How truncation and rounding affect attainment of the U.S. ozone standard

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Abstract

In the United States, ozone in outdoor air is limited by law to 70 parts per billion. Whether a monitoring site meets the limit is judged by a three-year statistic of its readings, the design value, which the regulation truncates at the last reported digit for ozone but rounds for fine particulate matter. For ozone the two conventions differ by half a part per billion at that digit, and environmental groups have repeatedly asked the Environmental Protection Agency (EPA) to round. However, the ozone design value results from a chain of calculations that begins with hourly concentrations and eight-hour averages, and the regulation discards digits at three points in that chain. From the public monitoring data we recompute those design values published by EPA for 2020–2025 that lie within one unit in the last digit of a standard. For about one in three of these borderline values, whether the site attains depends on the treatment of the final digit alone. For ozone, 61 of 190 borderline values that attain as published would violate if the final digit were rounded instead, and at least 148 if the eight-hour averages were rounded as well. As written, the rule also lets a site attain although its three-year mean computed without truncating the eight-hour averages exceeds the limit by almost three times the half part per billion in dispute. Whichever convention is kept, EPA could state beside each published design value whether the site's status depends on that choice, and we give the list of such values for the years studied.

Keywords: ozone; $PM_{2.5}$; NAAQS; design value; attainment; data handling; truncation; rounding

1 Introduction

Whether the outdoor air of a region of the United States meets a federal air-quality standard is determined by computing a statistic from several years of monitor readings and comparing it with a fixed limit. The regulation that prescribes the computation also prescribes what is done with the digits beyond the last one reported, and near the limit the outcome can depend on that choice, truncation or rounding. Within one body of federal regulation, 40 CFR Part 50 [Code of Federal Regulations, 2026], the statistic for ozone is truncated and the statistics for fine particulate matter are rounded.

Under the Clean Air Act the Environmental Protection Agency (EPA) sets National Ambient Air Quality Standards (NAAQS) and determines whether the air of each region meets them. For each monitoring site a design value is calculated from three years of measurements and compared with the level of the standard. For ozone the design value is the annual fourth-highest daily

* Work done with Anthropic, but results and views are not endorsed by Anthropic.

maximum eight-hour average, averaged over three years, and the level of the standard is 70 parts per billion (ppb), written as 0.070 ppm in the regulation. Fine particulate matter ($PM_{2.5}$) has two design values, three-year averages of the annual mean and of the annual 98th percentile of the daily means, with levels of 9.0 and 35 $\mu g/m^3$ respectively. Appendix U to Part 50 instructs that the three-year ozone average be truncated to three decimals. Thus a computed value of $0.070\overline{6}$ ppm is reported as 0.070 ppm and meets the standard, whereas the rounded value, 0.071, would exceed it. Appendix N instructs instead that the $PM_{2.5}$ statistics be rounded, which turns a daily value of 35.5 $\mu g/m^3$ into 36, a violation. In both cases a design value equal to the level of the standard meets it.

A nonattainment designation triggers mandatory state implementation plans and permitting constraints on industry, and, where a state fails to submit an adequate implementation plan, sanctions on federal highway funds under Section 179 of the Clean Air Act. Over 1972–1987, counties designated nonattainment lost, relative to attaining counties, approximately 590,000 jobs, $37 billion in capital stock, and $75 billion (in 1987 dollars) of output in pollution-intensive industries [Greenstone, 2001]. Recent determinations have turned on the last digit. In 2022, for example, Atlanta attained the 2015 ozone standard at a design value of 0.070 ppm, while Washington, DC, St. Louis, and Milwaukee, at 0.071 ppm, failed to attain and were reclassified from Marginal to Moderate [U.S. Environmental Protection Agency, 2022].

The published ozone design value is obtained through a chain of intermediate quantities: hourly concentrations, eight-hour averages, each day's maximum, each year's fourth-highest daily maximum, and the three-year mean. Appendix U truncates digits at three of these stages, namely at the hourly concentration, at each eight-hour average, and at the three-year mean. A site whose status does not depend on the final digit may therefore still attain only because the eight-hour averages were truncated.

That the digit conventions could affect attainment determinations has been remarked before: Fairley [1999] observed that rounding conventions can misclassify areas near the standard. In the ozone rulemakings of 1997 and 2008, health and environmental organizations asked EPA for a stricter treatment of the final digit, industry associations supported the existing one, and EPA declined the stricter alternative both times. In 2010 EPA itself proposed to carry all digits and round the three-year average once, citing the downward bias of the repeated truncation (75 FR 3031); the proposal was withdrawn in 2011. Sierra Club objected to the truncation conventions in a 2022 comment that is pending in EPA's current review of the standard. To our knowledge, none of these documents (Table 1) tabulates which of the published, legally operative determinations depend on the choice between truncation and rounding.

In this paper we examine every ozone and $PM_{2.5}$ design value in EPA's Design Value Reports for 2020–2025 that is within one unit in the last reported digit of its standard, and call such a value borderline. We calculate each from the daily and hourly data in EPA's Air Quality System (AQS) as Appendices U and N prescribe, and again with one provision changed: the final-digit rule, the comparison with the level, or the data-completeness requirements. The first of the three ozone truncations is applied to the hourly values before they are reported, but the other two act on quantities calculated from the reported values, so that their effect can be computed from the public data. For ozone we therefore also vary the truncation of the eight-hour averages, replacing it and the final truncation by rounding at both steps, by the single final rounding that EPA proposed in 2010, or by a single final truncation. Appendix A gives the resulting list of borderline values, with the status of each under every alternative examined.

We find that for about one in three of the borderline values, ozone and $PM_{2.5}$ together, attainment turns on the choice between truncation and rounding at the final digit. Here the $PM_{2.5}$ values of every period are measured against the levels in force since 2024. For ozone, the determinations that depend on the final digit alone are fewer than half of those that change when both the eight-hour and the final truncations are replaced by rounding. The counts are for site-level design values; a formal area designation involves further administrative steps that are not modeled here. Throughout, we make no claim that any area should or should not be designated nonattainment, and no claim that any convention is wrong. The conventions are law and EPA applies them as written. The counts that follow establish only which determinations would change if the convention alone were changed, with the measurements fixed, and how many.

