



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NC 27711

OFFICE OF
AIR QUALITY PLANNING
AND STANDARDS

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MEMORANDUM

FROM: Doug Solomon, Air Quality Analysis Group *Doug Solomon*
Air Quality Analysis Division

Nicole Hagan, Ambient Standards Group *Nicole Hagan*
Stephen Graham, Risk and Benefits Group *Stephen Graham*
Health and Environmental Impacts Division

TO: Docket for the Primary NAAQS for Sulfur Oxides (EPA-HQ-OAR-2013-0566)

SUBJECT: Additional SO₂ Air Quality Analyses

This document presents air quality analyses conducted to support the review of the primary national ambient air quality standard (NAAQS) for sulfur oxides, including sulfur dioxide (SO₂). The purpose of these analyses is to inform consideration of certain issues raised in public comments received on the proposed decision to retain the current standard, without revision (83 FR 26752, June 8, 2018). These analyses focus in particular on comments suggesting that EPA consider alternative forms or averaging times for this standard. The following are presented in this memo:

- I. Analyses of Recent National SO₂ Monitoring Dataset (2014-2016)
- II. Analysis of Modeled 1-hour Air Quality Scenarios in the Risk and Exposure Assessment (REA) Study Areas

I. Analyses of Recent National SO₂ Monitoring Dataset (2014-2016)

A. Overview of Dataset Preparation

The preparation of this air quality dataset is described in Appendix A of the Policy Assessment (PA) for the current review of the primary SO₂ NAAQS (U.S. EPA, 2018a). As described in the PA, the data were drawn from the EPA's Air Quality System database, the official repository of NAAQS-comparable ambient measurements, in August 2016 for 2015 and earlier data and in May 2017 for 2016 data. The dataset includes 1-hour and 5-minute SO₂ measurements at Federal Reference Method/Federal Equivalent Method monitors. Completeness criteria were applied to the data, followed by additional data screening for the 5-minute data. See Appendix A of the PA for more detail.

B. Summary of the Analyses

For all 337 monitors meeting the completeness criteria for the recent 3-year period (2014-2016), design values (DVs) were calculated based on the current 1-hour 99th percentile standard, averaged over 3 years, and based on standards with certain alternative forms or averaging times that were discussed in public comments. For the current standard and these alternatives, monitors were binned based on the magnitude of the DVs, and the count of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above certain benchmarks (200 ppb, 300 ppb, and 400 ppb) were tabulated for each year in the 3-year period. For the current standard, these counts are shown in Table 1. These counts for standards with alternative 98th percentile and 99th percentile hourly forms are shown in Tables 2 and 3. Design values for the current standard and an alternative 99th percentile hourly form are plotted for each monitor in Figure 1.

A similar analysis was also performed with the subset of monitors that did not meet the current standard (i.e., with DVs above 75 ppb). For those monitors, we tallied the number of instances when: (1) the 1-hour average concentration was above 75 ppb and the 5-minute hourly maximum concentration was at or above 200 ppb, and (2) the 1-hour average concentration was at or below 75 ppb and the 5-minute hourly maximum concentration was at or above 200 ppb. These counts are shown in Table 4 below.

A third type of analysis was performed for the subset of monitors sited within 1 kilometer of sources reporting at least 4000 tons per year SO₂ emissions in the 2014 National Emissions Inventory. Design values were calculated in terms of the current standard and in terms of standards with alternate 3-hour, 8-hour, and 24-hour averaging times. The standard form is the same for all the DVs (annual 99th percentile, daily maximum average concentration, averaged over 3-years). The count of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above certain 5-minute benchmarks (200 ppb, 300 ppb, and 400 ppb) were tabulated for monitors and binned based on their DV.

For the current standard, these counts are shown in Table 5. For standards calculated with alternate averaging times, these counts are shown in Tables 6 to 8 below. A summary of the various DVs for each of these monitors, along with the annual count of 5-minute daily maximum concentrations above 200 ppb, 300 ppb and 400 ppb, is presented in Table 9.

