816.5	832.6	50.5
MICHIGAN	5,560.1	3,279.8	2,280.3	41.0
MINNESOTA	4,038.3	2,190.2	1,848.0	45.8
MISSISSIPPI	946.8	652.0	294.8	31.1
MISSOURI	2,787.8	1,722.2	1,065.6	38.2
MONTANA	785.0	443.4	341.6	43.5
NEBRASKA	970.8	582.1	388.7	40.0
NEVADA	989.8	627.4	362.4	36.6
NEW HAMPSHIRE	632.5	347.0	285.5	45.1
NEW JERSEY	1,815.8	976.9	838.9	46.2
NEW MEXICO	1,698.0	1,079.3	618.7	36.4
NEW YORK	4,421.5	2,201.2	2,220.3	50.2
NORTH CAROLINA	3,836.4	2,474.0	1,362.4	35.5
NORTH DAKOTA	509.0	282.7	226.3	44.5
OHIO	4,536.7	2,595.6	1,941.1	42.8
OKLAHOMA	1,771.7	1,206.9	564.8	31.9
OREGON	3,631.9	2,270.3	1,361.5	37.5
PENNSYLVANIA	4,026.6	2,235.7	1,790.9	44.5
RHODE ISLAND	320.3	175.6	144.6	45.2
SOUTH CAROLINA	1,998.9	1,358.6	640.3	32.0
SOUTH DAKOTA	516.9	296.1	220.7	42.7
TENNESSEE	2,495.0	1,623.0	872.1	35.0
TEXAS	6,111.9	4,356.2	1,755.7	28.7
UTAH	1,705.9	1,041.8	664.2	38.9
VERMONT	457.1	246.7	210.4	46.0
VIRGINIA	3,271.3	1,977.9	1,293.4	39.5
WASHINGTON	5,778.8	3,564.6	2,214.2	38.3
WEST VIRGINIA	852.8	489.6	363.2	42.6
WISCONSIN	2,651.4	1,407.8	1,243.6	46.9
WYOMING	573.9	329.5	244.4	42.6
<b>2030 Benzene Totals</b>	<b>116,741.6</b>	<b>71,704.3</b>	<b>45,037.3</b>	<b>38.6</b>

## 2.2.2.2.3 Portable Fuel Container Control

The effect of PFC control on nationwide MSAT emissions are reported in Tables 2.2.-47 through 2.2.-50. Table 2.2.-51 reports benzene reductions by State in 2030 as a result of federal PFC control.

**Table 2.2.-47. Estimated Reductions in MSAT Emissions from PFC Control, 2010  
(No Fuel Benzene Control).**

Pollutant	Reference Case	Control Case	Reduction in Tons	Percent Reduction
2,2,4-Trimethylpentane	4,994	4,039	955	19
Benzene	943	743	201	21
Ethyl Benzene	1,805	1,450	355	20
n-Hexane	4,679	3,742	937	20
MTBE	0	0	0	0
Naphthalene	1	1	0	19
Toluene	8,764	7,021	1,743	20
Xylenes	5,004	4,015	989	20
<b>Total</b>	<b>26,189</b>	<b>21,010</b>	<b>5,179</b>	<b>20</b>

**Table 2.2.-48. Estimated Reductions in MSAT Emissions from PFC Control, 2015  
(No Fuel Benzene Control).**

Pollutant	Reference Case	Control Case	Reduction in Tons	Percent Reduction
2,2,4-Trimethylpentane	5,195	2,005	3,190	61
Benzene	992	320	672	68
Ethyl Benzene	1,884	695	1,189	63
n-Hexane	4,895	1,750	3,145	64
MTBE	0	0	0	0
Naphthalene	1	0	0	61
Toluene	9,161	3,316	5,846	64
Xylenes	5,226	1,912	3,314	63
<b>Total</b>	<b>27,355</b>	<b>9,998</b>	<b>17,357</b>	<b>63</b>



**Table 2.2.-49. Estimated Reductions in MSAT Emissions from PFC Control, 2020  
(No Fuel Benzene Control).**

Pollutant	Reference Case	Control Case	Reduction in Tons	Percent Reduction
2,2,4-Trimethylpentane	5,573	2,163	3,410	61
Benzene	1,063	345	718	68
Ethyl Benzene	2,021	750	1,271	63
n-Hexane	5,250	1,888	3,362	64
MTBE	0	0	0	0
Naphthalene	1	0	0	61
Toluene	9,825	3,577	6,248	64
Xylenes	5,605	2,063	3,543	63
<b>Total</b>	<b>29,338</b>	<b>10,785</b>	<b>18,553</b>	<b>63</b>

**Table 2.2.-50. Estimated Reductions in MSAT Emissions from PFC Control, 2030  
(No Fuel Benzene Control).**

Pollutant	Reference Case	Control Case	Reduction in Tons	Percent Reduction
2,2,4-Trimethylpentane	6,353	2,486	3,867	61
Benzene	1,210	396	814	67
Ethyl Benzene	2,303	862	1,442	63
n-Hexane	5,981	2,169	3,812	64
MTBE	0	0	0	0
Naphthalene	1	0	1	61
Toluene	11,195	4,110	7,085	63
Xylenes	6,387	2,370	4,017	63
<b>Total</b>	<b>33,430</b>	<b>12,394</b>	<b>21,036</b>	<b>63</b>

**Table 2.2.-51. Reductions in Benzene Emissions (Tons) with PFC Control by State, 2030 (No Fuel Benzene Control).**

State	Reference Case	Control Case	Reduction	% Change
ALABAMA	33.1	6.8	26.3	79.5
ALASKA	19.3	3.7	15.6	80.9
ARIZONA	25.8	7.3	18.6	71.8
ARKANSAS	23.7	4.3	19.4	82.0
CALIFORNIA	36.4	36.4	0.0	0.0
COLORADO	31.5	11.1	20.4	64.9
CONNECTICUT	3.5	3.0	0.4	12.8
DELAWARE	1.1	0.9	0.3	22.5
DISTRICT OF COLUMBIA	0.4	0.3	0.1	32.3
FLORIDA	138.2	30.0	108.3	78.3
GEORGIA	42.5	11.7	30.8	72.4
HAWAII	5.1	0.9	4.2	82.4
IDAHO	12.8	3.8	9.0	70.7
ILLINOIS	42.6	14.3	28.3	66.5
INDIANA	38.0	9.7	28.3	74.4
IOWA	20.8	4.7	16.1	77.5
KANSAS	20.8	5.3	15.5	74.5
KENTUCKY	25.3	5.9	19.3	76.6
LOUISIANA	39.2	6.3	32.9	83.9
MAINE	1.7	1.2	0.4	26.4
MARYLAND	7.0	5.5	1.6	22.1
MASSACHUSETTS	5.9	4.8	1.0	17.6
MICHIGAN	64.1	16.9	47.1	73.6
MINNESOTA	40.9	11.0	29.9	73.1
MISSISSIPPI	24.6	3.7	20.9	85.1
MISSOURI	31.7	8.4	23.3	73.4
MONTANA	8.0	2.1	6.0	74.2
NEBRASKA	12.7	3.1	9.5	75.2
NEVADA	11.9	3.2	8.7	73.1
NEW HAMPSHIRE	1.7	1.3	0.4	24.4
NEW JERSEY	8.7	7.0	1.7	19.5
NEW MEXICO	14.0	3.8	10.2	73.0
NEW YORK	17.9	13.7	4.2	23.5
NORTH CAROLINA	54.9	13.1	41.7	76.1
NORTH DAKOTA	4.5	1.2	3.4	73.9
OHIO	33.3	20.0	13.3	39.9
OKLAHOMA	20.8	5.0	15.8	75.9
OREGON	29.9	9.2	20.6	69.1
PENNSYLVANIA	16.3	11.6	4.7	28.7
RHODE ISLAND	0.9	0.8	0.2	18.9
SOUTH CAROLINA	31.5	6.5	25.0	79.4
SOUTH DAKOTA	4.8	1.2	3.6	75.1
TENNESSEE	41.8	8.2	33.6	80.3
TEXAS	42.5	26.2	16.3	38.4
UTAH	16.7	4.5	12.1	72.7
VERMONT	0.8	0.6	0.2	26.0
VIRGINIA	11.5	8.8	2.7	23.6
WASHINGTON	44.5	14.7	29.8	66.9
WEST VIRGINIA	14.3	3.2	11.1	77.5
WISCONSIN	26.0	8.1	17.9	69.0
WYOMING	4.2	1.2	3.0	70.5

#### 2.2.2.2.4 Cumulative Reductions of Controls

Air toxic emissions from light-duty vehicles depend on both fuel benzene content and vehicle hydrocarbon emission controls. Similarly, the air toxic emissions from PFCs depend on both fuel benzene content and the PFC emission controls. Tables 2.2.-52 and 2.2.-53 summarize the expected reductions in benzene and MSAT emissions, respectively, from the combined effects of our vehicle, fuel, and PFC controls.

Table 2.2.-54 summarizes the cumulative benzene emission reductions from these controls on highway gasoline vehicles, nonroad gasoline vehicles, PFCs, and gasoline distribution at the State level in 2030.

Table 2.2.-55 presents the impact of controls on total benzene emissions from mobile sources and PFCs, and the impacts on total benzene emissions from all sources. Table 2.2.-56 presents the cumulative impact of controls on total emissions of MSATs from mobile sources and PFCs, as well as the impact on total emissions of MSATs from both mobile and stationary sources. As discussed previously, the fuel benzene control reduces stationary source emissions of benzene associated with gasoline distribution.