2 Regulatory background

Appendix U to 40 CFR Part 50 [Code of Federal Regulations, 2026] prescribes the attainment calculation for ozone and Appendix N that for $PM_{2.5}$.

2.1 Design values under 40 CFR Part 50

For ozone the inputs are hourly concentrations reported to EPA in whole parts per billion. And the filed hourly integers are themselves the output of a truncation: Appendix U §3(a) cuts each hourly concentration to the thousandth of a ppm before it is filed, a digit loss that is systematic and unrecoverable from the public record. Appendix U itself reads: "Hourly average O3 concentrations shall be reported in parts per million (ppm) to the third decimal place, with additional digits to the right of the third decimal place truncated."

Each eight-hour average is the sum of eight of the reported hourly integers, or of six or seven where hours are missing, divided by their count. Hence it is a multiple of one sixth, one seventh, or one eighth of a part per billion. Appendix U truncates each average: "The 8-hour averages shall be reported to three decimal places, with additional digits to the right of the third decimal place truncated" (§3(b)), which removes the fractional part per billion. The next two steps are selections and lose no digits: the daily value is the highest of the 17 eight-hour averages beginning at each hour from 7:00 a.m. through 11:00 p.m., and each year contributes its fourth-highest daily maximum over its valid days.

The three-year mean of the annual fourth-highest values, each an integer in parts per billion, is a multiple of one third of a part per billion. Appendix U truncates this mean as well: "Design values shall be reported in ppm to three decimal places, with additional digits to the right of the third decimal place truncated" (§3(e)); its worked example truncates 0.065666... to 0.065. The standard is attained if the truncated value is "less than or equal to" the level (§50.19(b), §50.20(b,c)), and a design value equal to the level therefore attains. In symbols,

$$
\begin{aligned}
X_y &= \underset{d \in D_y}{\text{fourth}} \max_{1 \le w \le 17} \operatorname{tr}\Big(\frac{1}{n_{d,w}} \sum_{h \in H_{d,w}} c_{d,h}\Big), \\
\mathrm{DV} &= \operatorname{tr}\Big(\frac{X_1 + X_2 + X_3}{3}\Big), \qquad \text{attainment if and only if} \quad \mathrm{DV} \le 0.070\,\text{ppm},
\end{aligned}
\tag{1}
$$

where $c_{d,h}$ is the reported hourly concentration in ppm for hour h of day d, $H_{d,w}$ is the set of reported hours in the w-th eight-hour period of that day and $n_{d,w}$ their number, D_y is the set of valid days of year y, fourth selects the fourth-highest value, and tr truncates to 0.001 ppm. Thus digits are discarded at three points of the chain (Fig. 1): before reporting and at the two truncations in Eq. (1).

For $PM_{2.5}$, Appendix N *rounds* the final digit instead of truncating it. Its §4.3 rounds half-up, to the nearest 0.1 $\mu g/m^3$ for the annual standard and the nearest 1 $\mu g/m^3$ for the daily standard, and the boundary values 9.05 and 35.5 round upward into violation. The final ozone truncation is the more recent of the two conventions. Appendix I, written for the 1997 standard (62 FR 38895), truncated at the same three points but then *rounded* the third decimal for comparison with its two-decimal level. Appendix P, written for the three-decimal level of the 2008 standard (73 FR 16511), dropped that final rounding, and Appendix U follows Appendix P.

In both appendices the data-completeness requirements are relaxed or waived for violating values. Under Appendix U §4(b) a violating ozone design value is valid regardless of completeness, and Appendix N treats a violating $PM_{2.5}$ value as valid at reduced completeness, while an attaining value must meet the completeness requirements. In the extreme case Appendix N allows a single creditable sample to establish a valid violating year, although no such case arises in the 2020–2025 $PM_{2.5}$ record.

2.2 Three decades of comment and response

The truncation-versus-rounding question has been raised for three decades (Table 1). The earliest discussions that we found are journal papers of the 1990s: Chock and Nance [1993] and Chock [1995] on the stringency and the construction of the fourth-highest design value, and a 1997 paper by Chock, Winkler, and Pezda titled "Attainment Flip-Flops and the Achievability of the Ozone Air Quality Standard". Fairley [1999], in a study of overshoot bias, concluded that "rounding may tend to misclassify nonattainment areas as attainment".

EPA has solicited and answered comment on the convention in two rulemakings. In the 1997 ozone rulemaking it asked about an alternative 0.001 ppm rounding convention (62 FR 38856, at 38886–87), and in the 2008 rule, which moved the level to the third decimal place, whether that decimal should be rounded or truncated (73 FR 16501). In both exchanges environmental and health organizations supported the more stringent alternative, and industry associations the existing convention. EPA declined the alternative both times. In 1997 it cited fewer misclassifications of attainment areas as nonattainment and a more stable attainment test; in 2008 it kept truncation on the stated ground that "the 8-hour design value has an uncertainty of approximately 0.001 ppm" (73 FR 16501). The same year the D.C. Circuit upheld EPA's truncation in the Clean Air Interstate Rule's $PM_{2.5}$ transport test, in North Carolina v. EPA [2008], the only lawsuit we found in which the digit treatment itself was contested.