Table 1. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb for DVs in terms of the current standard (annual 99th percentile daily maximum 1-hour average concentrations, averaged over three years).

		DV ≤ 25 N = 252			DV >25-50 N = 47			DV >50-75 N = 19			DV >75-100 N = 11			DV >100-125 N = 1			DV >125-150 N = 2			DV >150 N = 5		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	9	5	2	31	8	3	47	11	1	241	59	15	52	9	0	120	10	1	307	111	51
	2015	6	1	0	14	2	1	4	1	0	107	14	2	12	1	0	122	9	0	231	87	47
	2016	8	3	1	10	3	2	0	0	0	25	2	0	0	0	0	37	2	0	353	160	81
Number of 5-min daily max conc. above benchmark	2014	6	4	2	21	7	2	31	8	1	127	39	13	25	4	0	63	9	1	181	76	42
	2015	6	1	0	12	2	1	4	1	0	61	7	2	5	1	0	56	8	0	160	66	38
	2016	5	2	1	8	3	2	0	0	0	15	2	0	0	0	0	23	2	0	175	92	57

Table 2. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb benchmarks for DVs in terms of a standard with an alternate 98th percentile form (annual 98th percentile daily maximum 1-hour average concentrations, averaged over three years).

		DV ≤ 25 N = 276			DV >25-50 N = 35			DV >50-75 N = 17			DV >75-100 N = 3			DV >100-125 N = 1			DV >125-150 N = 2			DV >150 N = 3		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	29	9	3	41	10	2	182	58	15	133	18	1	92	30	1	122	10	1	211	79	50
	2015	16	1	0	8	3	1	43	12	2	77	3	0	13	0	0	122	9	0	218	87	47
	2016	15	4	1	38	28	10	25	2	0	0	0	0	23	3	0	37	2	0	296	131	73
Number of 5-min daily max conc. above benchmark	2014	19	8	3	31	7	1	99	38	13	64	12	1	35	14	1	63	9	1	143	60	41
	2015	14	1	0	8	3	1	27	6	2	40	2	0	11	0	0	56	8	0	149	66	38
	2016	10	3	1	8	7	6	15	2	0	0	0	0	13	2	0	23	2	0	157	85	53

Table 3. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb benchmarks for DVs in terms of a standard with an alternate hourly form (annual 99th percentile of 1-hour average concentrations, averaged over three years).

		DV ≤ 25 N = 312			DV >25-50 N = 17			DV >50-75 N = 6			DV >75-100 N = 1			DV >100-125 N = 1			DV >125-150 N = 0			DV >150 N = 0		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	104	33	10	200	54	10	290	70	19	98	5	0	118	52	34	0	0	0	0	0	0
	2015	25	4	0	54	13	3	209	49	21	93	2	0	116	47	26	0	0	0	0	0	0
	2016	54	32	11	24	2	0	61	10	2	31	2	0	264	124	71	0	0	0	0	0	0
Number of 5-min daily max conc. above benchmark	2014	73	26	8	101	32	9	156	47	16	44	4	0	80	39	28	0	0	0	0	0	0
	2015	22	3	0	32	8	3	139	37	17	35	2	0	77	36	21	0	0	0	0	0	0
	2016	19	10	7	14	2	0	43	9	2	18	2	0	132	78	51	0	0	0	0	0	0

Table 4. Counts of 5-minute hourly maximum SO₂ concentrations at or above 200 ppb in hours with 1-hour concentrations above 75 ppb and in hours with 1-hour concentrations at or below 75 ppb at monitors that do not meet the current standard

