Summary and Analysis of the 2011-2019 Gasoline Sulfur Compliance Reports

United States Environmental Protection Agency

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Compliance Division
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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EPA United States Environmental Protection Agency

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List of Acronyms

ABT	Averaging, Banking, and Trading
ASTM	American Society for Testing and Materials
CBOB	Conventional Blendstock for Oxygenate Blending
CFR	Code of Federal Regulations
CG	Conventional Gasoline
EMTS	EPA Moderated Transaction System
EPA	United States Environmental Protection Agency
PADD	Petroleum Administration for Defense District
ppm	Parts per Million
RBOB	Reformulated Blendstock for Oxygenate Blending
RFG	Reformulated Gasoline
GSF0100	Gasoline sulfur credit averaging, banking and trading (ABT) report
GSF0200	Gasoline sulfur credit transfer report

GSF030X	Gasoline sulfur facility summary report
RFG030X	Batch report for RFG and CG
GSF0402	Gasoline sulfur supplementary batch report

I. Executive Summary

Beginning in 2004, the United States Environmental Protection Agency ("EPA" or "the Agency") set standards limiting the amount of sulfur in gasoline to help reduce vehicle emissions, and protect emission controls in vehicles and engines.[1] The Tier 2 gasoline sulfur program established standards beginning January 1, 2004, which phased down gasoline sulfur over a seven-year period. Under this program, all gasoline produced in or imported into the United States was required to meet an annual average sulfur standard of 30 parts per million ("ppm") beginning January 1, 2011, and also meet a maximum per-gallon standard of 80 ppm sulfur. The program allowed refiners and importers to generate gasoline sulfur credits by producing or importing gasoline containing less than 30 ppm sulfur on an annual average basis. These credits could be used by refiners and importers which produced or imported gasoline containing more than 30 ppm sulfur on an annual average basis. Credits could be "banked" for use in future years, and expired if not used within five years after the year of generation. The result was that the phasedown to 30 ppm continued beyond 2011.

The Tier 3 gasoline sulfur program further reduced gasoline sulfur so that all gasoline produced or imported in the United States met an annual average sulfur standard of 10 ppm. The Tier 3 standards began on January 1, 2017 and were fully phased in beginning January 1, 2020. Similar to the Tier 2 program, the Tier 3 program also provides refiners and importers the flexibility to generate and use credits in complying with the 10 ppm average standard, potentially allowing the phasedown to 10 ppm to continue beyond 2020.

The purpose of this report is to provide an explanation of how refiners and importers complied with the Tier 2 30 ppm annual average sulfur standard from 2011 through 2016, and the Tier 3 10 ppm annual average sulfur standard from 2017 through 2019. This period of time covers the six years leading up to the start date of the 10 ppm Tier 3 sulfur standard, and the first three years during which the 10 ppm Tier 3 sulfur standard was phased in. The report also discusses how refiners and importers used "early" Tier 3 credits for compliance with the 10 ppm average sulfur standard, and used a regulatory option that allowed small volume refineries and small refiners to delay compliance with the 10 ppm standard for 3 years. This report builds on the information and analysis in EPA's previous gasoline sulfur compliance report (published March, 2018), which covered gasoline sulfur compliance with the Tier 2 standards from 2011 through 2016.

The data in this report were aggregated from compliance data reported to the EPA by gasoline refiners and importers. Key findings include:

[1] In order to protect emission controls, a 1977 amendment to the Clean Air Act required unleaded gasoline in commerce to be "substantially similar" to the unleaded gasoline used in certifying vehicles to emission standards. In an interpretive rule, the Agency defined "substantially similar," including compliance with the ASTM standard which limited sulfur in unleaded gasoline to 1000 ppm. The rule also limited an additive's sulfur contribution to unleaded gasoline to 15 ppm.

- The reported national average gasoline sulfur content of gasoline decreased from 21.2 ppm in 2017 to 17.5 ppm in 2019. National gasoline sulfur is expected to average very near 10 ppm in 2020 and following years, since few credits from previous years were generated to use for compliance.
- Refiners and importers used large quantities of "early" Tier 3 credits (generated from 2012 through 2016) to comply with the 10 ppm annual average standard from 2017 through 2019
- Annual credit generation from 2017 through 2019 was relatively low, compared to annual credit generation from 2011 through 2016.
- Small volume refineries and small refiners used provisions in the Tier 3 regulations which allowed them 3 additional years to comply with the 10 ppm annual average standard.
- Although EPA has only limited reporting of 2020 data at this time, the data we have suggests that the average gasoline sulfur concentration for 2020 will be below 10 ppm (see Section III.6 for a discussion of the available 2020 data).

II. Background on Gasoline Sulfur Programs

A. Tier 2 Gasoline Sulfur Program

1. Overview

Beginning in 2004, refiners and importers were subject to gasoline sulfur standards established in the "Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements" ("Tier 2 rule"). The EPA finalized the Tier 2 rule on February 10, 2000, including gasoline sulfur requirements promulgated in 40 CFR Part 80, Subpart H. [2, 3] The purpose of these gasoline sulfur requirements was to reduce the sulfur concentration of all gasoline sold in the United States from approximately 300 ppm to an average of 30 ppm, in order to enable emissions control equipment on new vehicles to significantly reduce emissions of pollutants, such as nitrogen oxides and volatile organic compounds, as well as to provide public health and welfare benefits. The Tier 2 gasoline sulfur regulations achieved this reduction by establishing a series of annual sulfur standards that gradually decreased allowable sulfur concentrations so that by 2011, all refiners and importers had to meet an annual average sulfur standard of 30 ppm, and a per-gallon sulfur standard of 80 ppm.[4]

Gasoline refiners and importers could meet the annual average sulfur standard by either of two ways:

1) Producing or importing gasoline with an annual average sulfur content less than or equal to the 30 ppm average standard; or,
2) Producing or importing gasoline with an annual average sulfur content greater than the 30 ppm average standard, and using credits to meet the standard (more discussion below on credits).

The 80 ppm per-gallon sulfur standard had to be met directly; credits could not be used to meet the 80 ppm per-gallon standard.

2. Averaging, Banking and Trading (ABT) Program for Gasoline Sulfur Credits

Refiners and importers could generate gasoline sulfur credits (in ppm-gallons) on a refinery-specific or Petroleum Administration for Defense District (PADD) basis, respectively. Beginning in 2004, most refiners and all importers could generate credits for each year by producing gasoline with an annual average sulfur content less than 30 ppm, according to the formula "(30 – annual average sulfur) X total annual gasoline volume".[5] Beginning in 2011, all refiners and importers could generate credits using this formula. Credits could be used for

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[2] See 65 FR 6697, February 10, 2000.
[3] More information on the Tier 2 and Tier 3 gasoline sulfur programs can be found at the EPA's website at https://www.epa.gov/gasoline-standards/gasoline-sulfur.
[4] All gasoline downstream of refineries and import facilities had to meet a per-gallon standard of 95 ppm sulfur.
[5] From 2004 through 2010, some refineries had annual average standards that were greater than 30 ppm, and could generate credits by producing gasoline with an annual average sulfur content less than their specific standard, see 40 CFR 80.310.

compliance up to five years after the year that they were generated, and could be transferred no more than twice between refiners and/or importers. Credits expired if unused after five years.

3. California Gasoline

Gasoline produced or imported for use in California ("California gasoline") was exempt from all of the requirements in 40 CFR Part 80, Subpart H, provided it met certain requirements specified in 40 CFR 80.375. As a result, no California gasoline was reported to the EPA under the Tier 2 rule, and all volume and property data shown in this report does not include California gasoline.[6]

4. Oxygenate Blending and Accounting

Similar to Subparts D (Reformulated Gasoline) and E (antidumping) of 40 CFR Part 80, Subpart H also allowed refiners and importers to include downstream-blended oxygenate (typically ethanol) in their gasoline sulfur compliance calculations if they complied with the requirements in 40 CFR 80.69(a) or 80.101(d)(4).[7] Refiners and importers generally met the oversight program requirement in 40 CFR 80.69(a)(11) for downstream blending of oxygenate in reformulated blendstock for oxygenate blending ("RBOB"), by participating in the RFG Survey Association, and used the sulfur test result from their hand blend of RBOB and oxygenate per 40 CFR 80.69(a)(2) in their gasoline sulfur compliance calculations.[8] For downstream blending of oxygenate in CG or conventional blendstock for oxygenate blending ("CBOB"), refiners and importers met the oversight program requirement in 40 CFR 80.101(d)(4)(ii) on an individual basis. Refiners and importers that met the oversight program requirement in 40 CFR 80.101(d)(4)(ii) could assume that oxygenate blended into their conventional gasoline or CBOB contained no sulfur.[9] Oxygenate blenders (i.e., downstream parties that simply blended oxygenate into RBOB, CBOB, or CG) were only required to ensure that any ethanol they blended into RBOB, CBOB or CG contained no more than 30 ppm sulfur, prior to January 1, 2017. Beginning January 1, 2017, ethanol blended into RBOB, CBOB or CG was required to contain no more than 10 ppm sulfur. Tables 1 through 3 provide data on total volumes of ethanol in gasoline (not including California gasoline) from 2011 through 2019, based on reports submitted by refiners and importers to EPA.[10] These volumes are not the annual volumes of

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[6] California gasoline is also excluded from reports submitted by refiners and importers under 40 CFR Part 80, Subparts D (RFG) and E (antidumping), per 40 CFR 80.81.