In January 2010 EPA itself proposed to end the truncation, in its ozone reconsideration proposal (section V.G, "Truncation Versus Rounding", 75 FR 3031). In its words, "The effect of this repeated truncation is that there is a consistent downward bias in the calculation of the three-year design value. The size of this bias can be notable." The same section states that "the O3 NAAQS is the only NAAQS for which multi-hour, multi-day, or multi-year averages of concentrations are truncated rather than rounded". Its worked example is a design value of 0.075 ppm that meets the NAAQS although 23 of the 24 concentrations entering the computation exceed 0.075 ppm (75 FR 3032). The remedy EPA proposed in 2010 was to retain all digits through the computation and to round the three-year average once. In September 2011 the Administration withdrew the reconsideration proposal, and EPA did not pursue the change in any later ozone rulemaking. Truncation was not

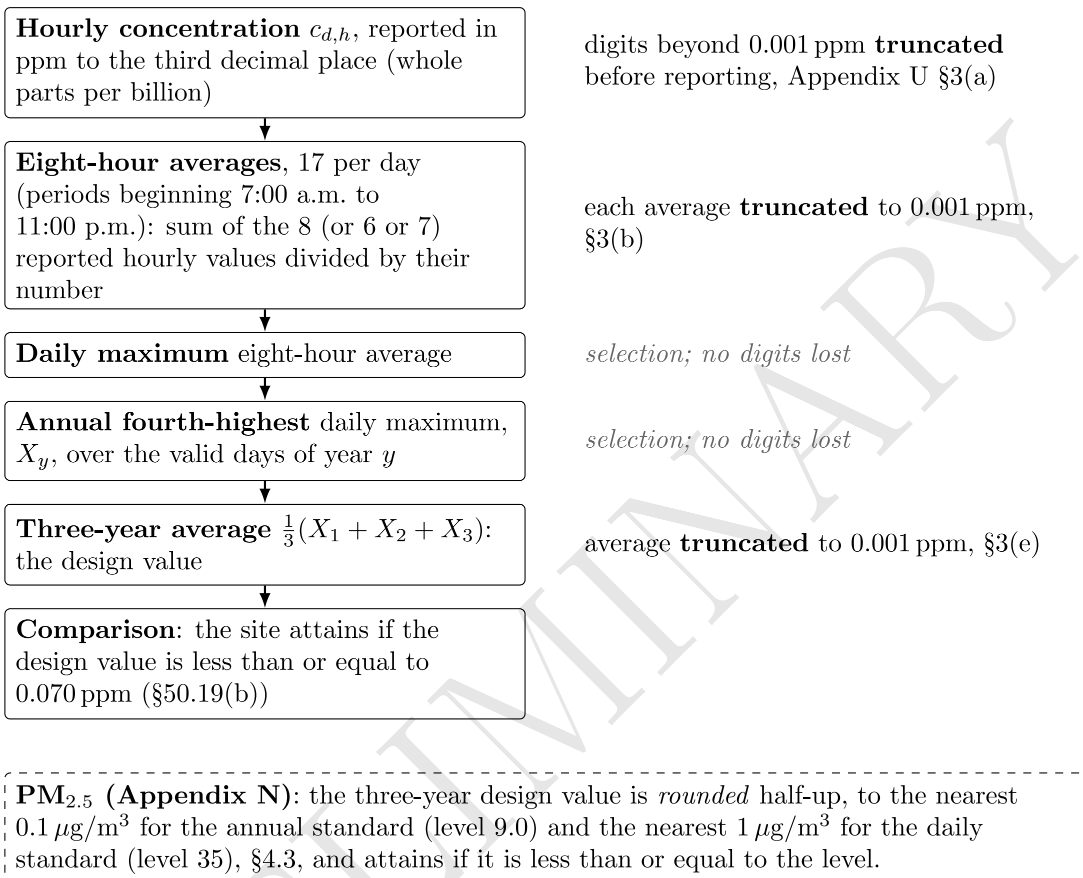

Figure 1: The ozone design-value calculation of 40 CFR Part 50, Appendix U, showing the three points at which digits are discarded. Hourly concentrations are truncated to 0.001 ppm, whole parts per billion, before they are reported (§3(a)); each of a day's 17 eight-hour averages is truncated to 0.001 ppm (§3(b)); and the three-year average of the annual fourth-highest daily maxima is truncated to 0.001 ppm (§3(e)) before it is compared with the level, attaining if it is less than or equal to 0.070 ppm. The daily maximum and the annual fourth-highest value are selections and lose no digits. Read this as: the first truncation precedes reporting and cannot be undone from the public data, while the second and third act on quantities calculated from the reported values. The dashed box gives the corresponding final step for $PM_{2.5}$, where Appendix N rounds half-up instead of truncating.

Table 1: The truncation-versus-rounding question in the ozone and $PM_{2.5}$ rulemaking record, 1997 to 2025: what each document proposed or argued about the digit conventions (quotations verbatim), and the outcome. ALA, American Lung Association; CASAC, Clean Air Scientific Advisory Committee; NESCAUM, Northeast States for Coordinated Air Use Management; CAIR, Clean Air Interstate Rule.