Monitors with 2014-2016 DV >75 ppb (DV)	Number of hourly maximum 5-minute concentrations ≥200 ppb								
	In hours >75 ppb				In hours ≤75 ppb				In all hours across all 3 years
	2014	2015	2016	3-yr Total	2014	2015	2016	3-yr Total	
040070009 (146)	16	25	3	44	8	4	3	15	59
040070011 (200)	39	40	16	95	10	12	7	29	124
040070012 (194)	40	44	6	90	4	6	3	13	103
040071001 (280)	78	63	170	311	40	53	93	186	497
120170006 (81)	4	4	0	8	6	1	0	7	15
171790004 (151)	58	8	15	81	34	5	8	47	128
181250005 (114)	21	1	0	22	6	2	1	9	31
191390016 (77)	4	0	0	4	0	0	0	0	4
191390019 (84)	18	1	0	19	6	5	0	11	30
191390020 (113)	41	10	0	51	11	2	0	13	64
211110051 (76)	37	1	0	38	31	1	0	32	70
220870007 (82)	2	3	5	10	3	0	6	9	19
290950034 (92)	40	44	0	84	36	17	0	53	137
390350065 (168)	4	0	34	38	0	0	1	1	39
390850007 (80)	4	9	7	20	3	4	3	10	30
391150004 (85)	13	4	0	17	2	2	0	4	21
420030064 (94)	0	4	3	7	0	0	0	0	7
421230004 (92)	5	3	0	8	0	1	0	1	9
550850996 (149)	77	72	16	165	19	21	15	55	220

Table 5. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb binned by DVs for the current 1-hour standard (annual 99th percentile daily maximum 1-hour average concentration, averaged over three years), for the subset of monitors within 1 km of sources emitting >4000 tpy.

		DV ≤ 25 N = 0			DV >25-50 N = 0			DV >50-75 N = 1			DV >75-100 N = 2			DV >100-125 N = 1			DV >125-150 N = 0			DV >150 N = 2		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	0	0	0	0	0	0	8	1	0	51	21	8	52	9	0	0	0	0	210	82	35
	2015	0	0	0	0	0	0	0	0	0	9	2	0	12	1	0	0	0	0	129	47	26
	2016	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	286	127	71
Number of 5-min daily max conc. above benchmark	2014	0	0	0	0	0	0	2	1	0	29	12	6	25	4	0	0	0	0	115	53	29
	2015	0	0	0	0	0	0	0	0	0	7	1	0	5	1	0	0	0	0	88	36	21
	2016	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	145	80	51

Table 6. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb binned by DVs for a standard with an alternate 3-hour averaging time (annual 99th percentile daily maximum 3-hour average concentration, averaged over three years), for the subset of monitors within 1 km of sources emitting >4000 tpy.

		DV ≤ 25 N = 0			DV >25-50 N = 0			DV >50-75 N = 3			DV >75-100 N = 1			DV >100-125 N = 1			DV >125-150 N = 0			DV >150 N = 1		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	0	0	0	0	0	0	59	22	8	52	9	0	92	30	1	0	0	0	118	52	34
	2015	0	0	0	0	0	0	9	2	0	12	1	0	13	0	0	0	0	0	116	47	26
	2016	0	0	0	0	0	0	1	0	0	0	0	0	23	3	0	0	0	0	263	124	71
Number of 5-min daily max conc. above benchmark	2014	0	0	0	0	0	0	31	13	6	25	4	0	35	14	1	0	0	0	80	39	28
	2015	0	0	0	0	0	0	7	1	0	5	1	0	11	0	0	0	0	0	77	36	21
	2016	0	0	0	0	0	0	1	0	0	0	0	0	13	2	0	0	0	0	132	78	51

Table 7. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb binned by DVs for a standard with an alternate 8-hour averaging time (annual 99th percentile daily maximum 8-hour average concentration, averaged over three years), for the subset of monitors within 1 km of sources emitting >4000 tpy.

		DV ≤ 25 N = 0			DV >25-50 N = 2			DV >50-75 N = 3			DV >75-100 N = 1			DV >100-125 N = 0			DV >125-150 N = 0			DV >150 N = 0		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	0	0	0	35	14	7	168	47	2	118	52	34	0	0	0	0	0	0	0	0	0
	2015	0	0	0	3	2	0	31	1	0	116	47	26	0	0	0	0	0	0	0	0	0
	2016	0	0	0	1	0	0	23	3	0	263	124	71	0	0	0	0	0	0	0	0	0
Number of 5-min daily max conc. above benchmark	2014	0	0	0	19	10	5	72	21	2	80	39	28	0	0	0	0	0	0	0	0	0
	2015	0	0	0	2	1	0	21	1	0	77	36	21	0	0	0	0	0	0	0	0	0
	2016	0	0	0	1	0	0	13	2	0	132	78	51	0	0	0	0	0	0	0	0	0