**Table 2.2-52. Estimated Reductions in Benzene Emissions from All Control Measures by Sector, 2015 to 2030.**

Benzene	1999	2015			2020			2030		
		Without Rule (tons)	With Rule (tons)	Reduction (tons)	Without Rule (tons)	With Rule (tons)	Reduction (tons)	Without Rule (tons)	With Rule (tons)	Reduction (tons)
<b>Gasoline Onroad Mobile Sources</b>	183,660	97,789	71,688	26,101	101,514	65,878	35,636	119,016	65,601	53,415
<b>Gasoline Nonroad Mobile Sources</b>	68,589	41,343	35,825	5,518	40,161	34,717	5,444	42,994	37,167	5,827
<b>PFCs</b>	853	992	215	777	1,063	232	831	1,210	267	944
<b>Gasoline Distribution</b>	1,984	2,445	1,635	810	2,621	1,772	849	2,621	1,772	849
<b>Total</b>	255,086	142,569	109,363	33,206	145,359	102,599	42,760	165,841	104,807	61,035

**Table 2.2.-53. Estimated Reductions in MSAT Emissions from All Control Measures by Sector, 2015 to 2030**

MSAT	1999	2015			2020			2030		
		Without Rule (tons)	With Rule (tons)	Reduction (tons)	Without Rule (tons)	With Rule (tons)	Reduction (tons)	Without Rule (tons)	With Rule (tons)	Reduction (tons)
<b>Gasoline Onroad Mobile Sources</b>	1,452,739	675,781	558,666	117,115	693,189	507,782	185,408	808,141	505,074	303,067
<b>Gasoline Nonroad Mobile Sources</b>	806,725	449,422	443,973	5,449	406,196	400,816	5,380	412,617	406,856	5,761
<b>PFCs</b>	37,166	27,355	9,893	17,462	29,338	10,672	18,666	33,430	12,264	21,166
<b>Gasoline Distribution</b>	57,765	62,870	62,059	811	64,942	64,092	850	64,942	64,092	850
<b>Total</b>	2,354,395	1,215,428	1,074,591	140,837	1,193,665	983,362	210,303	1,319,130	988,286	330,844

**Table 2.2.-54. Cumulative Benzene Emission Reductions From All Controls at the State Level in 2030.**

State	Gasoline Highway Vehicles		Nonroad Gasoline Engines		PFCs		Gasoline Distribution		Total	
	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%
ALABAMA	826.3	36.6	194.2	19.0	29.1	88.2	14.4	42.4	1,064.0	31.7
ALASKA	849.8	65.1	58.9	31.3	17.1	88.5	1.2	40.0	926.9	61.2
ARIZONA	665.3	37.2	100.2	14.0	21.5	83.1	16.4	40.0	803.4	31.2
ARKANSAS	534.7	39.6	123.5	19.4	21.3	89.7	7.1	43.0	686.5	33.9
CALIFORNIA	3,675.9	39.0	22.6	0.6	0.7	2.0	2.0	2.0	3,701.2	27.2
COLORADO	1,348.7	49.4	97.9	15.7	24.5	77.9	10.2	37.0	1,481.2	43.4
CONNECTICUT	488.0	47.2	9.4	2.3	0.7	19.8	1.5	8.0	499.6	34.0
DELAWARE	118.3	43.9	2.4	2.5	0.3	28.7	0.3	8.0	121.4	32.6
DISTRICT OF COLUMBIA	48.7	43.5	0.8	2.8	0.2	37.7	0.3	8.0	49.9	34.7
FLORIDA	1,090.6	26.1	682.0	18.2	120.2	87.0	35.4	40.0	1,928.2	23.6
GEORGIA	1,667.6	39.9	251.9	16.0	35.4	83.4	14.6	40.0	1,969.5	33.8
HAWAII	9.8	5.1	0.9	0.7	4.2	82.7	0.1	2.0	15.0	4.6
IDAHO	588.6	51.2	52.8	18.5	10.4	81.5	7.5	37.0	659.3	44.9
ILLINOIS	1,966.1	48.2	105.7	8.1	31.5	74.0	29.6	30.0	2,132.9	38.7
INDIANA	1,591.8	46.9	117.4	16.2	32.5	85.6	17.5	42.5	1,759.2	41.9
IOWA	780.9	49.4	84.9	17.4	18.3	87.9	24.7	46.0	908.8	42.4
KANSAS	658.6	47.5	63.7	20.6	18.0	86.3	32.2	46.0	772.5	43.3
KENTUCKY	915.2	46.0	79.5	16.4	21.5	85.1	20.0	41.3	1,036.1	40.7
LOUISIANA	528.2	34.3	237.1	20.9	35.6	90.8	46.8	43.0	847.8	30.0
MAINE	315.5	47.2	19.0	7.4	0.7	41.1	5.1	23.9	340.3	35.9
MARYLAND	776.5	45.2	52.0	6.6	2.2	31.8	5.5	16.1	836.2	32.8
MASSACHUSETTS	845.7	50.0	15.7	2.3	1.4	24.2	2.0	8.0	864.8	36.0
MICHIGAN	2,799.1	49.6	296.7	18.7	54.9	85.7	37.9	46.0	3,188.6	43.2
MINNESOTA	2,270.1	55.5	191.7	21.3	35.0	85.5	34.2	46.0	2,530.9	49.6
MISSISSIPPI	378.9	39.2	105.6	19.8	22.5	91.5	18.3	43.0	525.4	33.5
MISSOURI	1,316.8	46.4	124.1	15.9	26.4	83.3	9.9	37.4	1,477.3	40.2
MONTANA	413.0	52.0	23.3	17.5	6.7	83.7	4.4	37.0	447.5	47.2
NEBRASKA	487.8	49.5	40.8	19.5	11.0	86.6	5.1	46.0	544.6	44.7
NEVADA	402.7	39.4	31.2	10.0	9.8	82.4	2.1	27.1	445.8	33.0

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State	Gasoline Highway Vehicles		Nonroad Gasoline Engines		PFCs		Gasoline Distribution		Total	
	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%	Tons Reduced	%
NEW HAMPSHIRE	301.2	47.0	24.9	9.2	0.6	36.9	0.6	16.7	327.4	35.7
NEW JERSEY	855.1	46.0	24.3	2.3	2.3	26.0	3.3	8.0	885.1	29.9
NEW MEXICO	814.4	46.8	58.5	21.9	11.8	84.6	11.3	43.0	896.0	43.8
NEW YORK	2,354.8	52.1	212.1	9.0	6.9	38.5	46.3	12.9	2,620.1	36.1
NORTH CAROLINA	1,648.3	42.0	272.5	16.5	47.0	85.6	14.5	40.0	1,982.3	35.0
NORTH DAKOTA	276.2	53.6	21.2	19.8	3.9	85.9	4.3	46.0	305.6	48.0
OHIO	2,326.7	50.4	229.1	17.2	22.5	67.5	41.3	46.0	2,619.6	43.1
OKLAHOMA	717.4	39.7	112.4	18.9	18.1	87.0	28.1	46.0	876.0	35.2
OREGON	1,774.1	47.6	124.7	19.5	24.3	81.5	47.4	40.0	1,970.6	43.7
PENNSYLVANIA	1,963.3	47.9	162.6	10.7	8.1	49.7	26.6	36.6	2,160.6	37.9
RHODE ISLAND	147.3	45.4	2.5	2.2	0.2	25.4	0.4	8.0	150.4	34.1
SOUTH CAROLINA	791.2	38.8	157.8	17.4	27.6	87.6	8.0	40.0	984.6	32.8
SOUTH DAKOTA	267.2	51.0	20.5	18.7	4.2	86.6	3.0	46.0	294.9	45.8
TENNESSEE	1,093.5	43.0	133.3	18.0	37.4	89.4	26.7	46.0	1,290.9	38.1
TEXAS	2,255.3	35.8	468.5	14.8	23.7	55.7	100.6	29.2	2,848.0	28.9
UTAH	821.5	47.5	62.0	17.4	13.8	82.8	9.4	37.0	906.7	42.6
VERMONT	230.9	49.8	17.8	13.3	0.5	55.6	0.5	40.0	249.7	41.6
VIRGINIA	1,427.6	43.1	114.7	10.4	4.7	40.8	12.3	29.2	1,559.2	34.9
WASHINGTON	2,848.3	48.6	198.0	19.0	35.7	80.2	22.8	40.0	3,104.8	44.4
WEST VIRGINIA	425.9	49.4	57.3	17.5	12.3	86.5	22.1	40.0	517.7	41.1
WISCONSIN	1,417.3	52.6	146.9	15.3	20.7	79.8	8.6	36.4	1,593.5	43.0
WYOMING	298.3	51.3	19.6	18.2	3.4	81.4	4.4	37.0	325.7	46.2

**Table 2.2-55. Impact of Controls on Total Benzene Emissions From Mobile Sources and All Sources.**

	<b>Mobile Source and PFC Tons Reduced</b>	<b>Mobile Source and PFC Tons, Reference Case</b>	<b>% of Mobile Source and PFC Tons Reduced</b>	<b>Total Tons Reduced From All Sources</b>	<b>Total Mobile and Stationary Tons, Reference Case</b>	<b>% of Total Benzene Reduced</b>
2015						
Fuel Benzene Control	16,804	140,124	12	17,614	256,755	7
Vehicle Control	16,570	140,124	12	16,570	256,755	7
Fuel, Vehicle, and PFC Control	32,396	140,124	23	33,206	256,755	13
2020						
Fuel Benzene Control	16,768	142,738	12	17,617	262,828	7
Vehicle Control	27,097	142,738	19	27,097	262,828	10
Fuel, Vehicle, and PFC Control	41,911	142,738	29	42,760	262,828	16
2030						
Fuel Benzene Control	18,796	163,220	12	19,645	283,310	7
Vehicle Control	45,037	163,220	28	45,037	283,310	16
Fuel, Vehicle, and PFC Control	60,186	163,220	37	61,035	283,310	22



Table 2.2.-56. Cumulative Impact of Controls on Total MSAT Emissions From Mobile Sources and PFCs, and From All Sources.

	Mobile Source and PFC Tons Reduced	Mobile Source and PFC Tons, Reference Case	% of Mobile and PFC Tons Reduced	Total Tons Reduced	Total Mobile and Stationary Tons	% of Mobile and Stationary Tons Reduced
2015	140,726	1,215,146	12	141,536	2,636,063	5
2020	210,173	1,193,281	18	211,022	2,733,020	8
2030	330,713	1,318,746	25	331,562	2,858,485	12

## 2.3 Potential Implications of New Emissions Data for Inventories

### 2.3.1 Newer Technology Light Duty Vehicles

MOBILE6.2 explicitly estimates emissions for the following air toxic compounds: benzene, 1,3-butadiene, formaldehyde, acetaldehyde, MTBE, and acrolein.<sup>60, 61</sup> MOBILE6.2 estimates air toxics emission factors by multiplying an air toxic to VOC (volatile organic compound) ratio by MOBILE6.2 VOC. For light-duty gasoline vehicles and trucks, the product for exhaust emissions is then multiplied by an off-cycle adjustment factor, which accounts for the difference in toxic fractions between Federal Test Procedure (FTP) and Unified Cycle (UC) operation.