Year	Document	Proposed or argued	Outcome
1997	Ozone NAAQS final rule, 62 FR 38856, at 38886–87	Alternative 0.001 ppm convention: environmental and health associations for it; most State agencies and industry against	Rounding of the third decimal kept, as a more stable test
	EPA data-handling guideline for the 1997 standard [1998]	Worked example: 0.084 ppm is the largest value that attains 0.08 ppm	Effective level 0.084 ppm
2004	Ozone implementation rule, 69 FR 24000	40 CFR 51.907 conditions attainment-date extensions on a fourth-highest average of "0.084 ppm or less"	Effective level codified; digits not discussed
2006	$PM_{2.5}$ NAAQS rule, Appendix N, 71 FR 61229	Round-half-up for daily $PM_{2.5}$; NESCAUM (EPA-HQ-OAR-2001-0017-1468) noted inconsistent draft text on truncation	Adopted without comment-and-response discussion
2006, 2007	CASAC letters [Clean Air Scientific Advisory Committee, 2006, 2007]	"the NAAQS should be specified to the third decimal place of the ppm scale to avoid any rounding issues"	Three-decimal level adopted in 2008
2007	EPA Staff Paper [2007]; Johnson testimony, S. Hrg. 110-1100; Iowa agencies' comment	1997 standard "effectively 0.084 ppm because of our rounding conventions" (Johnson); Iowa (EPA-HQ-OAR-2005-0172-4078) asked EPA to round, citing the low bias of truncation	Truncation past the third decimal retained
2008	Ozone NAAQS final rule, 73 FR 16501; commenters at 73 FR 16475	"the appropriateness of rounding rather than truncating to the third decimal place": ALA, NESCAUM, and Pennsylvania DEP for rounding; API, EMA, and AAAM for the 1997 two-decimal rounding	Truncation kept (uncertainty of approximately 0.001 ppm)
2008	North Carolina v. EPA [2008], D.C. Circuit; CAIR $PM_{2.5}$ transport threshold	North Carolina challenged EPA's truncation of the contributions compared with the threshold	Truncation upheld
2010	Ozone reconsideration proposal, 75 FR 3031 (section V.G)	Repeated truncation produces a consistent downward bias; retain all digits and round the three-year average	Withdrawn September 2011; not pursued in later ozone rulemakings
2014, 2015	Ozone NAAQS proposal, 79 FR 75352; final rule, 80 FR 65410	Hourly truncation justified by instrument uncertainty; eight-hour procedure kept	Truncation not reopened for comment
2015	EPA response to comments [2015], pp. 301–302 and 195–196	Round the third decimal; "if a standard of 70 ppb is practically 71 ppb, there is even less of a margin"	EPA: already accounted for in setting the level
2017, 2018	Governor Abbott to EPA, EPA-HQ-OAR-2017-0548, February 28, 2018	Texas: 70.5 ppb attains the 2015 NAAQS; the attached regional modeling report (AACOG, November 2017) avoided double truncation	Invoked for San Antonio in the 2018 designations
2020	Ozone review, 85 FR 49830 and 85 FR 87256; EPA-452/R-20-001	Convention restated (measurement precision); digits discussed only for W126 (85 FR 87336)	Unchanged
2022	Sierra Club, EPA-HQ-OAR-2018-0279-0596, May 31, 2022	Truncation conventions lack scientific basis; under-protection of up to approximately 1.6 ppb	Pending; merged into a new review (August 18, 2023)
2025	EPA Inspector General, $PM_{2.5}$ monitor schedules [2025]	66 monitoring sites near the standard whose areas may be wrongly in attainment	Digit convention not mentioned

among the four Appendix U elements opened for comment in the 2015 rulemaking (80 FR 65410).

EPA's 2015 response to comments that urged rounding described the convention as "already implicitly accounted for in the Administrator's decision" [U.S. Environmental Protection Agency, 2015]. In the 2018 designations the Governor of Texas invoked the convention for San Antonio: "A design value of 70.5 ppb satisfies the 2015 NAAQS" (docket EPA-HQ-OAR-2017-0548, February 28, 2018). In the docket of EPA's reconsideration of the 2020 review, Sierra Club stated that "EPA's truncation conventions in the calculation of design values have no scientific basis and pointlessly water down the protectiveness of the standard". The same comment quantified the effect as "up to approximately 1.6 parts per billion of under-protection" (EPA-HQ-OAR-2018-0279-0596, May 31, 2022). EPA merged the reconsideration into a new statutory review before any rule was proposed (Administrator Regan to CASAC, August 18, 2023), and Sierra Club's objection is pending in that review, which has not concluded.

Where the documents in Table 1 describe the conventions' arithmetic at all, they do so in general terms or with a single example, and every example is hypothetical except one, the transport threshold litigated in 2008. To our knowledge none of these documents counts the actual determinations that depend on the conventions. This statement is limited by the scope of our search, which covered the Federal Register, the regulations.gov dockets, and the CourtListener case-law database, together with a general web search of limited depth. The search did not cover docket comments beyond those named here, litigation databases beyond CourtListener, administrative petitions to EPA, books, NESCAUM's publications archive, or the mainstream press of 1997–2008. The journal papers of the 1990s were read at the abstract or title level.

3 Data and methods

We analyze ozone and $PM_{2.5}$ design values for the four periods 2020–2022 through 2023–2025 from public data; the unit of analysis is one site's design value for one period, a site-period.

3.1 Design Value Reports and AQS data

EPA's eight Design Value Reports list 13,250 site-level values (4,929 ozone, 4,158 annual and 4,163 daily $PM_{2.5}$) with their validity status and per-year statistics. Concentrations come from the AQS AirData pre-generated files, twelve daily-summary and thirteen hourly year files retrieved in July 2026. Because EPA regenerates these files from its current database, our results apply to them as retrieved.

The Reports contain 340 borderline site-periods, design values that lie within one reporting increment of the standard. Of these, 202 are ozone values at 0.070 ppm, on the attaining side of the boundary; an ozone value one increment higher violates under every procedure considered. The remaining 92 annual and 46 daily $PM_{2.5}$ values lie at the 9.0 μg/m^3 and 35 μg/m^3 boundaries, the levels now in force; the 2020–2022 annual $PM_{2.5}$ values were published under 12.0 μg/m^3. A change of the final-digit or comparison convention cannot alter a determination away from the boundary. The procedures of Eq. (2) below, which also replace the eight-hour truncation, can raise a published ozone value by up to two thousandths of a ppm (one under procedure (d)), and in principle by more where they enlarge the set of valid days, so no screen on the published value is exact for them; we therefore applied them to all 4,929 ozone site-periods in the Reports and report the changes found outside the borderline set separately (Section 4.2).

The monitor combinations, completeness percentages, complete-quarter counts, and creditable-sample counts, which AirData lacks, are taken from the Reports as published. We take the hourly concentrations as given; instrument quality assurance and any corrections applied before archiving lie outside the recomputation. For exceptional events at ozone sites we choose between AirData's post-exclusion and as-measured daily series by matching the Report's annual fourth-highest value. For $PM_{2.5}$ we infer the excluded days quarter by quarter wherever the published quarterly mean determines them uniquely, and label them as inferred.