[7] Refiners and importers benefit from including ethanol in their gasoline sulfur compliance calculations because of ethanol's low sulfur content. The provisions in 40 CFR 80.69(a) and 80.101(d)(4) required refiners and importers to verify their included volumes of downstream-blended oxygenate through a combination of product transfer documents, contractual arrangements with oxygenate blenders, and periodic sampling and testing of oxygenate-blended gasoline.

[8] RBOB is a gasoline blendstock that becomes RFG upon blending with a specified type of oxygenate, typically ethanol. In order to comply with the RFG standards in Subpart D, refiners and importers of RBOB prepare a "hand blend" sample of RFG by blending a batch sample of RBOB with a refiner-specified percentage of ethanol, and test the RBOB/ethanol blend for several properties, including sulfur, per 40 CFR 80.69(a)(2). The refiner-specified percentage of ethanol is transmitted on the product transfer document for the RBOB to a downstream oxygenate blender, who blends the RBOB batch with the specified percentage of ethanol.

[9] CBOB is a blendstock that becomes conventional gasoline upon blending with a specific type of oxygenate.

[10] Gasoline volumes and ethanol concentrations were taken from the RFG030X reports. Volumes of ethanol in RFG, CG, and (RFG+CG) were calculated by multiplying the corresponding gasoline volumes and ethanol concentrations.

ethanol actually blended into gasoline, but simply the volumes of ethanol included in refiner and importer compliance reports.[11]

Table 1: Annual RFG Volumes, Ethanol Concentrations, and Ethanol Volume in RFG
(from Refiner and Importer Compliance Reports)

Year	Total RFG, million gallons	Ethanol in RFG, volume percent	Ethanol in RFG, million gallons
2011	30,901.7	9.65	2,982.4
2012	30,418.7	9.62	2,925.3
2013	30,689.7	9.63	2,956.1
2014	31,268.2	9.64	3,014.8
2015	32,125.3	9.66	3,104.6
2016	33,254.2	9.68	3,218.5
2017	32,809.9	9.69	3,179.7
2018	33,127.7	9.68	3,205.8
2019	32,592.4	9.72	3,166.8

Table 2: Annual CG Volumes, Ethanol Concentrations, and Ethanol Volume in CG
(from Refiner and Importer Compliance Reports)

Year	Total CG, million gallons	Ethanol in CG, volume percent	Ethanol in CG, million gallons
2011	84,305.6	2.08	1,751.8
2012	84,512.6	2.08	1,757.9
2013	84,354.7	2.06	1,738.3
2014	85,140.2	2.30	1,956.4
2015	87,169.6	2.40	2,096.3
2016	89,283.4	2.39	2,130.6
2017	90,135.9	2.35	2,115.4
2018	89,899.2	2.71	2,433.0
2019	90,650.5	2.40	2,174.3

Table 3: Annual (RFG+CG) Volumes, Ethanol Concentrations, and Ethanol Volume in (RFG+CG)
(from Refiner and Importer Compliance Reports)

Year	Total (RFG+CG), million gallons	Ethanol in (RFG+CG), volume percent	Ethanol in (RFG+CG), million gallons
2011	115,207.3	4.11	4,734.2

[11] The regulations for downstream oxygenate accounting have been significantly revised as part of the fuels regulatory streamlining rule. The new regulations are located in 40 CFR 1090.710, and broaden the oversight program approach for RFG to also apply to CG. This should enable refiners and importers to include larger volumes of ethanol in their compliance calculations and reports.

2012	114,931.3	4.07	4,683.2
2013	115,044.4	4.08	4,694.3
2014	116,408.4	4.27	4,971.2
2015	119,309.4	4.36	5,200.9
2016	122,537.6	4.36	5,349.1
2017	122,945.8	4.31	5,295.0
2018	123,026.9	4.58	5,638.7
2019	123,242.9	4.33	5,341.1

B. Tier 3 Gasoline Sulfur Program

The EPA finalized the "Tier 3 Motor Vehicle Emission and Fuel Standards" rulemaking ("Tier 3 rule") on April 28, 2014, including gasoline sulfur requirements promulgated in 40 CFR Part 80, Subpart O.[12] The purpose of the Tier 3 rule was to further reduce the sulfur concentration of all gasoline sold in the United States from an average of 30 ppm to an average of 10 ppm. This enabled emissions control equipment on new vehicles to further reduce emissions of pollutants, such as nitrogen oxides and volatile organic compounds, providing significant benefits to public health and welfare. The Tier 3 gasoline sulfur regulations required most refiners and all importers to meet an annual average standard of 10 ppm sulfur beginning January 1, 2017. Small volume refineries and small refiners (both defined in the regulations) were allowed to delay compliance with the 10 ppm annual average sulfur standard for 3 years, until January 1, 2020.[13] During this 3 year period, small volume refineries and small refiners continued to be subject to the previously established Tier 2 30 ppm annual average standard. [14]

The Tier 3 rule has many similarities to the Tier 2 rule. The 10 ppm average standard in the Tier 3 rule applies to each refinery's annual gasoline production, and each importer's annual gasoline importation on a PADD basis.[15] Refiners and importers continue to be subject to a per-gallon sulfur standard of 80 ppm, and all gasoline continues to be subject to a downstream per-gallon standard of 95 ppm. The Tier 3 gasoline sulfur regulations also include an ABT program for gasoline sulfur credits that allows refiners and importers to generate credits (in ppm-gallons) and use them to comply with the 10 ppm average standard. Beginning January 1, 2017, sulfur credits are generated by producing or importing gasoline containing an annual average sulfur of less than 10 ppm. These credits have a life of five years after the year of generation (i.e., 2017 credits expire if not used after the 2022 compliance period), and may be banked by the refiner or importer that generated them, or sold to another refiner or importer for use in complying with the 10 ppm standard.

[12] Additional information on the Tier 3 rule can be found on the EPA website at https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3.
[13] Small volume refineries were defined as refineries which processed an annual average of 75,000 barrels per day of crude oil or less during calendar year 2012, see 40 CFR 80.1621. Small refiners were defined as refiners which employed an average of 1,500 people or less during 2012, and had a corporate average crude oil capacity of 155,000 barrels per calendar day or less during 2012, see 40 CFR 80.1620.
[14] See 40 CFR 80.1603(a)(1)(iii)(B).
[15] Additional information on PADDs can be found on EIA's website at https://www.eia.gov/todayinenergy/detail.php?id=4890.

Additionally, the Tier 3 rule allowed refiners and importers to use Tier 2 gasoline sulfur credits generated from 2012 through 2016 for compliance with the 10 ppm average sulfur standard from 2017 through 2019.[16] From 2012 through 2016, refiners and importers could generate gasoline sulfur credits for use in meeting either the 30 ppm average sulfur standard through 2016, or for use in meeting the 10 ppm average sulfur standard from 2017 through 2019. Individual credits could be used to meet either the 30 ppm or 10 ppm average standard, but the same credits could not be used to meet both standards (see example in the Appendix of credit generation and use under the Tier 2 and Tier 3 programs). These credits have a maximum life of five years after the year of generation (i.e., 2012 credits expire if not used after the 2017 compliance period), and all expire if not used by the 2019 compliance period.

Lastly, the Tier 3 rule included provisions which established an additional temporary ABT program for only small volume refineries and small refiners. This ABT program lasted 3 years (2017 through 2019) and allowed small volume refineries and small refiners to generate gasoline sulfur credits by producing gasoline with an annual average sulfur content between 10 ppm and 30 ppm. These credits could be banked by the refiner that generated them or sold to another small volume refinery or small refiner for use in complying with their 30 ppm standard from 2017 through 2019.[17] However, these credits could not be used by non-small volume refineries, non-small refiners, or importers, and all of these credits expired after 2019. Small volume refineries and small refiners could also separately generate Tier 3 credits like other refiners, by producing gasoline with an annual average sulfur content of less than 10 ppm. These credits had a five year life, and could be banked or transferred to any other refiner or importer for compliance.

III. Gasoline Sulfur Compliance Analysis from 2017 through 2019

A. Summary

This report presents analyses of data, primarily from the gasoline sulfur reports, from 2017 through 2019. This report also includes data from 2011 through 2016, which was analyzed in EPA's previous gasoline sulfur compliance report[18], and is helpful in illustrating how refiners and importers used gasoline sulfur credits generated from 2012 through 2016 for compliance from 2017 through 2019. The data is reported to the EPA on various reporting forms by refiners and importers on an annual basis for all gasoline they produce for use in the U.S. outside of California. Thus, the report provides a comprehensive summary of gasoline sulfur concentrations, and gasoline sulfur credit generation and use for all gasoline reported to EPA from 2011 through 2019.