Toxic to VOC ratios vary by technology group, vehicle type, whether a vehicle is a normal or high emitter (same definition as MOBILE6.2), and fuel characteristics. Evaporative toxic/VOC ratios do not vary among gasoline vehicle classes. Since toxic emission rates are a product of toxic/VOC emission ratios and VOC emission rates, anything that reduces VOC will also result in toxic emission reductions. Toxic/VOC ratios for individual technology group/vehicle type/emitter class combinations are determined using a series of algorithms which calculate the ratios based on fuel parameter inputs. These algorithms were derived from tests on 1990 model year technology vehicles and form the basis of the Complex Model for Reformulated Gasoline. MOBILE6.2 assumes that the same ratios are applicable to all post-1990 technology vehicles, including advanced technology low emission vehicles (LEVs) meeting Tier 2 standards.<sup>62</sup>

Eastern Research Group, under contract to EPA, recently compared exhaust emissions data from newer technology vehicles to see if the toxics to VOC fractions estimated from these data were statistically different from ratios predicted by MOBILE6.2. To make these comparisons, we used data collected by EPA Office of Research and Development/National Exposure Research Laboratory on 23 1998-2003 vehicles, the California Air Resources Board (46 vehicles) and Southwest Research Institute (3 vehicles). The contractor report and the data used are available in the docket for this rule.<sup>63</sup> The data from EPA's Office of Research and Development have been published.<sup>64</sup>

The conclusions from t-test comparisons were as follows:

- 1) When the off-cycle adjustment for benzene is factored out of the model results, MOBILE6.2 predicts statistically higher toxic fractions than one gets from the California Air Resources Board and Southwest Research Institute data, although for the large California dataset, the difference is only 10%. The fractions from the EPA Office of Research and Development data are higher than predicted by MOBILE6.2, but the difference is not statistically significant.
- 2) MOBILE6.2 is over-predicting toxic fractions for 1,3-butadiene.

- 3) The available data do not support a conclusion that MOBILE6.2 underestimates or overestimates fractions for MTBE, formaldehyde, acetaldehyde or acrolein.

There is a significant amount of scatter in the available test data, which makes it difficult to draw strong conclusions from the statistical comparisons. Also data are very limited for high emitters and off-cycle operation, which make a large contribution to total emissions. Nonetheless, at this point it appears that MOBILE6.2 toxic to VOC fractions for benzene, MTBE, formaldehyde, acetaldehyde, and acrolein are reasonably accurate for newer technology vehicles, but that fractions used for 1,3-butadiene are overestimating emissions for this pollutant.

The recent Energy Policy Act passed by Congress requires EPA to develop a new fuel effects model that reflects a 2007 fleet. The collection of a large amount of data and substantial analytical work is needed to meet this requirement, and to update the algorithms used in the current Complex Model and MOBILE6.2. As part of this ongoing effort, EPA is reviewing engine exhaust data, which includes air toxic emissions, from the CRC (Coordinating Research Council) E-67 study on engine emissions from light-duty vehicles using ethanol fuels.<sup>65</sup> Likewise, work is underway in a collaborative test program between EPA and members of the Alliance of Automobile Manufacturers to examine emissions of both regulated pollutants and air toxics from Tier 2 compliant vehicles. The current program focuses on changes in fuel sulfur, vapor pressure, and benzene levels, and will provide data for the air toxics rulemaking process as well as inform the design of a more comprehensive program covering a wider range of fuel properties and vehicle certification levels.

### **2.3.2 Heavy-Duty Vehicles (CRC E-55/E-59)**

The primary objective of the E-55/59 research program was to quantify gaseous and PM emissions from primarily in-use heavy-duty diesel trucks in California's South Coast Air Basin, in support of emissions inventory development.<sup>66</sup> A second program objective was to quantify the influence of tampering and mal-maintenance on emissions from these vehicles. The program was conducted in four Phases (denoted as 1, 1.5, 2 and 3). The Phase 1 test fleet consisted of 25 heavy heavy-duty diesel trucks (HHDDT), selected to match a distribution of model years (MY) and to reflect engines in common use in California. In Phase 1.5 an additional twelve HHDDT were studied, with a thirteenth truck tested at idle alone. The Phase 2 test fleet consisted of ten HHDDT and nine medium heavy-duty trucks (MHDT), which included seven diesel-fueled medium heavy-duty trucks (MHDDT) and two gasoline-fueled medium heavy-duty trucks (MHDGT). Phase 3 gathered data from nine HHDDT, eight MHDDT, and two MHDGT. The Phase 2 and 3 data added post-2002 MY HHDDT (at 2.5 g/bhp-hr NO<sub>x</sub> standard) to the program.

Sampling for chemical speciation was performed on thirteen HHDDT in Phase 1 and on five HHDDT and one MHDDT in Phase 2. However, only three of the thirteen Phase 1 trucks had their exhaust samples analyzed for air toxic emissions, and the remaining samples were being archived. Toxics species were measured from five

HHDDT and one MHDDT (medium HDDTs) in the Phase 2 test fleet. PM data were acquired in Phases 1.5, 2 and 3. Exhaust data were acquired for methane and VOC. Semi-volatile organic compounds and PM soluble fractions were captured and analyzed, along with carbonyls and nitrosamines. Ions and elemental/organic carbon (EC/OC) split were determined from quartz filters. The ion and metal analyses varied widely between trucks.

These data will be incorporated into EPA's MSAT inventories, and will help address limitations discussed in Sections 2.1.4 and 2.2.1.1.5.

### **2.3.3 Small Spark Ignition Engines**

The National Mobile Inventory Model (NMIM) calculates air toxic emissions for small Spark Ignition (SI) engines by multiplying compound-specific fractions with volatile organic carbon (VOC) or particulate matter (PM) emission outputs from EPA's NONROAD model. These fractions were used in the 1999 National Air Toxics Assessment (NATA). These data were all obtained from a small number of uncontrolled engines.<sup>67,68,69,70,71</sup> In fiscal year 2004 EPA tested a mixture of in-use and new pre-control and Phase 1 small hand held SI trimmers, chain saws and a leaf blower.<sup>72</sup> In the same time period EPA performed engine tests on Phase I residential four-stroke lawn mowers. The emission data from both programs may impact future versions of NMIM and the inventories it calculates.

EPA tested four pre-control, nine Phase 1, two California-certified, and eight Phase 2 handheld engines. Five of the Phase 2 engines were new. All tests were fueled by either of two summer grades of gasoline. One was a gasoline ethanol blend meant to represent a reformulated gasoline and the other a conventional gasoline. All but one of the engines were two-cycle designs. However, the four-cycle engine was designed to operate on a typical two-cycle fuel lubricating oil mixture. All the test engines require that lubricating oil be mixed and consumed with the fuel. The program therefore used two different types of lubricating oil, one a mineral-based product and the other a "low smoke" synthetic. Both oils were commercially available. The testing was done over the Composite Two Mode (C2M) duty cycle. Table 2.3.-1 compares the emission factors used in NONROAD and the fractions used in NMIM with those based on the testing.

NONROAD and NMIM have not been adjusted to use the new data, but some increase in projected benzene inventories is likely once this occurs. In all but one engine and fuel combination the benzene/VOC fraction is greater than that currently used in NMIM. It is significant that two-cycle engines have a large proportion of their fuel being emitted in an unburned state. A reduction in fuel benzene content will have a significant effect on benzene emissions from them.

The other MSAT fractions are found in Table 2.3.-2. Some of the measured values are more consistent with NMIM values, but some are not (e.g., xylenes).

The second EPA test program involved six new Phase 2 four cycle lawn mower engines. These data are unpublished. The engines were tested after 20 hours of

operation. The testing was done using the certification test procedure on certification gasoline. Formaldehyde and acetaldehyde were the only MSATs measured in the test program. A comparison of NMIM fractions and measured fractions are in Table 2.3.-3.

The measured values are similar to the values used in NMIM. Incorporation of the new test data would not result in a dramatic change in inventories from these engines and use types.

**Table 2.3.-1. Comparison between NONROAD Outputs and NMIM MSAT Fractions and Averaged Test Data for PM, VOC and Benzene from EPA Testing of 18 Handheld SI Engines Aggregated by Use, Engine Class, Emission Standard (Phase), Catalyst, and Engine Cycle**

Type	Class	Condition	Phase	Catalyst Equipped	Engine Cycle	NONROAD PM10 EF (g/bhp)	Average Tested PM2.5 (g/bhp)	NONROAD HC EF (g/bhp)	Average Tested THC (g/bhp)	NMIM Benzene Fraction	Average Tested Benzene Fraction
BLOWER	V	New	2	YES	2	7.70	0.028	40.15	24.842	0.024	0.038
CHAIN SAW	IV	New	2	YES	2	7.70	0.228	26.87	30.254	0.080	0.022
CHAIN SAW	IV	Used	0	NO	2	9.24	3.072	313.20	185.976	0.080	0.016
CHAIN SAW	IV	Used	1	NO	2	9.93	2.051	231.84	110.567	0.080	0.014
CHAIN SAW	IV	Used	2	NO	2	9.93	1.483	42.66	98.066	0.080	0.014
CHAIN SAW	V	Used	1	NO	2	9.75	1.330	152.00	80.026	0.080	0.016
STRING TRIMMER	III	Used	0	NO	2	9.24	4.915	313.20	265.205	0.011	0.019
STRING TRIMMER	III	Used	1	NO	2	9.55	7.519	272.79	243.167	0.011	0.013
STRING TRIMMER	IV	New	2	YES	2	7.70	0.641	26.87	31.581	0.011	0.028
STRING TRIMMER	IV	New	2	NO	4	0.06	0.231	25.83	12.791	0.011	N.A.
STRING TRIMMER	IV	Used	0	NO	2	9.24	3.093	313.20	221.354	0.011	0.015
STRING TRIMMER	IV	Used	1	NO	2	9.93	3.856	231.84	154.140	0.011	0.017