Reading Appendices U, N, K, and H and the comparison clauses of §§50.6–50.20 as they stood in the Electronic Code of Federal Regulations (eCFR) on 16 July 2026, we count 59 distinct data-handling provisions (Appendix C). Thirty-six of the 59 are provisions whose change alone can move some achievable design value across the level of a standard, and for four the text does not state the operative reading. One of the four enters our computations: whether a value substituted from collocated monitors is truncated again after averaging. We truncate the substituted mean to the reporting increment, and for the affected site-periods agreement with the published value holds only under the reading adopted here. The other three, which concern PM_{10} and the one-hour ozone standard, play no part in this analysis.

3.2 Prescribed and alternative procedures

For each borderline site-period we calculate the design value from the AirData hourly (ozone) or daily ($PM_{2.5}$) files, step by step as Eq. (1) or Appendix N prescribes: eight-hour averages over ≥ 6 of 8 reported hours, truncation wherever Appendix U truncates, the inclusive comparison, and for $PM_{2.5}$ Appendix N's rounding, rank-based percentile (no interpolation), and completeness quotients. The final step is also recalculated for every design value, borderline or not, whose inputs the Reports list. The recomputation uses exact rational arithmetic on fractions whose denominators are fixed by the reporting conventions, with no floating point. Exact arithmetic matters only at ties: a computed value equal to a threshold must be recognized as equal, so that the comparison operator written in the rule decides the outcome, which floating-point arithmetic does not guarantee. We call a published determination *certified* when the exact recomputation from the archived inputs equals the published value and the outcome is therefore a theorem about the pinned inputs and conventions. Every count in this paper is exact; no confidence intervals appear because no sampling enters the computation. ("Certified" in this paper is used in the mathematical sense, an exact-arithmetic recomputation from archived inputs, and is unrelated to the annual data-certification process of 40 CFR 58.15.)

Each valid borderline value is recalculated with the measurements fixed and one provision changed: the final-digit rule (rounding, half-up or half-even, for ozone; truncation or half-even rounding for $PM_{2.5}$), the comparison ("$<$" for "$\leq$"), or the completeness waiver (equal completeness requirements for violating and attaining values). Because Appendices U and N make validity depend on which side of the level a value falls, validity is re-evaluated under each alternative from the completeness figures of the Design Value Reports: an ozone value that violates only under an alternative is then valid irrespective of completeness (Appendix U §4(b)), and a $PM_{2.5}$ value that attains only under an alternative must meet the completeness required of an attaining value or pass the maximum-value substitution test of Appendix N, failing which the alternative yields no valid determination (Appendix A). For ozone we also vary the eight-hour truncation. Writing T_{8h} and T_{3yr} for the operations that Eq. (1) applies to the eight-hour averages and to the three-year mean, we calculate each valid borderline ozone value from the same reported hourly integers under four procedures,

$$(T_{8\mathrm{h}}, T_{3\mathrm{yr}}) \;=\; \begin{cases} (\text{trunc, trunc}) & \text{(a), as written;} \\ (\text{round, round}) & \text{(b), rounding at both steps;} \\ (\text{id, round}) & \text{(c), EPA's 2010 proposal (75 FR 3032), one final rounding;} \\ (\text{id, trunc}) & \text{(d), one final truncation,} \end{cases} \tag{2}$$

where trunc and round (half-up) act at 0.001 ppm and id carries the eight-hour averages untruncated to the final step. The hourly truncation precedes reporting and cannot be varied from the public archive; the set of eight-hour periods, the completeness rules, and the comparison convention are held fixed. However, daily validity (Appendix U §3(d)) is judged on each procedure's own daily maximum. We did not carry out the corresponding variant computations for $PM_{2.5}$. Most borderline $PM_{2.5}$ records rest on daily filter measurements, which are primary measurements: there is no hourly-to-daily arithmetic in the public computation and hence no intermediate digit site to vary.

3.3 Independent implementation

A second implementation, written from the regulatory text alone, was applied to a stratified sample of twenty-five site-periods and agreed with ours in each of 281 comparisons (Appendix B). A separately written program working from the raw hourly files reproduced our values under procedures (a)–(d) for 14 site-periods drawn from different evaluation periods and outcome classes.

3.4 Limits of the public data

Ten of the 340 borderline values cannot be recalculated. For four, the exceptional-event data EPA approved for exclusion are identified only in Regional concurrence letters, which are not public. The other six are $PM_{2.5}$ values of the 2020–2022 era that no longer follow from the current AirData files, which carry no version history: the 2020–2022 $PM_{2.5}$ Report is a snapshot dated May 2023, whereas the AirData files we used were generated in 2026. The published determinations are correct for the data as they then stood but can no longer be checked.

At four borderline monitors reporting "corrected" Teledyne T640 data, the published daily mean is not the mean of the published hourly values under any digit treatment the regulation would allow, and the correction cannot be determined from public materials. Hence we count these site-periods as reproduced from the daily values only. Another 43 site-periods (42 ozone and one daily $PM_{2.5}$) likewise rest on the published daily values for the days partly excluded as exceptional events, whose excluded hours are not public. Neither the versioning gap nor the instrument correction changes any attainment determination in this analysis.