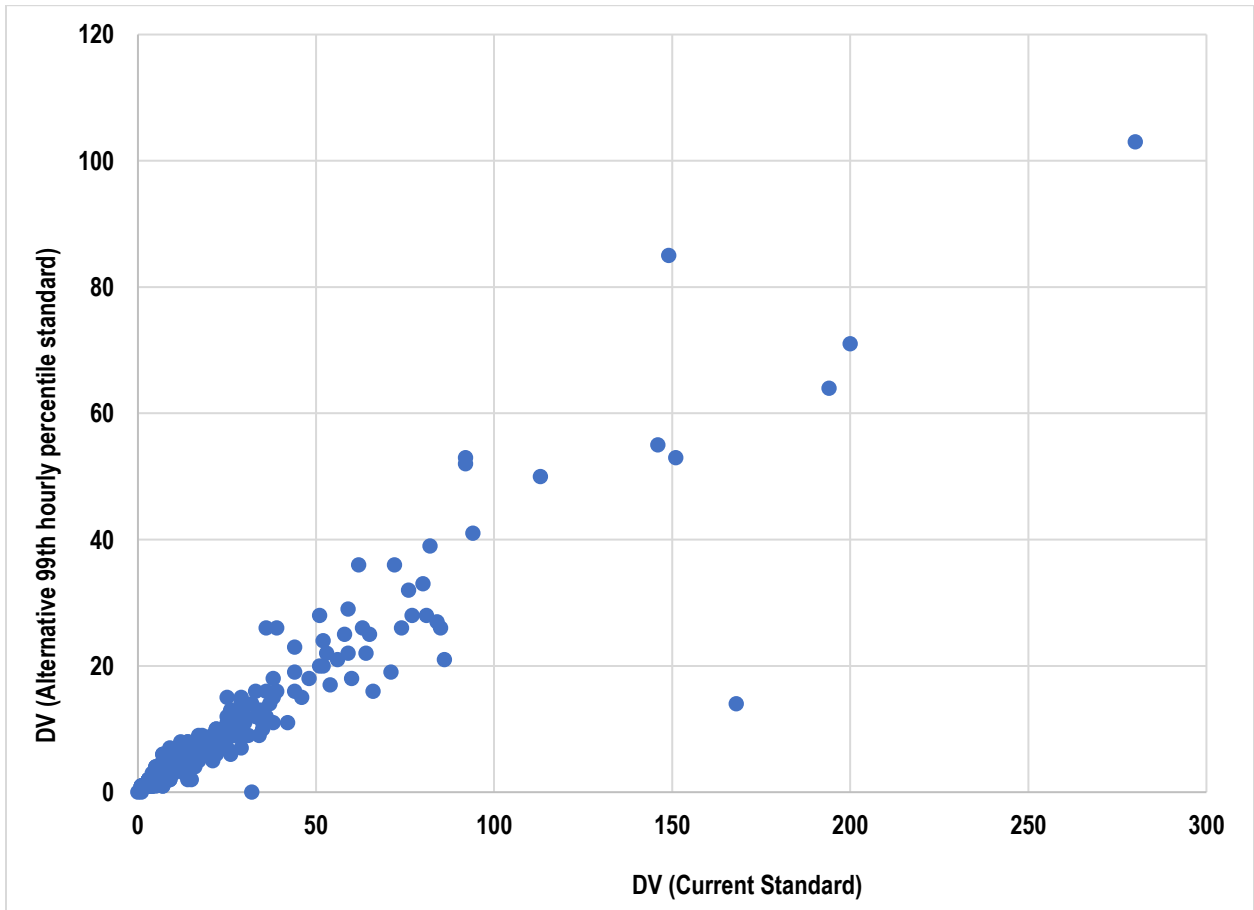
Table 8. Counts of hourly maximum and daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb binned by DVs for a standard with an alternate 24-hour averaging time (annual 99th percentile 24-hour average concentration, averaged over three years), for the subset of monitors within 1 km of sources emitting >4000 tpy.