**Table 2.3.-2. NMIM MSAT Fractions versus Fractions from EPA Testing of 18 Handheld SI Engines**

Type	Standard	Fuel	Formaldehyde		Acetaldehyde		Acrolein		Propionaldehyde		Toluene		2,2,4-Trimethylpentane		Xylene	
			NMIM	Tested	NMIM	Tested	NMIM	Tested	NMIM	Tested	NMIM	Tested	NMIM	Tested	NMIM	Tested
BLOWER	Ph2	CG									0.0978	0.0979	0.0372	0.0122	0.1075	0.0224
SAW		CG	0.0068	0.0050	0.0013	0.0011	0.0004	0.0003	0.0001	0.0002	0.0598	0.0998	0.0372	0.0490	0.0931	0.0166
SAW	Ph1	CG	0.0068	0.0042	0.0013	0.0009	0.0004	0.0003	0.0003	0.0002	0.0598	0.1064	0.0372	0.0487	0.0931	0.0151
SAW	Ph1	RFG	0.0068	0.0053	0.0013	0.0046	0.0004	0.0004	0.0004	0.0002	0.0598	0.1105	0.0372	0.0280	0.0931	0.0231
SAW	Ph2	CG	0.0068	0.0052	0.0013	0.0011	0.0004	0.0004	0.0004	0.0002	0.0598	0.1065	0.0372	0.0409	0.0931	0.0177
SAW	Ph2	RFG	0.0068	0.0056	0.0013	0.0055	0.0004	0.0004	0.0004	0.0002	0.0598	0.0955	0.0372	0.0252	0.0931	0.0228
TRIMMER		CG	0.0029	0.0072	0.0006	0.0016	0.0003	0.0006	0.0004	0.0002	0.0978	0.1049	0.0372	0.0437	0.1075	0.0174
TRIMMER		RFG	0.0029	0.0077	0.0006	0.0066	0.0003	0.0006	0.0004	0.0002	0.0890	0.0891	0.0372	0.0242	0.0978	0.0232
TRIMMER	Ph1	CG									0.0978	0.1093	0.0372	0.0432	0.1075	0.0204
TRIMMER	Ph1	CG	0.0029	0.0039	0.0006	0.0009	0.0003	0.0003	0.0003	0.0002	0.0978	0.1000	0.0372	0.0497	0.1075	0.0163
TRIMMER	Ph1	RFG									0.0890	0.1096	0.0372	0.0249	0.0978	0.0299
TRIMMER	Ph1	RFG	0.0029	0.0045	0.0006	0.0046	0.0003	0.0003	0.0004	0.0002	0.0890	0.0906	0.0372	0.0279	0.0978	0.0238
TRIMMER	Ph2	CG	0.0029	0.0050	0.0006	0.0010	0.0003	0.0003	0.0006	0.0002	0.0978	0.1303	0.0372	0.0559	0.1075	0.0205
TRIMMER	Ph2	RFG	0.0029	0.0080	0.0006	0.0073	0.0003	0.0005	0.0009	0.0002	0.0890	0.1014	0.0372	0.0326	0.0978	0.0235

**Table 2.3.-3. Comparison of NMIM Acetaldehyde and Formaldehyde to VOC fractions with Measured Fractions from OTAQ Test Program**

MSAT	NMIM Fraction	Average Measured Fraction
Acetaldehyde	0.00440	0.00396
Formaldehyde	0.01256	0.01541

### 2.3.4 Nonroad CI engines

The Agency conducted three separate emission test programs measuring exhaust emissions from fifteen nonroad diesel engines and in-use pieces of nonroad diesel equipment.<sup>73,74,75</sup> The engines tested derived from construction, utility and agricultural equipment applications for the most part and ranged from seven horsepower (hp) up through 850 hp (425 hp, as tested). The test fuels used varied by sulfur concentration from nonroad-grade diesel fuels at 2500 and 3300 ppm sulfur to a nominal “D-2” diesel at 350 ppm sulfur and, lastly, to an ultra-low sulfur diesel, measured at less than 10 ppm sulfur. Test engines were run over both steady-state and transient duty cycles. Several of the transient cycles were application-specific, having been based on rubber-tire loader or excavator operations, for example. Criteria pollutants in the exhaust emissions were quantified for each test engine as well as sulfate, ammonia, N<sub>2</sub>O and a range of C<sub>1</sub> - C<sub>12</sub> compounds (aldehydes, ketones, alcohols, etc.). Emissions of several additional air toxic compounds were identified in two of the three programs. These emission species included benzene, toluene, ethylbenzene, xylenes, polyaromatic hydrocarbons (PAH), nitrated-PAHs and several metals. Emission results were summarized in both grams/hour and grams/brake-horsepower/hour.

With this new emission data, the Agency has begun an effort to update the toxics

portion of its NMIM model. EPA will also address differences between Tier 1 and unregulated NR diesel emissions, the impact of diesel fuel sulfur level on engine emissions, whether any adjustments to default modeling TAFs (transient adjustment factors) used in the NONROAD emissions model are warranted by the new data and the necessity for creating category- and power-specific TAFs for NONROAD.

## **2.4 Description of Current Mobile Source Emissions Control Programs that Reduce MSATs**

As described above, existing mobile source control programs will reduce MSAT emissions (not including diesel PM) by 60% between 1999 and 2020. Diesel PM from mobile sources will be reduced by 75% between 2001 and 2030. The mobile source programs include controls on fuels, highway vehicles, and nonroad equipment. These programs are also reducing hydrocarbons and PM more generally, as well as oxides of nitrogen. The sections immediately below provide general descriptions of these programs, as well as voluntary programs to reduce mobile source emissions, such as the National Clean Diesel Campaign and Best Workplaces for Commuters.<sup>SM</sup>

### **2.4.1 Fuels Programs**

Several federal fuel programs reduce MSAT emissions. Some of these programs directly control air toxics, such as the reformulated gasoline (RFG) program's benzene content limit and required reduction in total toxics emissions, and the anti-backsliding requirements of the anti-dumping and current MSAT programs, which require that gasoline cannot get dirtier with respect to toxics emissions. Others, such as the gasoline sulfur program, control toxics indirectly by reducing hydrocarbon and related toxics emissions. Some fuel programs will have a mixed impact on the species and quantity of MSAT emissions expected with the introduction of these new fuels into commerce.

#### **2.4.1.1 RFG**

The RFG program contains two direct toxics control requirements. The first is a fuel benzene standard, requiring RFG to average no greater than 0.95 volume percent benzene annually (on a refinery or importer basis). The RFG benzene requirement includes a per-gallon cap on fuel benzene level of 1.3 volume percent. In 1990, when the Clean Air Act was amended to require reformulated gasoline, fuel benzene averaged 1.60 volume percent. For a variety of reasons, including other regulations, chemical product prices and refining efficiencies, most refiners and importers have achieved significantly greater reductions in benzene than required by the program. In 2003, RFG benzene content averaged 0.62 percent. The RFG benzene requirement includes a per-gallon cap on fuel benzene level of 1.3 volume percent.

The second RFG toxics control requires that RFG achieve a specific level of toxics emissions reduction. The requirement has increased in stringency since the RFG program began in 1995, when the requirement was that RFG annually achieve a 16.5% reduction in total (exhaust plus evaporative) air toxics emissions. Currently, a 21.5%

reduction is required. These reductions are determined using the Complex Model. As mentioned above, for a variety of reasons most regulated parties have overcomplied with the required toxics emissions reductions. During the 1998-2000 timeframe, RFG achieved, on average, a 27.5% reduction in toxics emissions.

#### **2.4.1.2 Anti-dumping**

The anti-dumping regulations were intended to prevent the dumping of “dirty” gasoline components, which were removed to produce RFG, into conventional gasoline (CG). Since the dumping of “dirty” gasoline components, for example, benzene or benzene-containing blending streams, would show up as increases in toxics emissions, the anti-dumping regulations require that a refiner’s or importer’s CG be no more polluting with respect to toxics emissions than the refiner’s or importer’s 1990 gasoline. The anti-dumping program considers only exhaust toxics emissions and does not include evaporative emissions.<sup>C</sup> Refiners and importers have either a unique individual anti-dumping baseline or they have the statutory anti-dumping baseline if they did not fulfill the minimum requirements for developing a unique individual baseline. In 1990, average exhaust toxics emissions (as estimated by EPA’s Complex Model) were 104.5 mg/mile<sup>D</sup>; in 2004, CG exhaust toxics emissions averaged 90.7 mg/mile. Although CG has no benzene limit, benzene levels have declined significantly from the 1990 level of 1.6 volume percent to 1.1 volume percent for CG in 2004.

#### **2.4.1.3 2001 Mobile Source Air Toxics Rule (MSAT1)**

As discussed above, both RFG and CG have, on average, exceeded their respective toxics control requirements. In 2001, EPA issued a mobile source air toxics rule (MSAT1, for the purposes of this second proposal), as discussed in section I.D. The intent of MSAT1 is to prevent refiners and importers from backsliding from the toxics performance that was being achieved by RFG and CG. In order to lock in superior levels of control, the rule requires that the annual average toxics performance of gasoline must be at least as clean as the average performance of the gasoline produced or imported during the three-year period 1998-2000. The period 1998-2000 is called the baseline period. Toxics performance is determined separately for RFG and CG, in the same manner as the toxics determinations required by the RFG<sup>76</sup> and anti-dumping rules.

Like the anti-dumping provisions, MSAT1 utilizes an individual baseline against which compliance is determined. The average 1998-2000 toxics performance level, or baseline, is determined separately for each refinery and importer.<sup>E</sup> To establish a unique individual MSAT1 baseline, EPA requires each refiner and importer to submit documentation supporting the determination of the baseline. Most refiners and many

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<sup>C</sup>See RFG rule for why evaporative emissions are not included in the anti-dumping toxics determination.

<sup>D</sup>Phase II

<sup>E</sup>Except for those who comply with the anti-dumping requirements for conventional gasoline on an aggregate basis, in which case the MSAT1 requirements for conventional gasoline must be met on the same aggregate basis (40 CFR Part 80, Subpart E).



importers in business during the baseline period had sufficient data to establish an individual baseline. An MSAT1 baseline volume is associated with each unique individual baseline value. The MSAT1 baseline volume reflects the average annual volume of such gasoline produced or imported during the baseline period. Refiners and importers who did not have sufficient refinery production or imports during 1998-2000 to establish a unique individual MSAT1 baseline must use the default baseline provided in the rule.

The MSAT1 program began with the annual averaging period beginning January 1, 2002. Since then, the toxics performance for RFG has improved from a baseline period average of 27.5% reduction to 29.5% reduction in 2003. Likewise, CG toxics emissions have decreased from an average of 95 mg/mile during 1998-2000 to 90.7 mg/mile in 2003.

#### **2.4.1.4 Gasoline Sulfur**

Beginning in 2006, EPA's gasoline sulfur program<sup>77</sup> requires that sulfur levels in gasoline can be no higher than 80 ppm as a per gallon cap and must average 30 ppm annually. When the program is fully effective, gasoline will have 90 percent less sulfur than before the program. Reduced sulfur levels are necessary to ensure that vehicle emission control systems are not impaired. These systems effectively reduce non-methane organic gas (NMOG) emissions, of which some are air toxics as well as emissions of NO<sub>x</sub>. With lower sulfur levels, emission control technologies can work longer and more efficiently. Both new and older vehicles benefit from reduced gasoline sulfur levels.