4 Results

The Design Value Reports list the inputs to the final arithmetic step for 12,025 of the design values, borderline or not. Carried out as Appendices U and N prescribe, that step reproduces the published value for each of them. The earlier steps, which produce the annual statistics listed in the Reports, are not tested by this comparison, and for the borderline values we calculated those

Table 2: Borderline attainment determinations of 2020–2025 that change when one convention at the final step is replaced, among the 304 valid borderline design values reproduced from the AirData daily files (190 ozone, 75 annual and 39 daily $PM_{2.5}$; in the $PM_{2.5}$ rows all four periods are evaluated against today's 9.0 and 35 μg/m^3 levels, although the 2020–2022 annual values were published under the earlier 12.0 μg/m^3 standard). Read this as: 61 of 190 borderline ozone values attain only because Appendix U truncates (A→V, the determination becomes a violation under the alternative), while 33 of 75 annual and 14 of 39 daily $PM_{2.5}$ values violate only because Appendix N rounds (V→A). Each entry is the number of changed determinations over the number of valid borderline values in the class.

	determinations that change under the alternative			
boundary class (rule as written)	truncate↔round	half-even	comparison $<$	symmetric completeness
ozone 0.070 ppm (truncate)	**61**/190 A→V	61/190	190/190 A→V	0/190
$PM_{2.5}$ annual 9.0 μg/m^3 (round-half-up)	**33**/75 V→A	0/75	42/75 A→V	1/75
$PM_{2.5}$ daily 35 μg/m^3 (round-half-up)	**14**/39 V→A	0/39	25/39 A→V	2/39

Notes. "Half-even" replaces round-half-up by round-half-to-even (for ozone, replaces truncation by round-half-to-even). "Comparison <" replaces "less than or equal to" by a strict comparison; it changes the determination of every value equal to a level. "Symmetric completeness" applies to violating values the completeness required of attaining ones; it removes determinations by leaving site-periods without a valid design value, and reverses none. When validity is re-evaluated under the alternative (Section 3), all 61 ozone changes are to valid violations, a violating ozone value being valid irrespective of completeness; of the 33 annual and 14 daily $PM_{2.5}$ changes, one annual and one daily lead to no valid determination rather than to a valid attainment, the value being valid as published only through the reduced completeness allowed a violating value, and one annual change depends on the reading of Appendix N §4.1(b) (Appendix A). Round-half-even is indistinguishable from half-up in these data: ozone three-year means are multiples of one third of a part per billion and so never fall exactly halfway between two whole parts per billion; two daily $PM_{2.5}$ values (Fresno County, California, 2021–2023, and Dakota County, Minnesota, 2023–2025) equal 35.5 μg/m^3, where half-even and half-up both give 36; and the annual tie at 9.05 μg/m^3, the one that would separate the two rules, occurs in none of the 75. The distinction exists in principle and changes no determination here.

statistics ourselves from the AirData files. Of the 340 borderline values, 330 can be calculated from the AirData daily files, and in each case the result equals the published design value. For 283 of the 330 the same holds with the daily values recalculated from the hourly files, wherever a monitor reports hourly values; for the other 47 some daily values cannot be derived from the public hourly data and are taken as published (Section 3.4).

Of the 202 borderline ozone values, all published at 0.070 ppm, 199 are among the 330 that can be calculated, and 190 of the 199 are also valid under the completeness rules. The other nine attain as published but are invalid for want of completeness and carry no determination; since Appendix U §4(b) makes a design value above the level valid irrespective of completeness, five of the nine would become valid violations if the final digit were rounded, seven under procedure (b) or (c) of Eq. (2), and six under (d) (Section 4.2). In all, 304 of the 330 are valid (190 ozone, 75 annual and 39 daily $PM_{2.5}$), and these 304 are the population of Table 2 and of Appendix A. Because the published values are reproduced, every dependence on a convention counted in this section arises when the rule as written is applied to the measurements as reported.

4.1 Determinations that depend on the final digit

Among the 304 valid borderline values, the treatment of the final digit is decisive for roughly one in three of the determinations, with opposite effects for the two pollutants. For ozone, 61 of 190 borderline values attain only because Appendix U truncates, while 33 of 75 annual and 14 of 39 daily $PM_{2.5}$ values violate only because Appendix N rounds (Table 2). Of these 47 $PM_{2.5}$ values, 43 have complete data and would be valid attaining values under truncation; the other four are valid as published only through an outcome-dependent completeness provision of Appendix N (Section 4.4). Re-evaluated as attaining values on the figures of the Reports, one of the four would remain valid because the incomplete year's own 98th percentile exceeds the level (§4.2(b)), two would have no valid determination without the Administrator's approval, the maximum-value substitution test failing or being unavailable (Cook County, Illinois (Site 17-031-0022, annual, 2020–2022); Los Angeles County, California (Site 06-037-0002, daily, 2020–2022)), and for one the outcome depends on whether the annual mean of the incomplete year is itself rounded or truncated in the test of §4.1(b) (Appendix A). The $PM_{2.5}$ counts are measured against the levels in force since 2024; for the 2020–2022 annual values the status counted here is therefore that under today's standard and not the legally operative determination of that period. Their validity is likewise that of the Report, which was decided under the $12.0\,\mu g/m^3$ standard; re-derived at $9.0\,\mu g/m^3$ from the Report's completeness figures, none of the 75 would lose validity, and one further value, Lucas County, Ohio (Site 39-095-1003, 2020–2022, $9.1\,\mu g/m^3$), invalid as an attaining value under the earlier standard, would be a valid violation by the eleven-sample rule of Appendix N §4.1(b) and would be a valid attaining value under truncation. Thus a computed value that exceeds its standard by a given fraction of a reporting increment can attain for ozone and violate for $PM_{2.5}$.

The comparison convention matters only when a published value equals the level of the standard. Of the 304 values, 257 equal a level, and each attains under the inclusive comparison. Rounding the final digit half-even gives the same determination as rounding it half-up for each of the 304 values (Table 2, notes). A completeness requirement applied symmetrically, to violating values as it is to attaining ones, would remove the determinations counted in the last column of Table 2 and would reverse none.

At the New Haven site (Site 09-009-0027, Connecticut) one published value depends on two conventions at once, the final truncation and the inclusive comparison. For this site EPA published an ozone design value of 0.070 ppm, the largest value that attains, for 2020–2022, 2021–2023, and 2023–2025, and a violating 0.072 for 2022–2024. Calculated from the hourly concentrations and kept as fractions, the three attaining three-year means are 211/3000, 212/3000, and 211/3000 ppm, that is, $70\frac{1}{3}$, $70\frac{2}{3}$, and $70\frac{1}{3}$ parts per billion. All three truncate to 0.070 and attain only because the comparison is inclusive. The middle value, 212/3000, also attains only through truncation: rounding it, as the same regulation prescribes for $PM_{2.5}$, would give a published value of 0.071 whether the rounding is half-up or half-even. Its determination therefore turns on the truncation and on the comparison together (Fig. 2). The completeness waiver for violating values plays no part at this site: in each of the four periods the published completeness (three-year averages of 90 to 95 percent, with no single year below 84) meets the thresholds required of an attaining value.