Under the pre-existing RFG and antidumping programs, refiners and importers were required to report several properties, including sulfur, for each batch of gasoline on the EPA batch report form RFG0300. In addition to the RFG and antidumping gasoline batch report form,

[17] Small volume refineries and small refiners could also use any credits generated by all other refiners and importers, for compliance from 2017 through 2019.
[17] Small volume refineries and small refiners could also use any credits generated by all other refiners and importers, for compliance from 2017 through 2019.
[18]See https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100U3P5.pdf

the EPA created four new reporting forms for refiners and importers to report data for the Tier 2 program. These five forms are listed below, along with a description of each form's purpose under Tier 2.

1) Gasoline Sulfur Credit Banking and Allotment Generation Report (GSF0100)
   - Refiners and importers report total annual gasoline sulfur credit generation, use, transfers, and expiration by facility (credit units are ppm-gallons)
   - All information is reported separately by credit creation year
2) Gasoline Sulfur Credit Transfer/Conversion Report (GSF0200) [19]
   - Refiners and importers report each transfer of credits to or from another party
   - Reported information includes credit quantity, transfer date, company and facility IDs for the buyer and seller, credit type, and credit creation year
3) Gasoline Sulfur Facility Summary Report (GSF0300)[20]
   - Refiners and importers report their total annual gasoline production, average sulfur before using credits, and average sulfur after using credits (if applicable) by facility
   - Demonstrates compliance with the 30 ppm annual average sulfur standard
4) Reformulated Gasoline and Anti-Dumping Batch Report (RFG0300) [21]
   - Refiners and importers report all complex model properties (including sulfur) for each batch of gasoline
   - Demonstrates compliance with the 80 ppm per-gallon sulfur standard, except for CG batches that are composited
5) Gasoline Sulfur and Benzene Batch Report (GSF0402)
   - Supplementary report used by refineries or importers which report properties for composited batches of CBOB and/or CG on the RFG0300 report[22]
   - Refiners and importers must report the volume and sulfur content of each sub-batch of CBOB and/or CG used to form the composite batch, in order to demonstrate compliance with the 80 ppm per-gallon standard for each sub-batch
   - Also used by ethanol producers beginning January 1, 2017 to report the volume and sulfur content of each batch of ethanol produced, in order to demonstrate compliance with the 10 ppm per-gallon standard for each batch of ethanol.

The analysis contained in this report is primarily focused on the period from 2017 through 2019, which were the first 3 years during which the 10 ppm sulfur standard was in effect. However, data from 2011 through 2016 is also included in the following graphs and tables in order to show the interrelationship between the Tier 2 and Tier 3 gasoline sulfur programs. The industry compliance trends reported here reflect, to a large extent, the ABT provisions which are a part of both the Tier 2 and Tier 3 gasoline sulfur regulations.

[19] The GSF0200 form has been superseded by EPA's Moderated Transaction System (EMTS), which allows refiners and importers to report credit transactions online.
[20] The GSF0300 reporting form was revised and was subsequently re-issued as the GSF0301 reporting form. In this report, both forms will be collectively referred to as the GSF030X reports.
[21] The RFG0300 reporting form was subsequently revised and re-issued 3 times as the RFG0301, RFG0302 and RFG0303 reporting forms, respectively. In this report, these 4 reporting forms will be collectively referred to as the RFG030X reports.
[22] 40 CFR Part 80, Subpart E (antidumping) allows refiners and importers to test a single composite sample prepared from all of the gasoline they produce or import for a period of up to one month, per 40 CFR 80.101(i)(2).

Data in this report does not include any volume or property data for California gasoline, and reflects the impact on actual in-use sulfur concentrations of only a portion of the total amount of ethanol that is actually blended into CG and CBOB at locations downstream of refineries and import facilities. Gasoline produced or imported for use in California is not reported to the EPA, under certain reporting exemptions in the EPA regulations. Also, refiners and importers calculate their total gasoline volume and average sulfur using only a portion of the total ethanol that is actually blended at downstream locations into their CG and CBOB, due to certain compliance requirements in the EPA regulations.[23] Lastly, butane and pentane that were blended into gasoline under the EPA's simplified compliance requirements are included in the GSF030X report data, but not in the GSF0100 report data, since butane blenders and pentane blenders may not generate gasoline sulfur credits.

In this report, the term "facilities" is generally used to describe all facilities that produce or import gasoline. These include refineries that produce gasoline by refining crude oil, and other facilities ("blender-refineries") that produce gasoline simply by combining gasoline blendstocks obtained from other refineries.[24] In the analysis section below from 2017 through 2019, the number of crude oil refineries in the facility counts varies from 105 to 109.[25] The number of blender-refineries in the EPA's facility count varies from 289 to 335.[26] Lastly, the number of import facilities varies from 26 to 30, where all of an importer's import locations in one PADD are typically reported as a single facility (e.g., an importer that imported gasoline into five different locations in PADD 1 would report the total volume of imported gasoline under a single "PADD 1" import facility).

B. Analysis

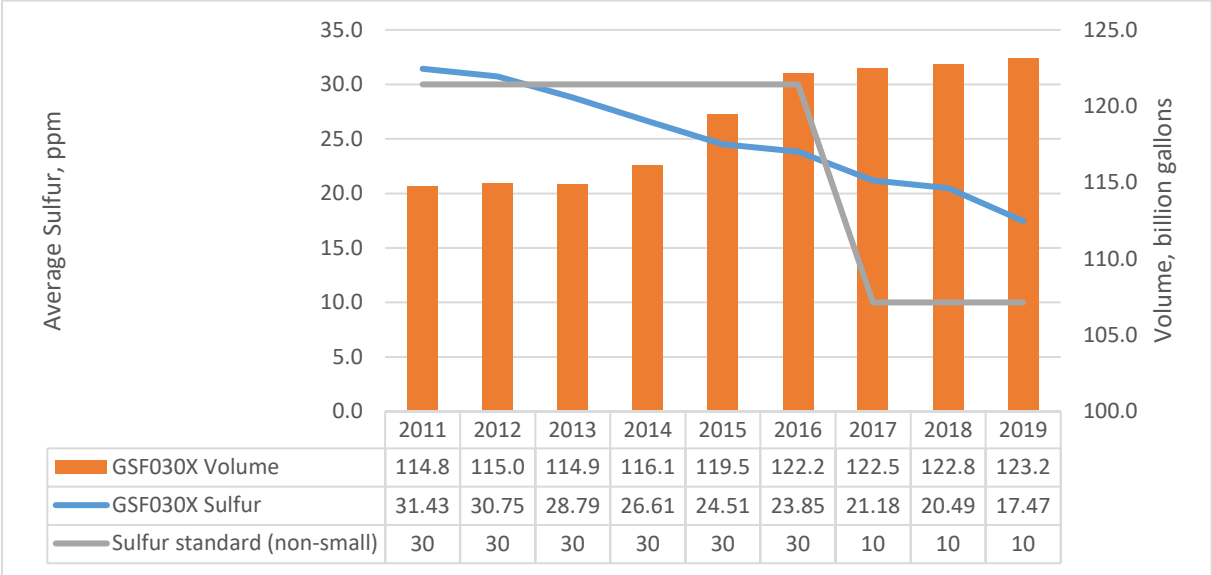
1. Compliance with 10 ppm Annual Average Sulfur Standard

Gasoline sulfur concentrations trended down from 2017 through 2019, continuing their downward trend from 2011 through 2016, as shown in Figure 1. As expected, the decrease in annual average sulfur from 2016 to 2017 was only 2.7 ppm, much less than the 20 ppm decrease in annual average sulfur standard from 2016 to 2017. Annual average sulfur exceeded 10 ppm

[23] See Tables 1 through 3.
[24] The EPA defines a refinery as "any facility, including but not limited to, a plant, tanker truck, or vessel where gasoline or diesel fuel is produced, including any facility at which blendstocks are combined to produce gasoline or diesel fuel, or at which blendstock is added to gasoline or diesel fuel". See 40 CFR 80.2(h). As part of the fuels regulatory streamlining rule, EPA has replaced the definitions of refiner and refinery with fuel manufacturer and fuel manufacturing facility, respectively. Also, a blender refiner is defined as a blending manufacturer. The new definitions are in 40 CFR 1090.80.
[25] The number of crude oil refineries was determined by comparing the list of reporting facilities with the annual lists of refineries with crude distillation units, prepared by the U.S. Energy Information Administration as part of its annual refinery capacity reports.
[26] The number of blender-refineries was calculated by subtracting the number of crude oil refineries and import facilities from the total number of reporting facilities. Blender-refineries also include a small number (between 5 and 8) of transmix processing facilities which distill transmix (i.e., pipeline interfaces of gasoline and distillate fuel) into gasoline and distillate, and sometimes add other blendstocks to the gasoline distilled from the transmix.

from 2017 through 2019, as refiners and importers used significantly more credits generated in previous years to comply with the 10 ppm standard.[27]