#### **2.4.1.5 Gasoline Volatility**

A fuel's volatility defines its evaporation characteristics. A gasoline's volatility is commonly referred to as its Reid vapor pressure, or RVP. Gasoline summertime RVP ranges from about 6 to 9 psi and wintertime RVP, when additional volatility is required for starting in cold temperatures, ranges from about 9 to 14 psi. Gasoline vapors contain a subset of the liquid gasoline components and thus can contain toxics compounds, such as benzene. Since 1989, EPA has controlled summertime gasoline RVP primarily as a VOC and ozone precursor control, resulting in additional toxics pollutant reductions.

#### **2.4.1.6 Diesel Fuel**

In early 2001, EPA issued rules requiring that diesel fuel for use in highway vehicles contain no more than 15 ppm sulfur beginning June 1, 2006.<sup>78</sup> This program contains averaging, banking and trading provisions during the transition to the 15 ppm level, as well as other compliance flexibilities. In June 2004, EPA issued rules governing the sulfur content of diesel fuel used in nonroad diesel engines.<sup>79</sup> In the nonroad rule, sulfur levels are limited to a maximum of 500 ppm sulfur beginning in 2007 (current levels are approximately 3000 ppm). In 2010, nonroad diesel sulfur levels must not exceed 15 ppm.

EPA's diesel fuel requirements are part of a comprehensive program to combine engine and fuel controls to achieve the greatest emission reductions. The diesel fuel provisions will enable the use of advanced emission-control technologies on diesel vehicles and engines. The diesel fuel requirements will also provide immediate public health benefits by reducing PM emissions from current diesel vehicles and engines.

#### **2.4.1.7 Phase-Out of Lead in Gasoline**

One of the first programs to control toxic emissions from motor vehicles was the removal of lead from gasoline. Beginning in the mid-1970s, unleaded gasoline was phased in to replace leaded gasoline. The phase-out of leaded gasoline was completed January 1, 1996, when lead was banned from motor vehicle gasoline.

#### **2.4.2 Highway Vehicle and Engine Programs**

The 1990 Clean Air Act Amendments set specific emission standards for hydrocarbons and for PM. Air toxics are present in both of these pollutant categories. As vehicle manufacturers develop technologies to comply with the hydrocarbon (HC) and particulate standards (e.g., more efficient catalytic converters), air toxics are reduced as well. Since 1990, we have developed a number of programs to address exhaust and evaporative hydrocarbon emissions and PM emissions. Table 2.4-1 shows current mobile source programs for highway vehicles.

Two of our recent initiatives to control emissions from motor vehicles and their fuels are the Tier 2 control program for light-duty vehicles and the 2007 heavy-duty engine rule. Together these two initiatives define a set of comprehensive standards for light-duty and heavy-duty motor vehicles and their fuels. In both of these initiatives, we treat vehicles and fuels as a system. The Tier 2 control program establishes stringent tailpipe and evaporative emission standards for light-duty vehicles and a reduction in sulfur levels in gasoline fuel beginning in 2004.<sup>80</sup> The 2007 heavy-duty engine rule establishes stringent exhaust emission standards for new heavy-duty engines and vehicles for the 2007 model year as well as reductions in diesel fuel sulfur levels starting in 2006.<sup>81</sup> Both of these programs will provide substantial emissions reductions through the application of advanced technologies. We expect 90% reductions in PM from new diesel engines compared to engines under current standards.

Some of the key earlier programs controlling highway vehicle and engine emissions are the Tier 1 and NLEV standards for light-duty vehicles and trucks; enhanced evaporative emissions standards; the supplemental federal test procedures (SFTP); urban bus standards; and heavy-duty diesel and gasoline standards for the 2004/2005 time frame.

**Table 2.4-1. Current On-Highway Engine and Vehicle Programs Providing Significant Additional MSAT Reductions.**

Category	Rule & FRM Date	Implementation Schedule	VOC Standards*	PM Standards
Light-duty cars and trucks	Tier 2 (including low sulfur fuel and enhanced evaporative emissions regulations) February 10, 2000	2004 - 2009	X	X
	NLEV (National Low-Emitting Vehicle)	1999 - 2003	X	X
	SFTP (Supplemental FTP) Procedures	2001 (start)	X	
Heavy-duty trucks	2004 Heavy-duty Rule October 6, 2000	2004 - 2007	X	X
	2007 Heavy-duty Rule (including low sulfur fuel) January 18, 2001	2007 - 2010	X	X
Urban Buses	HD Diesel Retrofit	1994 - 1998		X
Highway motorcycles	December 2003	2006 - 2010	X	

\* Standards in various forms including HC, NMHC, NMOG, and NO<sub>x</sub>+NMHC

**Table 2.4-2 Current Nonroad Engine/Vehicle Programs.**

Category	Rule & FRM Date	Implementation Schedule	VOC Standards*	PM Standards
Land-based diesel	Tier 2, October 23, 1998	2001-2006	x	x
	Tier 3, October 23, 1998	2006-2008	x	x
	Tier 4 (w/ low sulfur fuel) June 29, 2004	2008-2014	x	x
Locomotives	Tier 0, Tier 1, Tier 2 April 16, 1998	2002 – 2005	x	x
Marine	Spark-ignition Gasoline Engine Standards, October 4, 1996	1998 - 2006	x	
	Diesel Engines, less than 50hp	1999 - 2005		x
	Recreational Diesel, November 8, 2002	Starting 2006/2009	x	x
	Commercial Diesel, February 28, 2003	Starting 2004/2007	x	x
Large spark- ignition engines	Tier 1 Standards Tier 2 Standards November 8, 2002	2004 - 2006 2007, and later	x	
	Phase 1 Standards,	1997 - 2007	x	
Small spark- ignition engines	Handheld Phase 2 Standards, April 25, 2000	2002 - 2007	x	
	Non-handheld Phase 2 Standards, March 30, 1999	2001 - 2007		
Aircraft (NO <sub>x</sub> Std in 2005; Smoke Std in 1982)		No current/recent standards for VOC or PM		
Recreational vehicles	November 8, 2002	2006 - 2012	x	

\* Standards in various forms including HC, NMHC, NMOG, and NO<sub>x</sub>+NMHC

### 2.4.3 Nonroad Engine Programs

There are various categories of nonroad engines, including land-based diesel engines (e.g., farm and construction equipment), small land-based spark-ignition (SI) engines (e.g., lawn and garden equipment, string trimmers), large land-based SI engines (e.g., forklifts, airport ground service equipment), marine engines (including diesel and SI, propulsion and auxiliary, commercial and recreational), locomotives, aircraft, and recreational vehicles (off-road motorcycles, “all terrain” vehicles and snowmobiles). Table 2.4-2 shows current mobile source programs for nonroad engines. Brief summaries

of our current and anticipated programs for these nonroad categories follow. As with highway vehicles, the VOC standards we have established for nonroad engines will also significantly reduce VOC-based toxics from nonroad engines. In addition, the standards for diesel engines (in combination with the stringent sulfur controls on nonroad diesel fuel) will significantly reduce diesel PM and exhaust organic gases, which are mobile source air toxics.

In addition to the engine-based emission control programs described below, fuel controls will also reduce emissions of air toxics from nonroad engines. For example, restrictions on gasoline formulation (the removal of lead, limits on gasoline volatility and RFG) are projected to reduce nonroad MSAT emissions because most gasoline-fueled nonroad vehicles are fueled with the same gasoline used in on-highway vehicles. An exception to this is lead in aviation gasoline. Aviation gasoline, used in general (as opposed to commercial) aviation, is a high octane fuel used in a relatively small number of aircraft (those with piston engines). Such aircraft are generally used for personal transportation, sightseeing, crop dusting and similar activities.

#### **2.4.3.1 Land-based Diesel Engines**

We recently finalized stringent new emissions standards for land-based nonroad diesel engines, used in agricultural and construction equipment as well as many other applications (although the standards do not apply to locomotive engines, mining equipment or marine engines).<sup>82</sup> These standards are similar in stringency to the 2007 highway diesel engine standards, and are likewise enabled by stringent controls on sulfur levels in diesel fuel, as explained earlier in section 2.4.1.6. The new engine standards, starting in 2008, will reduce PM from new 2008 nonroad diesel engines by about 95 percent compared to engines under today's standards. The fuel controls are scheduled to begin in mid-2007.

#### **2.4.3.2 Land-Based SI Engines**

The category of land-based nonroad SI engines is comprised of a broad mix of service and recreational equipment with engines which range from less than 10 horsepower to several hundreds of horsepower. Most of these engines have been subject to one or more tiers of engine emission controls for some time, while others in the category, such as recreational vehicles, are just coming under engine emission control regulations in 2006.

##### **2.4.3.2.1 Large Land-Based SI Engines**

Since the MSAT1 rule was published, we have also finalized emissions standards for SI engines above 25 hp used in commercial applications.<sup>83</sup> Such engines are used in a variety of industrial equipment such as forklifts, airport ground service equipment, generators and compressors. The Tier 1 standards went into effect in 2004 and the Tier 2 standards will start in 2007, providing additional emissions reductions. These standards

will provide about a 90 percent reduction in HC emissions on average for new engines versus Tier 1 controlled engines.

#### 2.4.3.2.2 Recreational Vehicles

In 2006, new recreational vehicles, which include snowmobiles, off-road motorcycles and “all terrain vehicles”, began a first tier of engine emission standards. These standards require significant reductions in HC emissions from new engines, ranging from 50 to 86 percent compared to pre-controlled engines.<sup>84</sup>

#### 2.4.3.2.3 Small Land-Based SI Engines

Small land-based spark-ignition (small SI) engines at or below 25 hp may be either handheld or non-handheld and are used primarily in lawn and garden equipment such as walk-behind and tractor mowers, string trimmers, chain saws and other similar equipment. Our Phase 1 exhaust emission controls for this category of engines took effect beginning in 1997 and are projected to result in a roughly 32 percent reduction in VOC emissions for new engines, on average, versus pre-controlled engines.<sup>85</sup> We also have Phase 2 regulations for these engines which, when fully phased-in, are projected to result in additional combined HC and NO<sub>x</sub> exhaust emission reductions beyond the Phase 1 levels of 60 percent for new non-handheld engines and of 70 percent for new handheld engines.<sup>86</sup> We are currently developing a proposal for new combined HC and NO<sub>x</sub> exhaust standards for Phase 3 non-handheld small SI engines that should be approximately 35 to 40 percent lower than present Phase 2 standards for this class of engine. Further, we also expect to propose new evaporative emission standards for small SI engines and equipment to control fuel hose permeation, fuel tank permeation, diurnal and running loss emissions.