The New Haven site is at the boundary value in three of the four periods. This persistence may be partly mechanical, since successive three-year windows share two years of data and a value at the boundary therefore tends to recur. For scale, in the 2023–2025 period alone the Design Value Report lists 66 valid ozone values published at 0.070, a count that includes values that cannot be recalculated from AirData. Forty-two ozone sites are borderline in at least two of the four periods,

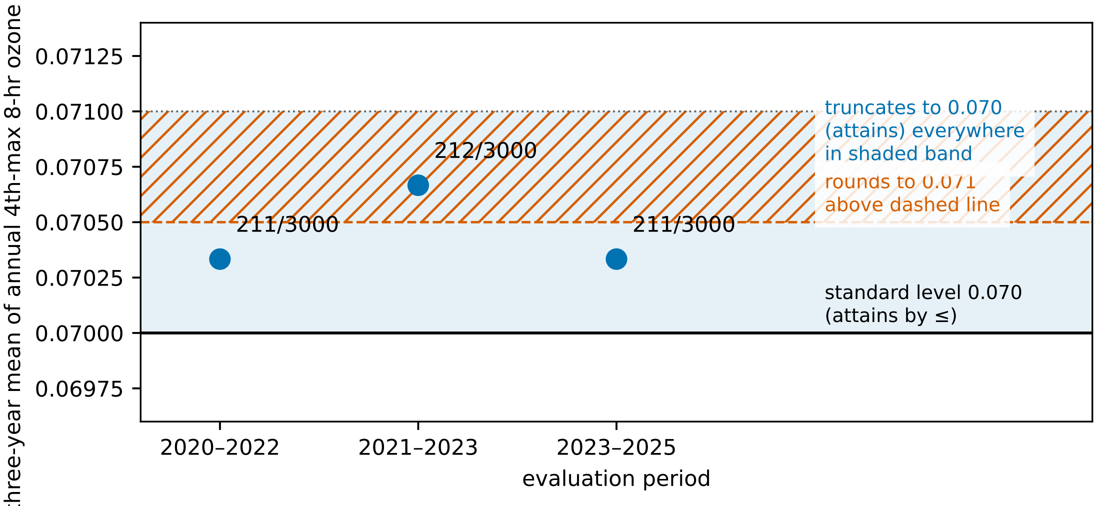

Figure 2: All three attaining three-year means of the New Haven site (Site 09-009-0027; 2020–2022, 2021–2023, and 2023–2025; the site violated at 0.072 in 2022–2024) lie in the half-open interval $[0.070, 0.071)$, in which truncation gives a published value of 0.070. Read this as: the blue points are the means calculated from the hourly data as fractions, 211/3000, 212/3000, and 211/3000 ppm, on the lattice of possible three-year means; in the blue band the truncated value is 0.070 and attains; rounding the middle value, $212/3000 = 0.070\overline{6}$, half-up or half-even, would give a published value of 0.071 (violation, orange hatching above 0.0705). A value at the level 0.070 attains because the comparison is inclusive; the determination for the middle value therefore depends on two conventions at once.

seven in three, and none in all four; New Haven is one of the seven. We have not tested whether this persistence is statistically significant.

4.2 Determinations that depend on the eight-hour truncation

At Site 17-031-4007 in Cook County, Illinois (Chicago), attainment depends on a convention applied at an earlier step of the computation, the truncation of the eight-hour averages. There the computation as written gives annual fourth-highest values of 0.072, 0.069, and 0.070 ppm for 2020–2022. The three-year mean is $211/3000$ ppm $= 0.0703\overline{3}$, the same as in New Haven's first attaining period. It truncates to 0.070, and the site attains at 70 ppb. If instead both the eight-hour averages and the final value are rounded, with the reported hourly values unchanged, each year's fourth-highest value rises by a full thousandth, to 0.073, 0.070, and 0.071. The mean becomes $214/3000 = 0.0713\overline{3}$ and the published value 0.071, a violation at 71 ppb.

Carrying the eight-hour averages of the Chicago site untruncated and cutting the digits only once, at the end, as EPA proposed in 2010 (75 FR 3032), we obtain a mean of $853/12000$ ppm $= 0.07108\overline{3}$ before that final step, above the limit whether that step truncates or rounds. This untruncated mean is 71.08 ppb, so the site can legally sit 1.08 ppb above the written limit. Under the computation as written the final digit is likewise immaterial at this site: neither rounding nor truncating the final value would change its status, because the excess is removed earlier, when the eight-hour averages are truncated. This monitor did not determine the status of its area. The

Table 3: Among the 190 valid borderline ozone design values of 2020–2025, rounding at both steps changes 148–149 attainment determinations and EPA's 2010 proposal changes 140, against 61 for the final digit alone (Table 2). Read this as: in each row one alternative procedure of Eq. (2) is applied to the same reported hourly values, with procedure (a), the computation as written, as the reference; "all" counts the determinations that differ from (a), every one of them a change from attainment to violation; "higher thousandth" counts those whose three-year mean before the final step already lies in a higher thousandth of a ppm than under (a), and "final rounding" those changed by the final rounding alone; the last four columns give the changes in each evaluation period.

	changed determinations, of 190			changed, by evaluation period			
procedure	all	higher thousandth	final rounding	2020–2022 ($n = 33$)	2021–2023 ($n = 45$)	2022–2024 ($n = 49$)	2023–2025 ($n = 63$)
(b) rounding at both steps	148–149	82–84	65–66	23	37–38	41	47
(c) 2010 proposal, round once	140	52–53	87–88	22	34	39	45
(d) carry, truncate once	52–53	–	–	7	10–11	17	18