Figure 1: Total Gasoline Volume and Average Sulfur from GSF030X Reports

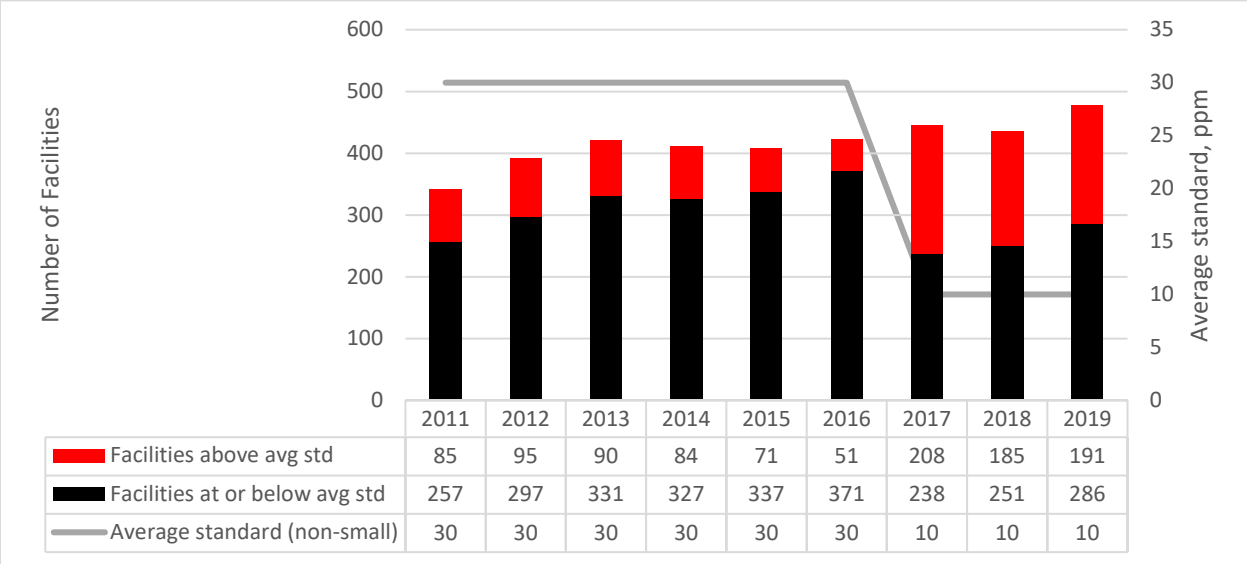


	2011	2012	2013	2014	2015	2016	2017	2018	2019
GSF030X Volume	114.8	115.0	114.9	116.1	119.5	122.2	122.5	122.8	123.2
GSF030X Sulfur	31.43	30.75	28.79	26.61	24.51	23.85	21.18	20.49	17.47
Sulfur standard (non-small)	30	30	30	30	30	30	10	10	10

Figure 2 shows the number of facilities producing gasoline with an annual average sulfur content over the applicable annual average standard, and the number of facilities producing gasoline with an annual average sulfur content equal to or less than the applicable annual average standard. From 2011 through 2016 the applicable annual average standard was 30 ppm for all facilities. From 2017 through 2019, the applicable annual average standard was 30 ppm for all small volume refineries and small refiners, and 10 ppm for all other facilities. The number of facilities above the applicable standard increased significantly (from 51 to 208) from 2016 to 2017, then decreased to 191 facilities in 2019. Conversely, the number of facilities at or below the applicable standard decreased significantly (from 371 to 238) from 2016 to 2017, then increased to 286 facilities in 2019.

[27] Refiners and importers reported on their 2011 GSF0100 reports that they held a total of 3,514 billion gasoline sulfur credits as of January 1, 2017.

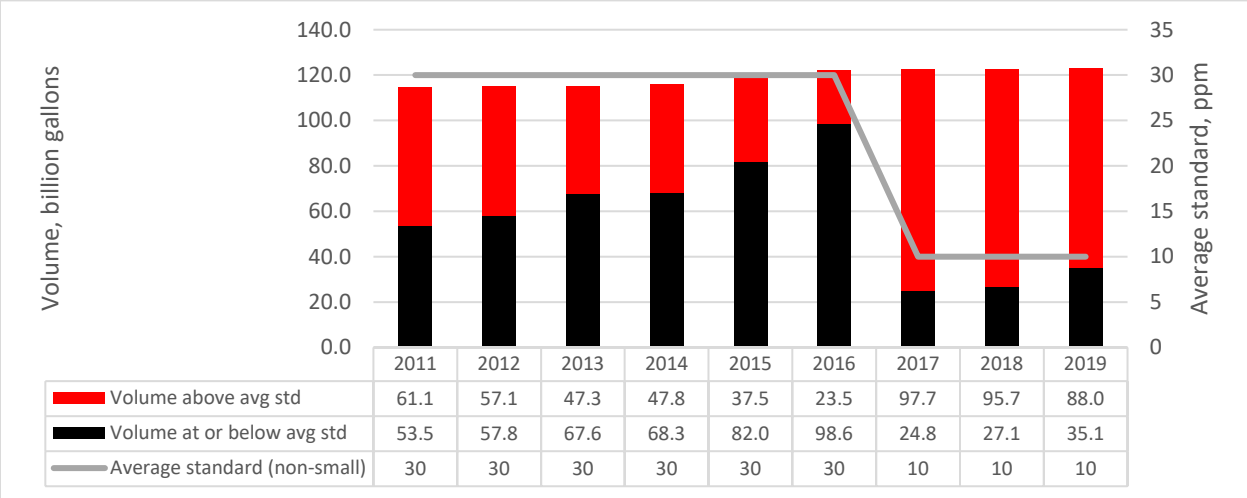
Figure 2: Facilities Producing Gasoline with Annual Average Sulfur Above/Below Annual Average Standard (pre-credits)



	2011	2012	2013	2014	2015	2016	2017	2018	2019
Facilities above avg std	85	95	90	84	71	51	208	185	191
Facilities at or below avg std	257	297	331	327	337	371	238	251	286
Average standard (non-small)	30	30	30	30	30	30	10	10	10

Figure 3 shows the volume of gasoline produced by facilities that averaged over the applicable annual average sulfur standards, and the volume of gasoline produced by facilities that averaged equal to or less than the applicable annual average sulfur standard. The volume above the applicable standard increased significantly (from 23.5 billion to 97.7 billion gallons) from 2016 to 2017, then decreased to 88.0 billion gallons in 2019. Conversely, the volume at or below the applicable standard decreased significantly (from 98.6 billion to 24.8 billion gallons) from 2016 to 2017, then increased to 35.1 billion gallons in 2019.

Figure 3: Volume of Gasoline Produced at Facilities with Annual Average Sulfur Above/Below Annual Average Standard (pre-credits)

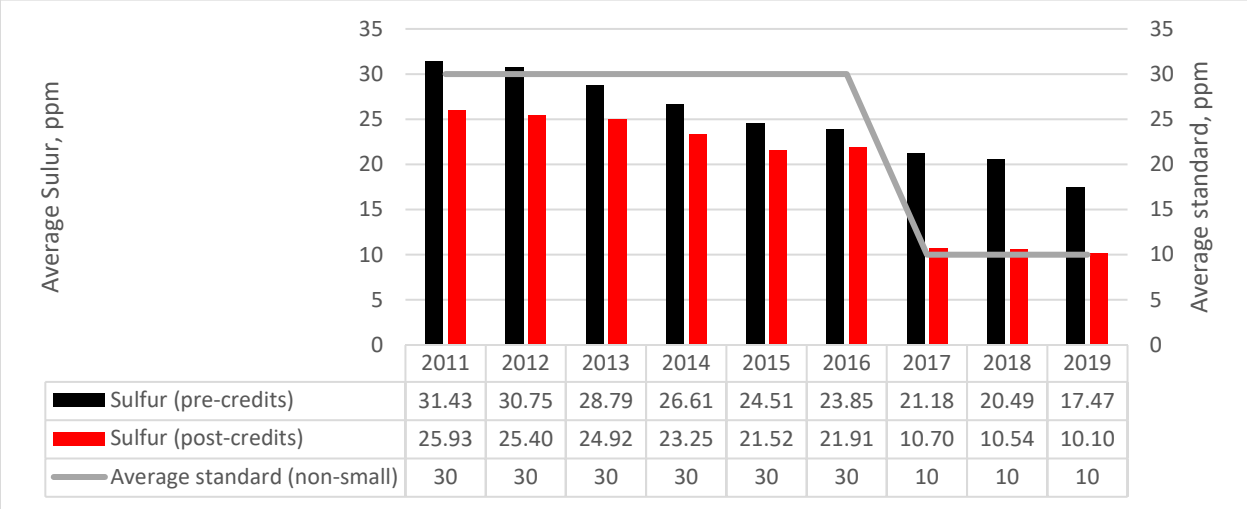


	2011	2012	2013	2014	2015	2016	2017	2018	2019
Volume above avg std	61.1	57.1	47.3	47.8	37.5	23.5	97.7	95.7	88.0
Volume at or below avg std	53.5	57.8	67.6	68.3	82.0	98.6	24.8	27.1	35.1
Average standard (non-small)	30	30	30	30	30	30	10	10	10

Figure 4 shows the average sulfur before and after use of gasoline sulfur credits from 2011 through 2019. The black bars (pre-credits) include all facilities, both credit generators, and credit users (prior to use of any credits). The red bars (post-credits) include all facilities, both credit generators, and credit users (after the use of credits). The difference between the black and red bars increased from approximately 2.0 ppm in 2016 to approximately 10.5 ppm in 2017, indicating an increase in the number of credits used for compliance with the 10 ppm average sulfur standard, compared to credit use for compliance with the 30 ppm standard.[28] By 2019, the difference between the black and red bars had decreased to approximately 7.4 ppm, indicating a decrease in the number of credits used for compliance.