Phase 3 standards for Small SI engines are expected to achieve toxics benefits through reduction of engine VOC emissions from three sources. The new standards would result in fewer evaporative VOC and, therefore, air toxics emissions by lowering hose and tank permeation losses for these types of equipment. Phase 3 engines will also have lower exhaust VOC emissions under these new standards. Finally, Phase 3 Small SI engines are expected to achieve a small fuel economy benefit during operation. While small, VOC emission savings from increased fuel economy will feed back through a reduced number of gallons of fuel kept onboard these engines during operation. This will result in less VOC from tank/hose permeation, and less fuel burned overall will mean fewer exhaust emissions

#### 2.4.3.3 Marine Engines

Marine engines cover a very wide range of products, from 10-horsepower outboard engines to 100,000-horsepower engines on oceangoing vessels. We have active emission-control programs to address the need for emission controls for every kind of marine engine.

#### 2.4.3.3.1 Marine SI Engines

For gasoline-fueled outboard and personal-watercraft engines, we adopted an initial phase of exhaust standards which became fully implemented with the 2006 model year. These standards have led to a major technology shift in this category of engines to four-stroke engines and advanced-technology two-stroke engines, for an estimated 75 percent reduction in HC emissions from uncontrolled levels.<sup>87</sup> We are developing a proposal to adopt new, more stringent exhaust standards for these engines that would further reduce emissions from this class of engines by an additional 60 percent or more from the initial phase of standards .

Another class of marine SI engine, referred to as stern drive and inboard engines, uses automotive-type engines. These engines have uncontrolled emission rates that are well below the current standards that apply to outboard and personal-watercraft engines. These engines are not currently subject to emission standards, but we intend to include new emission standards for these engines in an upcoming marine SI engine proposal.<sup>88</sup> These new standards would likely be based on the application of catalyst technology to substantially reduce HC and NOx emissions from the operation of these engines.

The proposals mentioned above will also cover fuel evaporative emission standards for fuel lines, fuel tanks and diurnal venting emissions for vessels powered by gasoline-fueled engines in both of these engine classes.

#### 2.4.3.3.2 Marine Diesel Engines

We have adopted emission standards for marine diesel engines in four separate rulemakings. All of these standards are based on in-engine controls and do not require aftertreatment. First, we adopted two tiers of standards for marine engines below 50 horsepower that apply equally to land-based and marine engines. These standards were phased in from 1999 to 2005. Second, we adopted emission standards for commercial marine diesel engines with per-cylinder engine displacement up to 30 liters. These standards are comparable to the standards for land-based nonroad diesel engines that apply in the same time frame, with several adjustments to test procedures and compliance provisions appropriate for marine engines.<sup>89</sup> The emission standards generally apply in 2007 for locomotive-size engines and in 2004 for smaller engines. Third, the emission standards adopted for recreational marine diesel engines are very similar to the comparable commercial engines, with implementation scheduled two years after the commercial standards take effect. All the emission standards in these three rulemakings targeted reductions in NOx and PM emissions. Finally, we adopted standards to control NOx emissions at levels consistent with the requirements from the International Maritime Organization (IMO), but we adopted these as EPA standards under the Clean Air Act to make them mandatory for all engines with per-cylinder displacement above 2.5 liters installed on U.S.-flag vessels starting in the 2004 model year. We are in the process of reviewing the emission standards for all sizes of marine diesel engines and expect to propose new requirements in the near future.

EPA is also investigating the possibility of designating U.S. coastal areas as SO<sub>x</sub> (oxides of sulfur) Emission Control Areas (SECAs) under the IMO. Such a designation would trigger a requirement for any vessel entering such an area to use reduced-sulfur fuel or operate exhaust scrubbers to prevent SO<sub>x</sub> emissions.

#### **2.4.3.4 Locomotives**

Our regulations for locomotive engines consist of three tiers of standards, applicable depending on the date a locomotive or a particular engine was originally manufactured.<sup>90</sup> The first set of standards (Tier 0) applies to locomotives and their locomotive engines originally manufactured from 1973 through 2001, starting from the time the engine was manufactured or later at “remanufacture.”<sup>F</sup> The second set of standards (Tier 1) applies to locomotives and their engines manufactured from 2002 through 2004 and again at engine manufacture or rebuild. The third set of standards (Tier 2) applies to locomotive engines manufactured in 2005 and later. The Tier 0 and Tier 1 regulations were primarily intended to reduce NO<sub>x</sub> emissions. The Tier 2 regulations are projected to result in 50 percent reductions in VOC and diesel PM as compared to unregulated engine emission levels, as well as additional NO<sub>x</sub> reductions beyond the Tier 0 and Tier 1 regulations. We are currently developing a new tier of more stringent emissions standards for locomotive engines.

#### **2.4.3.5 Aircraft**

A variety of emission regulations have been applied to commercial gas turbine aircraft engines, beginning with limits on smoke and fuel venting in 1974. In 1984, limits were placed on the amount of unburned HC that gas turbine engines can emit per landing and takeoff cycle. In 1997, we adopted standards that were equivalent to the existing International Civil Aviation Organization (ICAO) NO<sub>x</sub> and CO emission standards for gas turbine engines. In 2005, we tightened the NO<sub>x</sub> emission standards to levels that are equivalent to the ICAO standards that became effective in 2004. These actions have resulted in minimal emissions reductions, and have largely served to prevent increases in aircraft emissions. We continue to explore ways to reduce emissions from aircraft throughout the nation.

#### **2.4.4 Voluntary Programs**

In addition to the fuel and engine control programs described above, we are actively promoting several voluntary programs to reduce emissions from mobile sources, such as the National Clean Diesel Campaign, anti-idling measures, and Best Workplaces for Commuters. While the stringent emissions standards described above apply to new highway and nonroad diesel engines, it is also important to reduce emissions from the existing fleet of about 11 million diesel engines. EPA has launched a comprehensive initiative called the National Clean Diesel Campaign, one component of which is to promote the reduction of emissions in the existing fleet of engines through a variety of

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<sup>F</sup> To “remanufacture” an engine is to rebuild that engine to “new condition” at the end of four-to-eight year long maintenance cycles.



cost-effective and innovative strategies. The goal of the Campaign is to reduce emissions from the 11 million existing engines by 2014. Emission reduction strategies include switching to cleaner fuels, retrofitting engines through the addition of emission control devices and engine replacement. For example, installing a diesel particulate filter achieves diesel particulate matter reductions of approximately 90 percent (when combined with the use of ultra low sulfur diesel fuel). The Energy Policy Act of 2005 includes grant authorizations and other incentives to help facilitate voluntary clean diesel actions nationwide.

The National Clean Diesel Campaign is focused on leveraging local, state, and federal resources to retrofit or replace diesel engines, adopt best practices and track and report results. The Campaign targets five key sectors: school buses, ports, construction, freight and agriculture. Almost 300 clean diesel projects have been initiated through the Campaign. These projects will reduce more than 20,000 PM lifetime tons. PM and NO<sub>x</sub> reductions from these programs will provide nearly \$5 billion in health benefits.

Reducing vehicle idling provides important environmental benefits. As a part of their daily routine, truck drivers often keep their vehicles running at idle during stops to provide power, heat and air conditioning. EPA's SmartWay Transport Partnership is helping the freight industry to adopt innovative idle reduction technologies and to take advantage of proven systems that provide drivers with basic necessities without idling the main engine. To date, there are 80 mobile and stationary idle-reduction projects throughout the country. Emission reductions, on an annual basis, from these programs are in excess of 157,000 tons of CO<sub>2</sub>, 2,000 tons of NO<sub>x</sub> and 60 tons of PM; over 14 million gallons of fuel are being saved annually. The SmartWay Transport Partnership also works with the freight industry by promoting a wide range of new technologies such as advanced aerodynamics, single-wide tires, weight reduction, speed control and intermodal shipping.

Daily commuting represents another significant source of emissions from motor vehicles. EPA's Best Workplaces for Commuters<sup>SM</sup> program is working with employers across the country to reverse the trend of longer, single-occupancy vehicle commuting. OTAQ recognizes employers that have met the *National Standard of Excellence for Commuter Benefits* by adding them to the List of Best Workplaces for Commuters<sup>SM</sup>. These companies offer superior commuter benefits such as transit subsidies for rail, bus, and vanpools and promote flexi-place and telework. Emergency Ride Home programs provide a safety net for participants. More than 1,600 employers representing 3.5 million U.S. workers have been designated Best Workplaces for Commuters<sup>SM</sup>.

Much of the growth in the Best Workplaces for Commuters<sup>SM</sup> program has been through metro area-wide campaigns. Since 2002, EPA has worked with coalitions in over 14 major metropolitan areas to increase the penetration of commuter benefits in the marketplace and the visibility of the companies that have received this distinguished designation. Another significant path by which the program has grown is through Commuter Districts including corporate and industrial business parks, shopping malls, business improvement districts and downtown commercial areas. To date EPA has

granted the Best Workplaces for Commuters<sup>SM</sup> “District” designation to over twenty locations across the country including sites in downtown Denver, Houston, Minneapolis, Tampa, and Boulder.