		DV ≤ 25 N = 3			DV >25-50 N = 3			DV >50-75 N = 0			DV >75-100 N = 0			DV >100-125 N = 0			DV >125-150 N = 0			DV >150 N = 0		
Benchmark (ppb)		200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400	200	300	400
Number of 5-min hourly max conc. above benchmark	2014	59	22	8	262	91	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2015	9	2	0	141	48	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	1	0	0	286	127	71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Number of 5-min daily max conc. above benchmark	2014	31	13	6	140	57	29	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2015	7	1	0	93	37	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2016	1	0	0	145	80	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 9. Annual counts of daily maximum 5-minute SO₂ concentrations at or above 200, 300, and 400 ppb for the subset of monitors within 1 km of sources emitting >4000 tpy.

Monitor ID	2016 DV for current standard (1 hr averaging time)	Year	Number of daily max 5-min concentrations above benchmark for current standard			2016 DV for standards with alternate averaging time		
			200 ppb	300 ppb	400 ppb	3 hrs	8 hrs	24 hrs
191130041	72	2014	2	1	0	57	42	19
		2015	0	0	0			
		2016	0	0	0			
		Total	2	1	0			
181250005	86	2014	17	9	5	58	32	13
		2015	2	1	0			
		2016	1	0	0			
		Total	20	10	5			
191390020	113	2014	25	4	0	65	74	33
		2015	5	1	0			
		2016	0	0	0			
		Total	30	5	0			
191390019	84	2014	12	3	1	73	54	17
		2015	5	0	0			
		2016	0	0	0			
		Total	17	3	1			
171790004	151	2014	35	14	1	116	74	29
		2015	11	0	0			
		2016	13	2	0			
		Total	59	16	1			
040071001	280	2014	80	39	28	172	87	39
		2015	77	36	21			
		2016	132	78	51			
		Total	289	153	100			

Figure 1. Design values at U.S. monitoring locations in terms of the current standard and a standard with an alternate hourly form (annual 99th percentile of 1-hour average concentrations, averaged over three years).



II. Analysis of Modeled 1-hour Air Quality Scenarios in the REA Study Areas

A. Overview of Dataset Preparation

As described in Chapter 3 of the REA (U.S. EPA, 2018b), the EPA's preferred model for near-field dispersion, American Meteorological Society/EPA regulatory model (AERMOD) (U.S. EPA, 2016 a, b), was used to generate 1-hour concentrations to a fine-scale spatial grid of receptor points (sized from between 100 meters and 2 kilometers) for the 3-year period (2011-2013) in three study areas: Fall River, MA, Indianapolis, IN, and Tulsa OK. Details regarding modeling approaches and input data used are provided in Chapter 3 and Appendices A, B, and C of the REA. These modeled hourly ambient air concentrations were then adjusted to just meet the current primary SO₂ standard and were combined with air quality monitoring data and other information to estimate exposure and health risk. See Chapter 3 of the REA for more detail on estimation of ambient air concentrations in the REA study areas.

B. Summary of the Analyses

For each study area, the modeled fine-scale hourly air quality surface adjusted to just meet the current standard was used to calculate DVs for all modeled receptor concentrations based on potential standards with certain alternate forms or averaging times discussed in public comments. Maximum DVs for potential alternate standards in each study area are shown in Table 10 below.

Table 10. Maximum design values (ppb) derived for certain alternative standards from model-estimated hourly air quality adjusted to just meet the current standard in REA study areas.

Study Area	Maximum DV (ppb) for alternate hourly form (annual 99th percentile of 1-hour average concentrations, averaged over three years)	Maximum DV (ppb) for alternate 98th percentile form (annual 98th percentile daily maximum 1-hour average concentrations, averaged over three years)
Fall River, MA	31	59
Indianapolis, IN	50	71
Tulsa, OK	65	73

References

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