[28] The differences in sulfur before and after using credits in 2015 and prior years also include the effect of refiners and importers using credits that they had generated and banked prior to 2011.

Figure 4: Average Annual Sulfur Content Before and After Using Credits



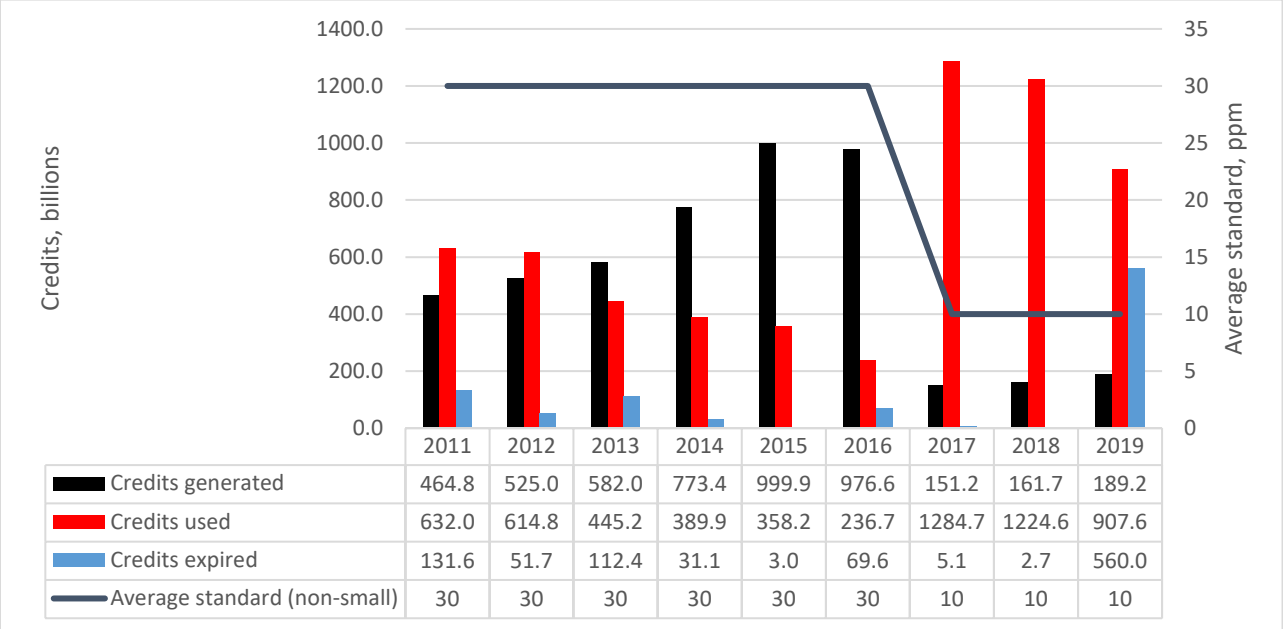
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sulfur (pre-credits)	31.43	30.75	28.79	26.61	24.51	23.85	21.18	20.49	17.47
Sulfur (post-credits)	25.93	25.40	24.92	23.25	21.52	21.91	10.70	10.54	10.10
Average standard (non-small)	30	30	30	30	30	30	10	10	10

2. Credit Generation and Use

Figure 5 shows total annual credit generation, use, and expiration from 2011 through 2019 for all refiners and importers, including small volume refineries and small refiners. Credit generation increased by approximately 512 billion credits from 2011 through 2016, then decreased by approximately 825 billion credits from 2016 to 2017, as fewer facilities produced gasoline containing 10 ppm sulfur or less. Credit use decreased by approximately 395 billion credits from 2011 through 2016, then increased by 1,048 billion credits from 2016 to 2017, as more facilities produced gasoline containing more than 10 ppm sulfur. These changes in credit generation and use from 2016 to 2017 were due to refiners and importers choosing to use "early" Tier 3 credits in 2017 through 2019. The number of expired credits was relatively small in 2017 and 2018, indicating overall efficiency in management of credit inventories by refiners and importers.[29] However, expired credits increased to 560 billion in 2019, as all "early" Tier 3 credits, and credits generated by small refineries and small refiners under their temporary ABT program from 2017 through 2019, expired under the Tier 3 regulations.

[29] "Early" Tier 3 credits were generated under the Tier 2 program by refiners and importers prior to 2017, by producing gasoline containing less than 30 ppm sulfur on an annual average basis. These credits all expired after the 2019 compliance period, resulting in over-compliance with the 30 ppm average sulfur standard.

Figure 5: Credit Generation, Use and Expiration



	2011	2012	2013	2014	2015	2016	2017	2018	2019
Credits generated	464.8	525.0	582.0	773.4	999.9	976.6	151.2	161.7	189.2
Credits used	632.0	614.8	445.2	389.9	358.2	236.7	1284.7	1224.6	907.6
Credits expired	131.6	51.7	112.4	31.1	3.0	69.6	5.1	2.7	560.0
Average standard (non-small)	30	30	30	30	30	30	10	10	10

Figure 6 and Table 4 show credit use by year of credit generation, including credit information reported by small volume refineries and small refiners. Figure 6 and Table 4 indicate how refiners and importers manage their credit inventories.[30] They show that refiners and importers typically try to use credits as late as possible by banking them until the last year in which they can be used, and use them in that last year. For example, most credits used in 2017 were generated in 2012 and 2013, most credits used in 2018 were generated in 2014 and 2015 (most 2013 credits had already been used), and most credits used in 2019 were generated in 2015 and 2016 (most 2014 credits had already been used).

[30] The EPA periodically posts updated data on current inventories of gasoline sulfur credits at https://www.epa.gov/fuels-registration-reporting-and-compliance-help/fuels-averaging-banking-and-trading-abt-credit-data. Figure 8 shows historical sulfur credit inventories on a monthly basis beginning June, 2015.

Figure 6: Credit Use (colors show year of credit generation)

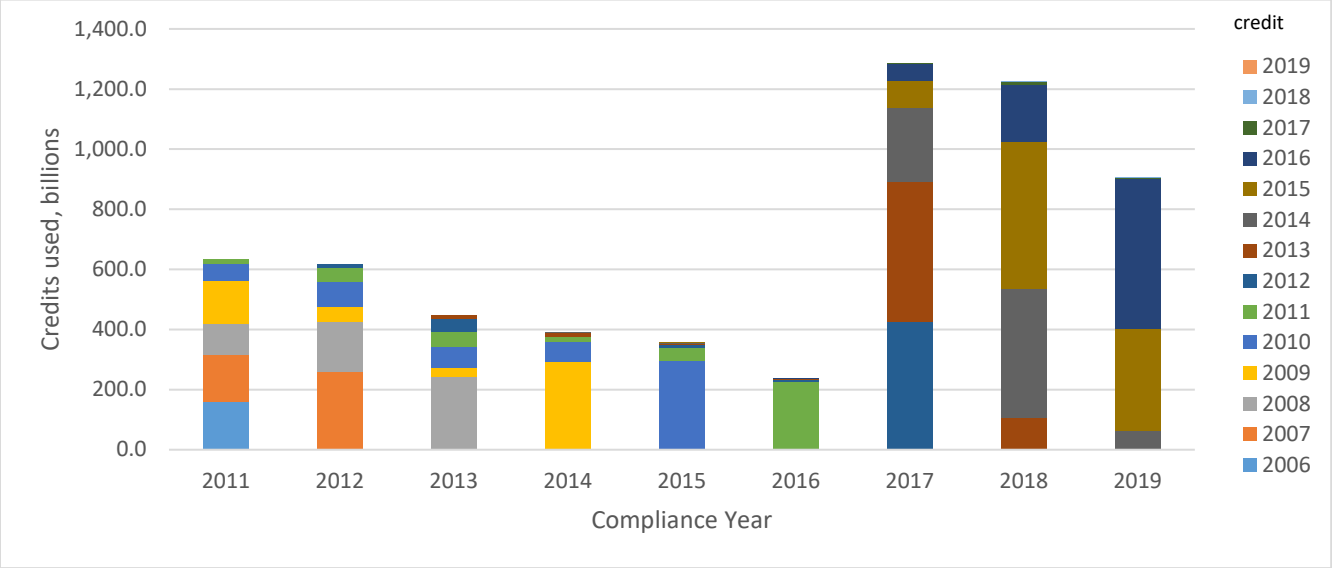


Table 4: Credit Use (in billions), by Year of Credit Generation

Year of Credit Use

Year of Credit Generation	2011	2012	2013	2014	2015	2016	2017	2018	2019
2006	160.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2007	155.6	260.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2008	104.2	163.9	241.1	0.0	0.0	0.0	0.0	0.0	0.0
2009	141.5	52.1	29.5	293.9	0.0	0.0	0.0	0.0	0.0
2010	55.0	84.8	73.3	66.8	294.3	0.0	0.0	0.0	0.0
2011	14.9	43.4	50.4	13.4	46.0	224.1	0.0	0.0	0.0
2012	0.0	10.5	40.4	3.1	8.2	9.9	427.3	0.0	0.0
2013	0.0	0.0	10.6	10.5	4.4	1.0	462.9	106.6	0.0
2014	0.0	0.0	0.0	2.2	2.6	0.6	248.4	429.7	64.2
2015	0.0	0.0	0.0	0.0	2.6	0.9	88.2	489.0	336.8
2016	0.0	0.0	0.0	0.0	0.0	0.3	56.1	189.7	500.8
2017	0.0	0.0	0.0	0.0	0.0	0.0	1.9	9.1	4.0
2018	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.8
2019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	632.0	614.8	445.2	389.9	358.2	236.7	1284.7	1224.6	907.6