## References for Chapter 2

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- <sup>1</sup> Federal Register. Regulation of Fuels and Fuel Additives: Renewable Fuel Standard Program; Proposed Rule, 70(184): Page 55551-55600, September 22, 2006.
- <sup>2</sup> Renewable Fuel Standard Program, Draft Regulatory Impact Analysis, EPA420-D-06-008, September 2006. <http://www.epa.gov/otaq/renewablefuels/index.htm>.
- <sup>3</sup> <http://www.epa.gov/otaq/nonrdmdl.htm#model>
- <sup>4</sup> <http://www.epa.gov/otaq/models/mobile6/m6tech.htm>
- <sup>5</sup> Mullen, M., Neumann, J. Technical Memorandum: Documentation of 2003 VMT Projection Methodology, Prepared by E. H. Pechan and Associates and Industrial Economics, Inc. for James DeMocker, Office of Air and Radiation, Office of Policy Analysis and Review, U. S. EPA, Contract No. 68-W-02-048, WA B-41, March 2004. Included as Appendix G: Clean Air Interstate Rule: Emission Inventory Technical Support Document. <http://www.epa.gov/cair/technical.html>. This document is available in Docket EPA-HQ-OAR-2003-0053.
- <sup>6</sup> “VOC/PM Cold Temperature Characterization and Interior Climate Control Emission/Fuel Economy Impact”, Alan P. Stanard , Southwest Research Institute Project No. 03.11382.01, October 2005
- <sup>7</sup> Brzezinski, D.; Fernandez; A. (2005) Cold Temperature Effects on Vehicle HC Emissions. U. S. EPA, Assessment and Standards Division, National Vehicle and Fuel Emissions Laboratory, Ann Arbor, MI, Report No. EPA420-D-06-001.
- <sup>8</sup> <http://www.epa.gov/otaq/models/mobile6/m6tech.htm>
- <sup>9</sup> Landman, L. C. (2007) Estimating Emissions Associated with Portable Fuel Containers (PFCs). U. S. EPA, Assessment and Standards Division, National Vehicle and Fuel Emissions Laboratory, Ann Arbor, MI, Report No. EPA420-R-07-001. This document is available in Docket EPA-HQ-OAR-2003-0053.
- <sup>10</sup> Watson, J., Fujita, E., Chow, J., Zielinska, B., Richards, L., Neff, W., Dietrich, D. Northern Front Range Air Quality Study Final Report: Volume 1. June 30, 1998. Colorado State University. This document is available in the EPA Docket as EPA-HQ-OAR-2005-0036-1179.
- <sup>11</sup> Stanard, A.P. (2005) VOC/PM cold temperature characterization and interior climate control emissions/fuel economy impact. Draft final report volume I. EPA contract 68-C-06-018. Work assignment No. 0-4. Southwest Research Institute project No. 03.11382.04.

<sup>12</sup> Bailey, C.R. (2005) Cold-temperature exhaust particulate matter emissions. Memorandum to Docket EPA-HQ-OAR-2005-0036.

<sup>13</sup> Energy Information Agency, Annual Energy Outlook 2006, Table 17.  
<http://www.eia.doe.gov/oiaf/forecasting.html>

<sup>14</sup> Pollack, A. K.; Lindhjem, C.; Stoeckenius, T. E.; Tran, C.; Mansell, G.; Jiminez, M.; Wilson, G.; Coulter-Burke, S. 2004. CRC Project E-64: Evaluation of the U. S. EPA MOBILE6 Highway Vehicle Emission Factor Model. Prepared by Environ Corp. for Coordinating Research Council and U. S. EPA. March, 2004.  
<http://www.epa.gov/otaq/m6.htm#m60>

<sup>15</sup> National Research Council. 2000. Modeling Mobile Source Emissions. National Academy Press; Washington, D.C. <http://www.nap.edu/books/0309070880/html/>

<sup>16</sup> National Research Council. 2000. Modeling Mobile Source Emissions. National Academy Press; Washington, D.C. <http://www.nap.edu/books/0309070880/html/>.

<sup>17</sup> Strum, M., Cook, R., Pope, A., Palma, T., Shedd, S., Mason, R., Michaels, H., Thurman, J., Ensley, D. 2006. Projection of Hazardous Air Pollutant Emissions to Future Years. *Science of the Total Environment*, 366: 590-601.

<sup>18</sup> Michaels, H., Brzezinski, D., Cook, R.. EPA's National Mobile Inventory Model (NMIM), A Consolidated Emissions Modeling System for MOBILE6 and NONROAD. U. S. Environmental Protection Agency, Office of Transportation and Air Quality, Assessment and Standards Division, Ann Arbor, MI, March 2005; Report No. EPA-420-R-05-003. <http://www.epa.gov/otaq/nmim.htm>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>19</sup> Cook, R., Glover, E., Michaels, H., Brzezinski, D. 2004. Modeling of Mobile Source Air Toxic Emissions Using EPA's National Mobile Inventory Model. Proceedings, 2004 Emission Inventory Conference, Clearwater Beach, FL.  
<http://www.epa.gov/ttn/chief/conference/ei13/index.html>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>20</sup> U. S. EPA. NMIM2005. <http://www.epa.gov/otaq/nmim.htm>

<sup>21</sup> Stump, F., Tejada, S., Ray, W., Dropkin, D., Black, F., Snow, R., Crews, W., Siudak, P., Davis, C., Baker L., Perry, N. 1989. The Influence of Ambient Temperature on Tailpipe Emissions from 1984 to 1987 Model Year Light-Duty Gasoline Vehicles. *Atmospheric Environment* 23: 307-320.

<sup>22</sup> Stump, F., Tejada, S., Ray, W., Dropkin, D., Black, F., Snow, R., Crews, W., Siudak, P., Davis C., Carter, P. 1990. The Influence of Ambient Temperature on Tailpipe

Emissions from 1985-1987 Model Year Light-Duty Gasoline Vehicles -- II. Atmospheric Environment 24A: 2105-2112.

<sup>23</sup> Stump, F., Tejada, S., Dropkin, D. Loomis, C. Unpublished. Characterization of Emissions from Malfunctioning Vehicles Fueled with Oxygenated Gasoline-MTBE Fuel – Part I. U. S. EPA, National Exposure Research Laboratory, Office of Research and Development. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>24</sup> Stump, F., Tejada, S., Dropkin, D. Loomis, C., Park, C. Unpublished. Characterization of Emissions from Malfunctioning Vehicles Fueled with Oxygenated Gasoline-Ethanol (E10) Fuel – Part II. U. S. EPA, National Exposure Research Laboratory, Office of Research and Development. Unpublished. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>25</sup> Stump, F., Tejada, S., Dropkin, D. Loomis, C., Park, C. Unpublished. Characterization of Emissions from Malfunctioning Vehicles Fueled with Oxygenated Gasoline-Ethanol (E10) Fuel – Part III. U. S. EPA, National Exposure Research Laboratory, Office of Research and Development. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>26</sup> Stanard, Alan P. 2005. VOC/PM Cold Temperature Characterization and Interior Climate Control Emissions/Fuel Economy Impact. Prepared for U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI, by Southwest Research Institute. Southwest Research Project No. 03.11382.04. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>27</sup> U. S. EPA. 2004. 1999 National Emissions Inventory, Final Version 3. <http://www.epa.gov/ttn/chief/net/1999inventory.html>.

<sup>28</sup> MathPro. 1998. Costs of Alternative Sulfur Content Standards for Gasoline in PADD IV. Final Report. Prepared for the National Petrochemical and Refiners Association. December 30. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>29</sup> Mathpro, 1999. Costs of meeting 40 ppm Sulfur Content Standard for Gasoline in PADDs 1-3, Via MOBIL and CD Tech Desulfurization Processes. Final Report. Prepared for the American Petroleum Institute. February 26. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>30</sup> MathPro. 1999. Analysis of California Phase 3 RFG Standards. Prepared for the California Energy Commission. December 7. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>31</sup> Mullen, M., Neumann, J. Technical Memorandum: Documentation of 2003 VMT Projection Methodology, Prepared by E. H. Pechan and Associates and Industrial

Economics, Inc. for James DeMocker, Office of Air and Radiation, Office of Policy Analysis and Review, U. S. EPA, Contract No. 68-W-02-048, WA B-41, March 2004. Included as Appendix G: Clean Air Interstate Rule: Emission Inventory Technical Support Document. <http://www.epa.gov/cair/technical.html>. This document is available in Docket EPA-HQ-OAR-2003-0053.

<sup>32</sup> Wyborny, Lester; Memorandum to the Docket; Effect of Benzene Control on Gasoline Quality, February 22, 2006.

<sup>33</sup> Fritz, S. 2000. Diesel Fuel Effects on Locomotive Exhaust Emissions. Prepared by Southwest Research for the California Air Resources Board. This document is available in Docket EPA-HQ-OAR-2003-0053.

<sup>34</sup> Eastern Research Group and E. H. Pechan and Associates. 2005. Documentation for Aircraft, Commercial Marine Vessels, Locomotive and Other Nonroad Components of the National Emissions Inventory. Prepared for U. S. EPA, Office of Air Quality Planning and Standards. <http://www.epa.gov/ttn/chief/net/1999inventory.html>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>35</sup> Federal Aviation Administration, 2004. Terminal Area Forecast System. <http://www.apo.data.faa.gov/main/taf.asp>.

<sup>36</sup> Hester, Charles. 2006. Review of Data on HAP Content in Gasoline. Memorandum from MACTEC to Steve Shedd, U. S. EPA, March 23, 2006. This document is available in Docket EPA-HQ-OAR-2003-0053.

<sup>37</sup> Haskew, H. M.; Liberty, T. F.; McClement, D. 2004. Fuel Permeation from Automotive Systems. Prepared for the Coordinating Research Council by Harold Haskew and Associates and Automotive Testing Laboratories, Inc. September 2004. CRC Project No. E-65. <http://www.crao.com>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>38</sup> Hester, Charles. 2006. Review of Data on HAP Content in Gasoline. Memorandum from MACTEC to Steve Shedd, U. S. EPA, March 23, 2006. This document is available in Docket EPA-HQ-OAR-2003-0053.

<sup>39</sup> U. S. EPA. 2006. Determination that Gasoline Distribution Stage 1 Area Source (GD AS) Category Does Not Need to Be Regulated Under Section 112(c)6. Memorandum from Stephen Shedd to Kent Hustvedt, May 9, 2006. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>40</sup> U. S. EPA. 2005. Documentation for the Final 2002 Mobile National Emissions Inventory. Prepared by U. S. EPA, Assessment and Standards Division and E. H. Pechan and Associates for U. S. EPA, Office of Air Quality Planning and Standards. September 2005.

