Refiners Switch to Reformulated Gasoline Complex Model

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Summary

On January 1, 1998, domestic and foreign refineries and importers must stop using the "simple" model and begin using the "complex" model to calculate emissions of volatile organic compounds (VOC), toxic air pollutants (TAP), and nitrogen oxides (NOx) from motor gasoline. The primary differences between application of the two models is that some refineries may have to meet stricter standards for the sulfur and olefin content of the reformulated gasoline (RFG) they produce and all refineries will now be held accountable for NOx emissions. Requirements for calculating emissions from conventional gasoline under the anti-dumping rule similarly change for exhaust TAP and NOx. However, the change to the complex model is not expected to result in an increase in the price premium for RFG or constrain supplies.

Introduction

Objectives of the RFG Program. The purpose of the RFG program is reduce automobile emissions of tropospheric ozone-forming VOC during the summer high-ozone season and TAP during the entire year in certain areas of the United States. RFG must be sold in the nine largest metropolitan areas with the most severe summertime ozone levels and other ozone nonattainment areas that opt into the program. The regulations also prohibit conventional gasoline sold in the rest of the country from becoming any more polluting than it was in 1990. This "anti-dumping" requirement ensures that refiners do not blend fuel components into conventional gasoline that are restricted in reformulated gasoline and that cause environmentally harmful emissions.

Phase I and Phase II RFG Requirements. For a gasoline to be certified as reformulated, it must contain at least 2.0 weight percent oxygen, no more than 1.0 volume percent benzene, and no heavy metals; result in no increase in NOx emissions; and achieve required TAP and VOC emission reductions. The TAP and VOC emissions reduction targets are being implemented in two phases. The Phase I regulations, effective from 1995 to 1999, require a reduction of at least 15 percent in VOC and TAP emissions compared with those from 1990 model-year automobiles burning a specified baseline motor gasoline (the "statutory baseline" fuel). The Phase II emission performance standards will take effect on January 1, 2000 and will require additional reductions in TAP, VOC, and NOx.

Phase I Simple and Complex Models. Phase I has been implemented in 2 steps. The first step took effect in 1995 and utilized a "simple" model to certify that a gasoline meets applicable TAP and VOC emission reduction standards (there is no simple model NOx standard). The simple model allows certification based on a fuel's oxygen, benzene, and aromatics content and Reid Vapor Pressure (RVP). Under the second step, which begins on January 1, 1998, a "complex" model replaces the simple model for certifying compliance with the TAP, VOC, and NOx standards. The complex model quantifies not only the effects of oxygen, benzene, aromatics, and RVP on emissions, but also olefins, sulfur, and the percent of fuel evaporated at 200 and 300 degrees Farenheit (E200 and E300, respectively). The standards for oxygen and benzene content are the same under the simple and complex models.

Table 1. Comparison of Simple Model and Complex Model RFG Per Gallon Requirements

Gasoline Property		Simple Model	Phase I Complex Model
Oxygen (weight %)		2.0 min	2.0 min
Benzene (volume %)		1.0 max	1.0 max
Heavy Metals		nil	nil
TAP Emissions Reduction (%)		15.0 min	15.0 min
NOx Emission Reduction (%)		n/a	0.0 min
VOC Emission Reduction (%)			
	Region 1 (southern states)	n/a	35.1 min
	Region 2 (northern states)	n/a	15.6 min
Reid Vapor Pressure (psi)			
	Region 1 (southern states)	7.2 max	CM

	Region 2 (northern states)	8.1 max	CM
Sulfur (ppm)		IRB max	CM
Olefins (volume %)		IRB max	CM
Total Aromatics (volume %)		SM	CM
T90 (degrees F)		IRB max	n/a
E200 (%)		n/a	CM
E300 (%)		n/a	CM

Notes:	n/a = not applicable
	IRB = Individual Refinery Baseline
	SM = Variable in the Simple Model
	CM = Variable in the Complex Model
	Refineries that "average" their production face slightly stricter requirements.
	Simple model RVP and complex model VOC emissions reduction requirements apply only during the high ozone season, June 1 through September 15 (and May 1 through May 31 at facilities upstream of retail outlets).

The primary difference between the application of the two models for production of reformulated gasoline is that the levels of sulfur and olefins had been constrained to the individual refinery baselines under the simple model. Sulfur and olefins in the complex model are measured against the statutory baseline. Thus, refineries that produced gasoline in 1990 (the individual refinery baseline) that was worse than average (the statutory baseline) will now be held to stricter standards for these components.

Anti-dumping Rule. The average per gallon emissions of specified pollutants from non-reformulated (i.e., conventional) gasoline must not deteriorate relative to emissions from 1990 gasoline. Compliance is measured by comparing emissions of a refiner's conventional gasoline against that refiner's individual baseline gasoline. An individual refinery baseline, consisting of fuel parameters and emissions, is developed for each refiner based on the quality of the gasoline it produced and sold in the U.S. in 1990. The anti-dumping requirements apply to all conventional gasoline producers and importers whether or not they also produce or import reformulated gasoline.

Prior to mandatory use of the complex model on January 1, 1998, the annual average exhaust benzene emissions of a refiner's conventional gasoline must not exceed its baseline exhaust benzene emissions calculated using the simple model. Also the annual average sulfur, olefin and T90 values of a refiner's conventional gasoline cannot exceed its baseline values of those parameters by more than 25 percent. Beginning January 1, 1998, the NOx and *exhaust* TAP emissions of a refiner's conventional gasoline must not exceed that refiner's baseline emissions using the complex model. Nonexhaust benzene and VOC emissions are not controlled for under either the simple or complex models. The change to the complex model primarily tightens the restrictions on benzene, total aromatics, and sulfur, which are the dominant variables in the complex model NOx and exhaust TAP equations.