Credits can be traded only twice before they are used, to enable reasonable enforcement oversight of the program. Figure 7 and Table 5 present credit use data according to the number of times credits were transferred between refiners and/or importers. CC0 credits are credits that were never transferred by the refiner or importer that generated them, CC1 credits are credits that

were transferred once, and CC2 credits are credits that were transferred twice. Figure 7 and Table 5 indicate that a significant percentage of credits used by refiners and importers each year for compliance are obtained from other refiners and/or importers. [31]

Figure 7: Credit Use (colors show numbers of times credits were transferred)

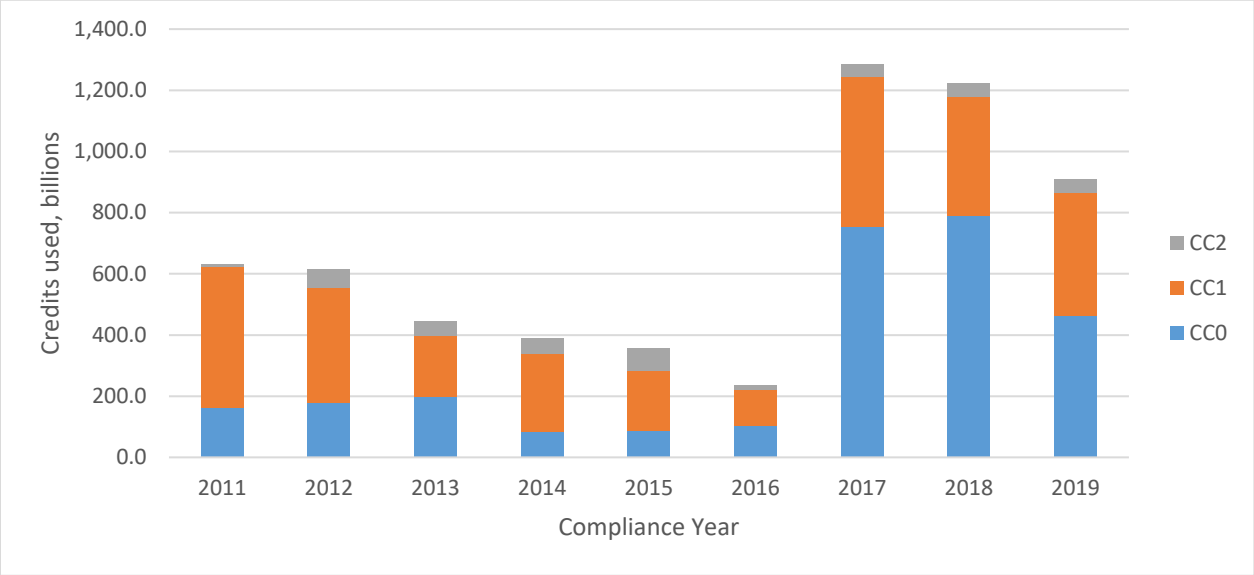


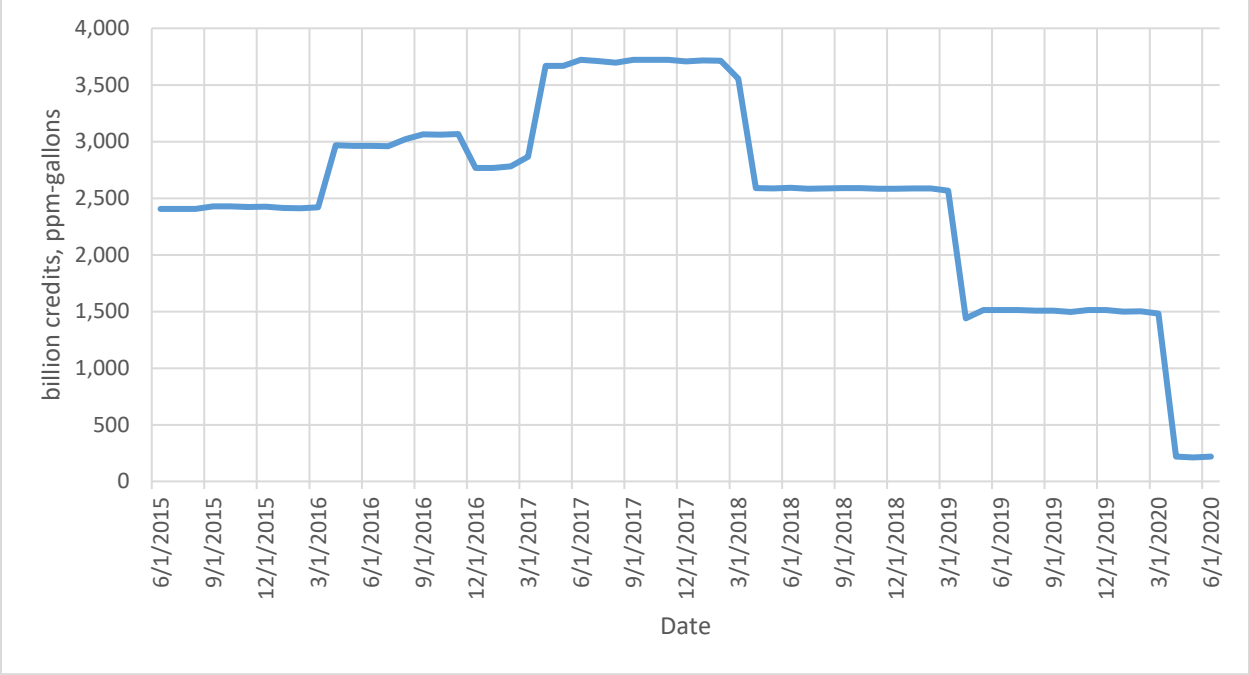
Table 5: Credit Use (in billions), by Number of Times Credits Transferred

Year of Credit Use	Type of Credit Used			Total Use
	CC0	CC1	CC2	
2011	161.8	460.8	9.5	632.0
2012	177.4	378.2	59.2	614.8
2013	197.8	201.8	45.5	445.2
2014	85.2	255.6	49.2	389.9
2015	88.1	196.4	73.7	358.2
2016	104.2	116.6	16.0	236.7
2017	753.9	490.8	40.0	1,284.7
2018	787.2	392.4	45.0	1,224.6
2019	462.1	402.1	43.4	907.6

[31] The limit on credit transfers only applied to transfers between companies (intercompany transfers). Companies that owned more than one refinery and/or more than one import facility could transfer credits between their refineries and import facilities (intracompany transfers) without limit. EPA is aware of a few instances where refiners accidentally assigned a credit transfer code of CC1 (instead of CC0) to intracompany credit transfers, so the number of intercompany-transferred credits is expected to be slightly less than indicated in Figure 7 and Table 5.

Figure 8 shows the variation in the total number of usable credits held by all refiners and importers each month from June, 2015 through June, 2020.[32] Figure 8 shows that the biggest changes in total usable credits held occurs in March of each year, and that the total number of usable credits remained relatively constant for the remainder of the year for most years.[33] Figure 8 also shows how the total number of usable credits held increased in 2015 and 2016, before being drawn down significantly through use or expiration of credits in the 2017, 2018 and 2019 compliance periods.

Figure 8: Total Usable Credits Held by All Refiners and Importers



3. Combined Annual Data from GSF030X and GSF0100 Reports

Tables 6 through 14 show the combined data from the GSF030X reports and the GSF0100 reports for each year from 2011 through 2019, summarizing the data for credit generators, credit users, and total combined credit generators and users. Each table quantifies the relationship between the number of reporting facilities, gasoline volume/sulfur, and quantity of credits generated/used for each year.