- <sup>41</sup> ERG, Inc. 2003. Documentation for the for the Final 1999 Nonpoint Area Source National Emission Inventory for Hazardous Air Pollutants (Version 3). Prepared for U. S. EPA, Office of Air Quality Planning and Standards, August 26, 2003. <http://www.epa.gov/ttn/chief/net/1999inventory.html>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>42</sup> Driver, L. 2005. Memorandum to State/Local Agencies that submitted 2002 gasoline distribution emissions requesting review/comments on EPA plans for final 2002 NEI. [ftp://ftp.epa.gov/EmisInventory/draftnei2002/nonpoint/gasoline\\_marketing/gasdistributioninstructions.pdf](ftp://ftp.epa.gov/EmisInventory/draftnei2002/nonpoint/gasoline_marketing/gasdistributioninstructions.pdf). This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>43</sup> Strum, M., Cook, R., Pope, A., Palma, T., Shedd, S., Mason, R., Michaels, H., Thurman, J., Ensley, D. 2006. Projection of Hazardous Air Pollutant Emissions to Future Years. *Science of the Total Environment*, 366: 590-601.
- <sup>44</sup> ERG, Inc. 2003. Documentation for the Final 1999 Point Source National Emissions Inventory for Hazardous Air Pollutants (Version 3). Prepared for U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, July 2003. <http://www.epa.gov/ttn/chief/net/1999inventory.html>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>45</sup> ERG, Inc. 2003. Documentation for the Final 1999 Nonpoint Source National Emissions Inventory for Hazardous Air Pollutants (Version 3). Prepared for U. S. Environmental Protection Agency, Office of Air Quality Planning and Standards, August 2003. <http://www.epa.gov/ttn/chief/net/1999inventory.html>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>46</sup> U. S. Environmental Protection Agency. User's Guide for the Emissions Modeling System for Hazardous Air Pollutants (EMS-HAP) Version 3.0 EPA-454/B-03-006 August 2004 by: Madeleine Strum, Ph.D. U.S. EPA, Office of Air Quality Planning and Standards Emissions, Monitoring and Analysis Division Research Triangle Park, NC And, Under Contract to the U.S. This document is available in Docket EPA-HQ-OAR-2005-0036 and at <http://www.epa.gov/scram001/userg/other/emshapv3ug.pdf>.
- <sup>47</sup> Regional Economic Models, Inc. 2004. REMI Policy Insight. <http://www.remi.com>.
- <sup>48</sup> Fan W, Treyz F, Treyz G. An evolutionary new economic geography model. *J Regional Sci* 2000 40: 671- 696.
- <sup>49</sup> Energy Information Administration. Annual Energy Outlook 2005 with Projections to 2025. 2005, Report No. DOE/EIA-0383. <http://www.eia.doe.gov/oiaf/aeo/index.html>.

- <sup>50</sup> U. S. Environmental Protection Agency. Clean Air Interstate Rule: Emissions Inventory Technical Support Document, 2005b. Available from: <http://www.epa.gov/cair/technical.html>. This document is available in Docket EPA-HQ-OAR-2003-0053.
- <sup>51</sup> U. S. Environmental Protection Agency. SPECIATE, Version 3.2. Available at: <http://www.epa.gov/ttn/chief/software/speciate/index.html>
- <sup>52</sup> Cook, R., Beidler, A., Touma, J., Strum, M. 2006. Preparing Highway Emissions Inventories for Urban Scale Modeling: A Case Study in Philadelphia. Transportation Research Part D: Transport and Environment, 11: 396-407.
- <sup>53</sup> U. S. EPA. 2001. National-Scale Air Toxics Assessment for 1996: Draft for EPA Science Advisory Board Review. Report No. EPA-453/R-01-003 This document is available in Docket EPA-HQ-OAR-2005-0036. <http://www.epa.gov/ttn/atw/sab/natareport.pdf>
- <sup>54</sup> Taylor, M. Memorandum: Revised HAP Emission Factors for Stationary Combustion Turbines, Prepared by Alpha-Gamma Technologies, Inc for Sims Roy, EPA OAQPS ESD Combustion Group. August, 2003. Docket ID: OAR-2003-0189. <http://docket.epa.gov/edkpub/do/EDKStaffItemDetailView?objectId=090007d480271237>
- <sup>55</sup> U. S. EPA. 2006. Regulatory Impact Analysis for the Review of the Particulate Matter National Ambient Air Quality Standards. Office of Air Quality Planning and Standards, Research Triangle Park, NC. [http://www.epa.gov/ttn/naaqs/standards/pm/s\\_pm\\_cr\\_ria.html](http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr_ria.html). This document is available in Docket EPA-HQ-OAR-2006-0834.
- <sup>56</sup> Glover, E.; Brzezinski, D. 2001. Soak Length Activity Factors for Start Emissions. U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI. Report No. EPA420-R-01-011. <http://www.epa.gov/otaq/models/mobile6/r01011.pdf>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>57</sup> Enns, P.; Brzezinski, D. 2001. Comparison of Start Emissions in the LA92 and ST01 Test Cycles. U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI. Report No. EPA420-R-01-025. <http://www.epa.gov/otaq/models/mobile6/r01025.pdf>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>58</sup> Glover, E; Carey, P. 2001. Determination of Start Emissions as a Function of Mileage and Soak Time for 1981-1993 Model Year Light-Duty Vehicles. U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI. Report No. EPA420-R-01-058. <http://www.epa.gov/otaq/models/mobile6/r01058.pdf>. This document is available in Docket EPA-HQ-OAR-2005-0036.
- <sup>59</sup> Glover, E.; Brzezinski, D. 2001. Exhaust Emission Temperature



Correction Factors for MOBILE6: Adjustments for Engine Start and Running LA4 Emissions for Gasoline Vehicles. U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI. Report No. EPA420-R-01-029.

<http://www.epa.gov/otaq/models/mobile6/r01029.pdf>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>60</sup> Cook, R.; Glover, E. “Technical Description of the Toxics Module for MOBILE6.2 and Guidance on Its Use for Emission Inventory Preparation”, U.S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI, November 2002; Report No., EPA420-R-02-011. <http://www.epa.gov/otaq/m6.htm>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>61</sup> MOBILE6 Vehicle Emissions Modeling Software. <http://www.epa.gov/otaq/m6.htm>.

<sup>62</sup>EPA. 1993. Final Regulatory Impact Analysis for Reformulated Gasoline. December 13, 1993. <http://www.epa.gov/otaq/regs/fuels/rfg/>. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>63</sup> Weatherby, M. F., Fincher, S., DeFries, T. H., Kishan, S. 2005. Comparison of Toxic to Hydrocarbon Ratios from In-Use New Technology Vehicles to Those Used in MOBILE6.2. Prepared by Eastern Research Group, Austin, TX, for Rich Cook, Office of Transportation and Air Quality, U. S. EPA. ERG Report No. ERG No.: 0136.04.001.001. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>64</sup> Baldauf, R. W., P. Gabele, W. Crews, R. Snow, and R. Cook. 2005. Criteria and Air Toxic Emissions from In-Use Automobiles in the National Low-Emission Vehicle Program. *Journal of the Air and Waste Management Association*, 55:1263-1268.

<sup>65</sup> Durbin, T., Miller, J. W., Younglove, T., Huai, T. and Cocker, K. “Effects of Ethanol and Volatility Parameters on Exhaust Emissions: CRC Project No. E-67.” January 30, 2006. Coordinating Research Council # 06-VE-59596-E67.

<sup>66</sup> Clark, N., Gautam, M., Wayne, W., Lyons, D., & Thompson, G., “California Heavy Heavy-Duty Diesel Truck Emissions Characterization for Program E-55/59: (Draft) Final Report” (Short Title: “E-55/59 All Phases”) Nov. 11, 2005 West Virginia University Research Corporation, Morgantown, WV. EPA document # 420-D-06-005.

<sup>67</sup> Censullo, A. 1991. Development of Species Profiles for Selected Organic Emission Sources. California Polytechnic State University. San Luis Obispo, CA. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>68</sup> Gabele, Peter. 1997. Exhaust emissions from four-stroke lawn mower engines. *J. Air & Waste Manage. Assoc.* 47:945-950.

<sup>69</sup> Hare, C. T.; Carroll, J. N. 1993. Speciation of Organic Emissions to Study Fuel Dependence of Small Engine Exhaust Photochemical Reactivity. Report for Advisory Committee on Research, Southwest Research Institute, July 1993. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>70</sup> Hare, C.T.; White, J.J. 1991. Toward the Environmentally Friendly Small Engine: Fuel, Lubricant, and Emission Measurement Issues. SAE Paper No. 9 11222. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>71</sup> Carroll, J. N. 1991. Emission Tests of In-use Small Utility Engines: Task III Report, Nonroad Source Emission Factors Improvement. Prepared for U. S. EPA by Southwest Research Institute. Report No. SwRI 3426-0006. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>72</sup> “Characterization of Emissions from Small Hand-Held, In-Use 2- Cycle Engines”, Richard Snow and William Crews, BKI, Inc , EPA/600/X-4/191, October 2004. This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>73</sup> Starr, M. February, 2004 “Air Toxic Emissions from In-Use Nonroad Diesel Equipment; Final Report” (SwRI-08.05004.04). Prepared for U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI by Southwest Research Institute. (EPA document # 420-R-04-019). This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>74</sup> Starr, M. February, 2004 “Nonroad Duty Cycle Testing for Toxic Emissions; Final Report” (SwRI-08.05004.05). Prepared for U. S. EPA, Office of Transportation and Air Quality, Ann Arbor, MI by Southwest Research Institute. (EPA document # 420-R-04-018). This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>75</sup> Starr, M. May, 2003 “Transient and Steady-State Emissions Testing of Ten Different Nonroad Diesel Engines Using Four Fuels; Final Report” (SwRI-08.03316). Prepared for California Air Resources Board, El Monte, CA by Southwest Research Institute. (EPA document # 420-R-03-901). This document is available in Docket EPA-HQ-OAR-2005-0036.

<sup>76</sup>40 CFR Part 80, Subpart D.

<sup>77</sup> 65 FR 6822 (February 10, 2000)

<sup>78</sup> 66 FR 5002 (January 18, 2001) <http://www.epa.gov/otaq/diesel.html>

<sup>79</sup> 69 FR 38958 (June 29, 2004)

<sup>80</sup> 65 FR 6697, February 10, 2000.

<sup>81</sup> 66 FR 5001, January 18, 2001.

<sup>82</sup> 69 FR 38958, June 29, 2004.

<sup>83</sup> 67 FR 68241, November 8, 2002.

<sup>84</sup> 67 FR 68241, November 8, 2002.

<sup>85</sup> 60 FR 34582, July 3, 1995.

<sup>86</sup> 64 FR 15208, March 30, 1999 and 65 FR 24267, April 25, 2000.

<sup>87</sup> 61 FR 52088, October 4, 1996.

<sup>88</sup> 67 FR 53050, August 14, 2002.

<sup>89</sup> 64 FR 73300, December 29, 1999 and 68 FR 9746, February 28, 2003.

<sup>90</sup> 63 FR 18978, April 16, 1998.