Statutory, Individual Refinery, and Compliance Baselines

Statutory Baseline. In order to determine whether fuels meet the performance requirements of reformulated gasoline under the simple or complex models, EPA established a "statutory" baseline fuel against which the emission performance of reformulated fuels are to be compared (with the exception of certain fuel properties under the simple model, which are measured against the individual refinery baseline as noted above.) The statutory baseline is intended to approximate the national average gasoline parameter values for gasoline used in the United States in 1990.

Table 2. Statutory Baseline Fuel Compositions

	Summer	Winter
Rvp, pounds per square inch (psi)	8.7	11.5
Benzene, volume percent	1.53	1.64
Aromatics, volume percent	32.0	26.4
Olefins, volume percent	9.2	11.9
Sulfur, ppm	339	338
E200, percent	41.0	50.0
E300, percent	83.0	83.0
Oxygen, weight percent	0.0	0.0
Summer = June 1 through September 15		

Individual Refinery Baseline The conventional gasoline anti-dumping requirements are based on individual refinery baselines rather than the statutory baseline. An individual refinery baseline represents the average quality of gasoline produced by that refinery and sold in the U.S. in 1990.[(1)] The RFG requirements for sulfur and olefin content and T-90 rely on individual refinery baselines only under the simple model.

Compliance Baseline Application of an individual refinery baseline for calculating NOx and exhaust TAP emissions requirements is limited to the volume of gasoline produced by that refiner and sold in the U.S. in 1990. If the current calendar year's production (conventional gasoline and RFG) exceeds the refiner's 1990 baseline volume, all additional production is subject to evaluation against the statutory baseline. The possible linear combination of an individual refinery baseline and the statutory baseline is referred to as the refiner's "compliance" baseline (62 FR 68196)[(2)].

Simple Model

At the time of the simple model proposal, while a number of fuel parameters were thought to impact emissions, data were sufficient for only a few of these parameters (Reid vapor pressure, oxygen, benzene, and aromatics). For those additional parameters that were thought to impact emissions in a directionally clear, but as of then unquantifiable manner (sulfur, olefins, and T90),

EPA proposed that they be capped at the refiner's individual baseline level (1990 average) to prevent undercutting the emission reductions achieved by the parameters contained in the simple model. The effect of aromatics on VOC and NOx emissions was also unclear, but instead of being capped, it was believed that the level of aromatics would be controlled by the role aromatics plays in the TAP emissions.

Simple VOC Emissions Model. The simple model is not directly used for monitoring VOC emissions (VOC emissions estimated using the simple model are used to calculate TAP emissions). EPA determined that a fuel with an RVP of 8.1 psi and 2.0 weight percent oxygen in VOC control region 2 (the northern areas typically covered by ASTM class C during the summer) would be sufficient to achieve the minimum 15 percent VOC emission reduction. A fuel with 7.2 psi RVP and 2.0 weight percent oxygen would provide VOC emission reductions in VOC control region 1 (the southern areas typically covered by ASTM class B during the summer) similar to those obtained in VOC control region 2.

Simple TAP Emissions Model. Five pollutants are covered in the TAP category: benzene, 1,3-butadiene, polycyclic organic matter (POM), formaldehyde, and acetaldehyde. Benzene is present in both exhaust and non-exhaust (evaporative, running loss, and refueling) emissions. However, nonexhaust benzene emissions data are only available in sufficient quantities under high ozone test conditions. Therefore, nonexhaust benzene emissions are not considered outside of the summer high ozone season. The four other toxic air pollutants are not present in gasoline and are solely products of combustion (exhaust emissions).

Simple NOx Emissions Model. The Clean Air Act requires that there be no NOx emissions increase from reformulated fuels. EPA proposed that all oxygenates be assumed to result in no NOx emission increase under the simple model up to 2.7 weight percent oxygen. Any oxygenate up to 3.5 weight percent oxygen is also presumed to result in no NOx emission increase under the simple model during those months without ozone violations (e.g., winter months) unless a state requests that oxygenate levels be limited to 2.7 weight percent. Calculation of NOx emissions was not required when the simple model was in use.

Complex Model

Beginning in 1998, all reformulated gasoline will be certified using the complex model. All refiners and importers will calculate emissions performance reductions from the statutory baseline gasoline. Individual refiner baselines will not be relevant to reformulated gasoline.

Table 3. Complex Model Variables

	VOC	NOx	Exhaust Benzene	Nonexhaust Benzene	Formaldehyde	Acetaldehyde	Polycyclic Organic Matter	1,3-Butadiene
Benzene			X	X				
MTBE				X	X	X		
ETBE						X		

Ethanol						X		
Total Oxygen	X	X	X				X	X
RVP	X	X		X		X	X	
Total Aromatics	X	X	X		X	X	X	X
Sulfur	X	X	X			X	X	X
Olefins	X	X			X		X	X
E200	X	X	X				X	X
E300	X	X	X		X	X	X	X
RVP squared	X							
Aromatics squared		X						
Sulfur squared		X						
Olefins squared		X						
E200 squared	X						X	
E300 Squared	X						X	
Aromatics x E300	X						X	

VOC emission reduction is primarily achieved by lowering RVP. Sulfur should be the primary target for NOx reduction, with aromatics also a possible control mechanism. TAP control typically requires reduction in benzene or total aromatics.

Endnotes:

(1)A very limited number of refineries may be able to adjust their individual baselines if they produced a significant volume of JP-4 jet fuel in 1990 or are now unable to acquire extremely sweet crude oil (i.e., low in sulfur) that had been available in 1990 (62 FR 9871).

(2) the "62 FR 68196" notation is a reference to the *Federal Register*, volume 62, page 37363.

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