For credit generators, each table shows the number of facilities that generated credits, total gasoline production, average sulfur, and total credits generated. For credit users, each table shows the number of facilities that used credits, total gasoline production, average sulfur before use of credits, total credits used, and average sulfur after credit use. For some years from 2011 through 2016, average sulfur after credit use is slightly lower than 30 ppm due to over-compliance by some facilities which used more credits than necessary to meet the 30 ppm

[32] June of 2015 is the first month for which total numbers of credits were available from EMTS.
[33] March is the last month during which refiners and importers can submit compliance reports for the previous compliance year. EPA receives the bulk of its gasoline compliance reports in March.

average sulfur standard. For 2017 through 2019, the results include information reported by small volume refineries and small refiners, which continued to have an annual average compliance standard of 30 ppm sulfur during this time, and information from all other refineries and importers, which had an annual average compliance standard of 10 ppm sulfur beginning in 2017.

Table 6: 2011 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	257	53,474,891,296	21.27	464,872,004,037	----------	21.27
Sulfur credit users	85	61,143,086,933	40.32	----------	631,997,949,988	29.99
Total	342	114,617,978,229	31.43	464,872,004,037	631,997,949,988	25.93

Table 7: 2012 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, pm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	297	57,840,914,920	20.85	521,752,433,180	----------	20.85
Sulfur credit users	95	57,139,164,526	40.76	----------	614,752,724,705	30.00
Total	392	114,980,079,446	30.75	521,752,433,180	614,752,724,705	25.40

Table 8: 2013 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	331	67,617,998,125	21.36	581,985,499,587	----------	21.36
Sulfur credit users	90	47,297,601,663	39.41	----------	445,166,177,796	29.99
Total	421	114,915,599,788	28.79	581,985,499,587	445,166,177,796	24.92

Table 9**:** 2014 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	327	68,296,832,085	18.54	773,369,798,536	----------	18.53
Sulfur credit users	84	47,841,073,575	38.13	----------	389,948,545,636	29.99
Total	411	116,137,905,660	26.61	773,369,798,536	389,948,545,636	23.25

Table 10**:** 2015 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	337	81,954,525,179	17.66	999,863,511,293	----------	17.66
Sulfur credit users	71	37,524,437,331	39.48	----------	358,167,066,402	29.95
Total	408	119,478,962,510	24.51	999,863,511,293	358,167,066,402	21.52

Table 11: 2016 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	371	98,634,876,413	19.99	976,572,320,993	----------	19.99
Sulfur credit users	51	23,546,921,946	39.99	----------	236,741,413,865	29.97
Total	422	122,181,798,359	23.85	976,572,320,993	236,741,413,865	21.91

Table 12: 2017 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	238	24,824,233,110	11.96	151,169,101,590	----------	11.96
Sulfur credit users	208	97,704,257,887	23.53	----------	1,284,698,534,287	10.37
Total	446	122,528,490,997	21.18	151,169,101,590	1,284,698,534,287	10.70

Table 13: 2018 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	251	27,060,133,076	10.05	161,687,588,154	----------	10.05
Sulfur credit users	185	95,707,680,789	23.45	----------	1,224,606,711,464	10.68
Total	436	122,767,813,865	20.49	161,687,588,154	1,224,606,711,464	10.54

Table 14: 2019 Combined Data from GSF0301 and GSF0100 Reports

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	286	35,100,701,584	9.06	189,176,187,090	----------	9.06
Sulfur credit users	191	88,035,606,175	20.82	----------	907,597,343,328	10.52
Total	477	123,136,307,759	17.47	189,176,187,090	907,597,343,328	10.10

4. Small Volume Refinery and Small Refiner Data

Tables 15 through 20 parse the data from Tables 12 through 14 into two separate tables for each year, one table with data for small volume refineries and small refiners, and one table with data for all other refiners and importers. Tables 15 and 16 show data for 2017, tables 17 and 18 show data for 2018, and tables 19 and 20 show data for 2019. A total of 39 refineries were approved under 40 CFR 80.1622 either as small volume refineries, or refineries owned by qualified small refiners.[34] Three of these refineries stopped producing gasoline before 2017, and two more were disqualified in 2015 as small volume refineries under 40 CFR 80.1621(d), because they processed more than 75,000 bpd crude oil on an annual average basis during 2015. Both of the disqualified refineries began complying with the 10 ppm sulfur standard in late December, 2018.[35]

Tables 15 through 20 illustrate how small volume refineries and small refiners collectively complied with the 30 ppm annual average sulfur standard from 2017 through 2019, and how the remaining refiners and importers complied with the 10 ppm annual average sulfur standard beginning in 2017. Annual average sulfur (before credit use) for small volume refineries and small refiners ranged from 22.8 ppm in 2017 to 22.2 ppm in 2019, less than their 30 ppm annual average standard, and required the use of only 53.2 billion credits total from 2017 through 2019. Annual average sulfur (before credit use) for all other refineries and importers ranged from 21.0 ppm in 2017 to 17.0 ppm in 2019, above their 10 ppm annual average standard, and required the use of 3.36 trillion credits total from 2017 through 2019.

Table 15 through 20 also show that the majority of credits generated from 2017 through 2019 were generated by small volume refineries and small refiners. A total of approximately 508.8 billion credits were generated by all refiners and importers from 2017 through 2019, including 307.7 billion credits generated by small volume refineries and small refiners, and 201.1 billion credits generated by all other refiners and importers.

[34] This total included 37 small volume refineries and 2 refineries owned by approved small refiners. Both of the refineries owned by approved small refiners could have also qualified as small volume refineries because they processed less than 75,000 bpd crude oil on an annual average basis during 2012.

[35] Small volume refineries or small refiners that were disqualified had a 30 month grace period to begin complying with the 10 ppm sulfur standard. For refineries disqualified in 2015, the grace period started June 21, 2016, which was the effective date of a rulemaking which established the disqualification provisions in the Tier 3 gasoline sulfur regulations.

Of the 307.7 billion credits generated by small volume refineries and small refiners from 2017 through 2019, 283.5 billion credits were generated by refineries producing gasoline with an annual average sulfur between 10 ppm and 30 ppm, and 24.2 billion credits were generated by refineries producing gasoline with an annual average sulfur less than 10 ppm. The 283.5 billion credits were generated under the temporary ABT program for small volume refineries and small refiners, and were all either used by small volume refineries and small refiners from 2017 through 2019, or expired after 2019. The remaining 24.2 billion credits generated by small volume refineries and small refiners could be used like the 201.1 billion credits generated by other refiners and importers from 2017 through 2019.

Table 15: 2017 Combined Data from GSF0301 and GSF0100 Reports
Small Volume Refineries and Small Refiners

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	30	10,148,048,885	19.69	104,650,642,484	----------	19.69
Sulfur credit users	6	1,715,789,834	41.13	----------	19,068,489,682	30.02
Total	36	11,863,838,719	22.79	104,650,642,484	19,068,489,682	21.18

Table 16: 2017 Combined Data from GSF0301 and GSF0100 Reports
Non-Small Volume Refineries, Non-Small Refiners, and Importers

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	208	14,676,184,225	6.62	46,518,459,106	----------	6.62
Sulfur credit users	202	95,988,468,053	23.21	----------	1,265,630,044,605	10.02
Total	410	110,664,652,278	21.01	46,518,459,106	1,265,630,044,605	9.57

Table 17: 2018 Combined Data from GSF0301 and GSF0100 Reports
Small Volume Refineries and Small Refiners

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	27	8,316,615,081	16.93	108,608,464,516	----------	16.93
Sulfur credit users	9	3,249,110,645	36.56	----------	21,351,283,894	30.00
Total	36	11,565,725,726	22.44	108,608,464,516	21,351,283,894	20.60

Table 18: 2018 Combined Data from GSF0301 and GSF0100 Reports
Non-Small Volume Refineries, Non-Small Refiners, and Importers

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	224	18,743,517,995	6.99	53,079,123,638	----------	6.99
Sulfur credit users	176	92,458,570,144	22.99	----------	1,203,255,427,570	10.00
Total	400	111,202,088,139	20.29	53,079,123,638	1,203,255,427,570	9.49

Table 19: 2019 Combined Data from GSF0301 and GSF0100 Reports
Small Volume Refineries and Small Refiners

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	24	7,973,909,082	18.16	94,404,778,041	----------	18.16
Sulfur credit users	8	2,447,053,084	35.23	----------	12,783,875,809	30.00
Total	32	10,420,962,166	22.17	94,404,778,041	12,783,875,809	20.94

Table 20: 2019 Combined Data from GSF0301 and GSF0100 Reports
Non-Small Volume Refineries, Non-Small Refiners, and Importers

Report	GSF0301	GSF0301	GSF0301	GSF0100	GSF0100	GSF0301
	Number of facilities	Gasoline produced, gallons	Average sulfur, ppm	Total credits generated, ppm-gallons	Total credits used, ppm-gallons	Average sulfur after credit use, ppm
Sulfur credit generators	262	27,126,792,502	6.38	94,771,409,049	----------	6.38
Sulfur credit users	183	85,588,553,091	20.41	----------	894,813,467,519	9.96
Total	445	112,715,345,593	17.03	94,771,409,049	894,813,467,519	9.10

5. Compliance with 80 ppm Per-Gallon Standard

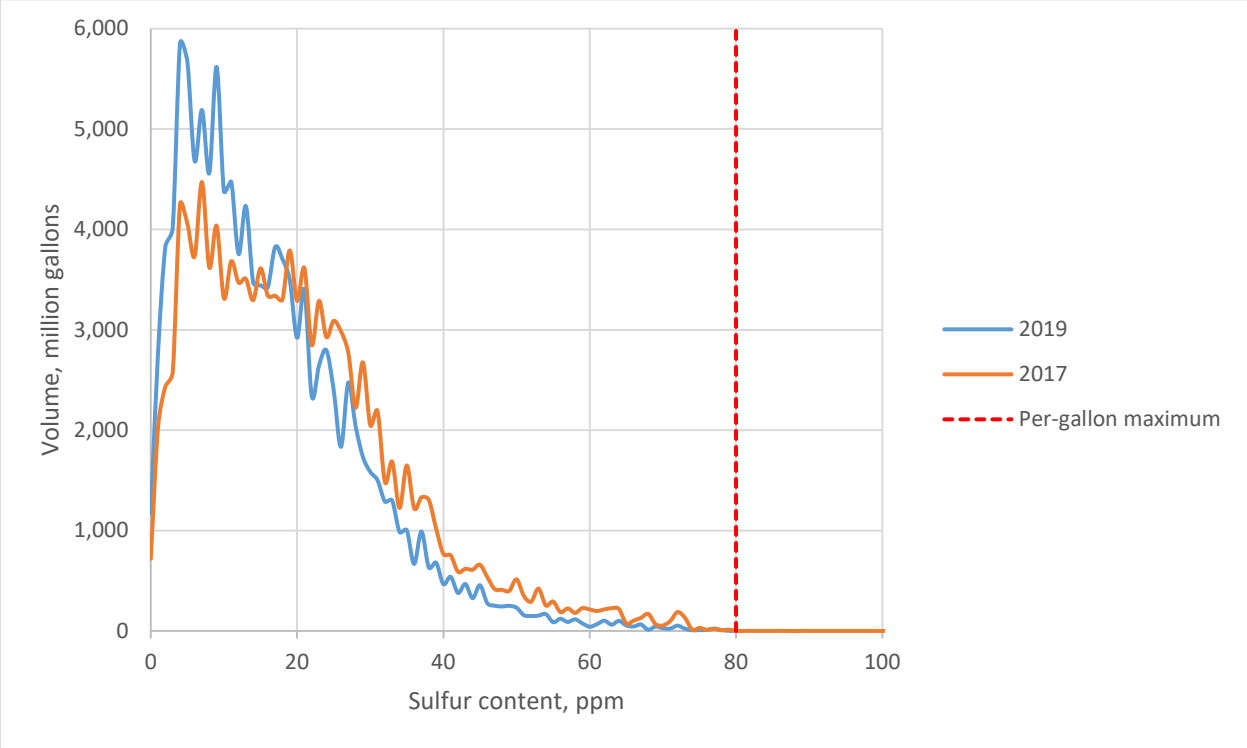
Figure 9 illustrates how sulfur in individual batches of gasoline changed from 2017 to 2019. Based on batch data submitted in the RFG030X reports, Figure 9 shows the percentage of total gasoline for 2017 (orange line) and 2019 (blue line), as a function of sulfur content (in 1 ppm increments). As expected, the 2019 distribution curve is shifted to the left compared to the 2017 curve, due to sulfur reductions by refiners and importers from 2017 to 2019.

Figure 9 also illustrates compliance by refiners and importers with the 80 ppm per-gallon sulfur standard. The right side of the curve indicates that a small percentage (0.0019 percent) of total gasoline exceeded the 80 ppm per-gallon standard in 2017, and approximately the same percentage (0.003 percent) exceeded 80 ppm in 2019. From 2017 through 2019, a total of only 105 batches out of approximately 180,000 batches were reported containing more than 80 ppm

sulfur. Ninety nine of these batches were reported in 2018, and were blendstocks which were added to previously certified gasoline (PCG), where the final blends of blendstock and PCG had a sulfur content less than 80 ppm. Another 3 of these batches contained less than 95 ppm sulfur, which is the per-gallon sulfur standard downstream of refineries and import facilities. The remaining 3 batches were reported with a sulfur concentration of 970 ppm, which is the default sulfur concentration specified in 40 CFR 80.80 that is used when a refiner or importer doesn't have a sulfur test result for a batch of gasoline.

The total volume of these 105 batches was 26 million gallons, which represented approximately 0.007 percent of the total reported volume of 363 billion gallons from 2017 through 2019. Most of this volume (20 million gallons) was blendstocks that were blended into PCG, where each blend of PCG and blendstock was tested to ensure that the sulfur of the blend was less than 80 ppm, Therefore, all gasoline used in vehicles was likely to have been below the 95 ppm downstream per-gallon standard.

Figure 9: Annual Distribution of Gasoline Sulfur Content in 2017 and 2019 (from RFG030X Reports)



6. 2020 Gasoline Sulfur Data Submitted to EPA

At the time this report was published, EPA had not yet received annual gasoline sulfur reports for 2020. However, EPA had received RFG0303 gasoline batch reports from refiners

and importers for all RFG produced or imported during the first two quarters of 2020.[36] These batch reports include the volume and properties of each batch of RFG produced or imported during the first six months of 2020, including the sulfur concentration of each batch. The total volume of gasoline included in these reports is 13.74 billion gallons, and the average sulfur content of this volume is 7.7 ppm. Although this volume represents only approximately 11% of 2019 total gasoline production and importation, EPA believes the relatively low average RFG sulfur concentration for the first 6 months of 2020 indicates significant progress by refiners and importers towards complying with the 10 ppm annual average sulfur standard in 2020. Also, although the sulfur concentration of CG produced in 2020 is unknown to EPA at this time, the annual average sulfur concentrations of CG and RFG have been relatively close since 2011, as shown in Table 21 below.

Table 21: Annual Average Sulfur Concentrations for CG and RFG from RFG030X Reports

Year	Annual average sulfur, ppm		Sulfur difference, ppm
	CG	RFG	(CG minus RFG)
2011	31.57	31.28	0.29
2012	30.71	31.25	-0.54
2013	29.08	28.36	0.72
2014	26.08	28.08	-2.00
2015	25.01	23.37	1.64
2016	23.96	23.83	0.13
2017	20.99	21.54	-0.55
2018	20.36	20.52	-0.16
2019	17.32	17.21	0.11

[36] Refiners and importers are required to submit RFG030X batch reports on a quarterly basis for all RFG produced or imported during each quarter. Refiners and importers are only required to submit RFG030X batch reports on an annual basis for all CG produced or imported during a compliance year.

IV. Conclusion

The gasoline sulfur analysis presented in this report shows a high level of compliance with refinery and importer annual average and per-gallon sulfur standards under the Tier 3 gasoline sulfur program from 2017 through 2019, and a significant increase in the use of gasoline sulfur credits for compliance with the 10 ppm annual average standard beginning in 2017. The gasoline sulfur credit program analysis further illustrates the beneficial flexibility it has provided the industry in lowering gasoline sulfur levels over time.

Compliance data reported to the EPA by refiners illustrates several key findings:

- Refiners and importers have taken full advantage of the flexibilities of the ABT program to reduce sulfur levels at a rate and time that is most conducive to their business plans.
- The national annual average reported sulfur content of gasoline, before credits, decreased from 21.18 ppm in 2017 to 17.47 ppm in 2019.
- Although EPA has only limited reporting of 2020 data at this time, the data we have suggests that the average gasoline sulfur concentration for 2020 will be below 10 ppm without the use of credits (see Section III.6 for a discussion of the available 2020 data).
- Tier 3 credit generation (beginning in 2017) was much lower than Tier 2 credit generation, as refiners and importers generated a total of 224.3 billion standard Tier 3 credits (i.e., credits with a 5 year life) from 2017 through 2019, compared to 976.6 billion Tier 2 credits generated in 2016.
- The percentage of gasoline produced or imported at facilities averaging 10 ppm sulfur or less on an annual basis increased from 20.3 percent in 2017 to 28.5 percent in 2019.
- Refiners and importers used large quantities of sulfur credits for compliance with the 10 ppm annual average standard in 2017 through 2019, but still let560 billion credits expire at the end of the 2019 compliance period, including both "early" Tier 3 credits and credits generated by small volume refineries and small refiners.
- Small volume refineries and small refiners successfully utilized the provisions in the Tier 3 regulations which allowed them 3 additional years to comply with the 10 ppm annual average sulfur standard.

This report, along with other fuels trends analyses and sulfur compliance credit data posted on the agency's website, provide comprehensive information about the EPA's national gasoline sulfur control programs and their effects in reducing gasoline sulfur levels in the U.S.[37] The EPA will continue to make gasoline sulfur data available to maximize the transparent implementation of its regulatory programs.

[37] See https://www.epa.gov/fuels-registration-reporting-and-compliance-help/public-data-gasoline-programs.

V. Appendix

Life of a Standard Sulfur ABT Credit