Notes. n is the number of valid borderline ozone values in the period. Procedure (d) has no final rounding; all of its changes arise because the untruncated mean already lies at or above 0.071, and they coincide with those counted under "higher thousandth" for (c). Ranges span the two admissible treatments of exceptional-event days: at twelve site-periods both the post-exclusion and the as-measured AirData series reproduce the published fourth-highest value in one year, and the choice between them moves a determination at two site-periods, Monmouth County, New Jersey, 2021–2023, under (b), and Ada County, Idaho, 2021–2023, under (d) (Appendix B); it does not affect procedure (a), the 61, or the 140. The daily validity condition of Appendix U §3(d) is applied to each procedure's own daily maximum; Hunterdon County, New Jersey, 2023–2025, is the only one of the 199 recalculable borderline ozone values whose set of valid days then differs between procedures, and its value and status under each procedure are nonetheless unambiguous, since no partially excluded day enters its computation.

2020–2022 design value of the Chicago, IL-IN-WI nonattainment area was 0.075 ppm, set by two other monitors of the area (one in Cook County, one in Kenosha County, Wisconsin), and the area did not meet the standard.

We applied the four procedures (a)–(d) of Eq. (2) to all 190 valid borderline ozone values, starting each from the same reported hourly values; procedure (a) reproduces the published value in each case. Where a site-period includes days partly excluded as exceptional events, whose excluded hours are not public (Section 3.4), the maximum of such a day under (b)–(d) is carried as an interval between its smallest and largest possible values. Both ends of the interval give the same design value and determination at each site-period whose calculation uses such a day (Appendix B). Counts under (b)–(d) are given as ranges where they depend on a choice of data series. At twelve site-periods both the post-exclusion and the as-measured AirData series reproduce the published fourth-highest value in one year, and either series is then admissible. The choice between them moves a determination at two of the twelve (Table 3, notes; Appendix B).

Rounding at both steps instead of truncating, procedure (b), changes the determination for 148–149 of the 190 values, against 61 for the final step alone (Table 3). For 82–84 of the 190 the three-year mean under (b), before any final rounding, already lies in a higher thousandth of a ppm than the mean computed as written, and the treatment of the final digit is then immaterial. The other 65–66 of the 148–149 have means in the same thousandth, and their determinations change only at the final rounding. Procedure (c), EPA's 2010 proposal, changes 140 of the 190, 52–53 of them because the untruncated mean already lies at or above 0.071 and the remaining 87–88 through its single final rounding. Procedure (d), which keeps the final truncation as written and removes only the intermediate one, changes 52–53 of the 190.

Of the 148–149 determinations that change under (b), 87–88 are not among the 61 that change at the final digit and would be missed by any analysis confined to the final step. Counted by area rather than by monitor, taking an area's status to be that of its highest monitor with a valid design value, as the Reports do (Table 1a), and the boundaries as fixed, most of these changes have no effect on an area's status because another monitor of the area already violates, as at Chicago: 44 of the 61 final-digit changes, 102 of the 148 under (b) and 99 of the 140 under (c) fall in core-based statistical areas that violate as published. Of the 1,558 such areas attaining as published, 17 would violate under a final rounding, 41 under (b), 37 under (c), and 12 or 13 under (d); among the 48 attaining area-periods of the nonattainment areas designated under the 2015 standard the counts are 6, 11, 11, and 3 to 5. Each of the three alternative procedures (b)–(d) can only raise the design value, because a truncation never increases the number it acts on, and among the 190 every change of determination is accordingly from attainment to violation.

We also applied procedures (a)–(d) to every other ozone site-period in the four Reports, 4,929 in all, of which 4,870 can be recalculated from the AirData files under the Reports' exceptional-event treatment, 4,578 of them with three years of data. Under (b)–(d) no published violation is reversed, and no value published at 0.068 ppm or below reaches 0.071. Two classes of site-period outside the 190 do change, and we report them separately rather than in Table 3. First, three of the 219 recalculable values published at 0.069 (Pima County, Arizona, 2023–2025; Madison County, Indiana, 2021–2023; Minnehaha County, South Dakota, 2022–2024) violate under (b): at each the published fourth-highest values sum to 0.209 ppm and every year's value is one thousandth higher when the eight-hour averages are rounded, which gives a mean of 212/3000 and a published 0.071; none of the 219 violates under (c) or (d), and of the three published-0.069 values that cannot be recalculated two have the sum 0.209 and are undetermined under (b). Second, of the nine borderline values that are invalid as published, seven reach 0.071 or 0.072 under (b) and under (c), six under (d), and five under a final rounding alone; a design value above the level is valid regardless of completeness (Appendix U §4(b)), although several of these records have a year well short of the 75% requirement, so each would then be a valid violation where the Report records no determination. The set of valid days grows under (b) or (c) at 50 of the 4,870 site-periods, by one day in each affected year; none of the changes just listed involves such growth, and among the 50 the only determination that differs from (a) is that of Hunterdon County, 2023–2025, one of the 190 (Table 3, notes). Figure 3 shows each of the 190 values at its untruncated three-year mean and indicates which procedures change its determination; Table 3 gives the counts by evaluation period.

4.3 Largest excess above the level

The amount by which the untruncated mean of an attaining value can exceed the level depends on the conventions, and we express it in parts per billion, the unit of the last digit of the written standard. With a single final truncation this excess is less than one part per billion (a mean of up to 70.9 ppb to one decimal), and with a single final rounding less than half a part per billion (up to 70.4). Thus the two conventions differ by 0.5 ppb at the final digit, the amount at issue in the docket comments that ask EPA to round.

When the truncation of the eight-hour averages is considered as well, the untruncated mean of an attaining value can lie further above the level than it can when only the final digit is cut.

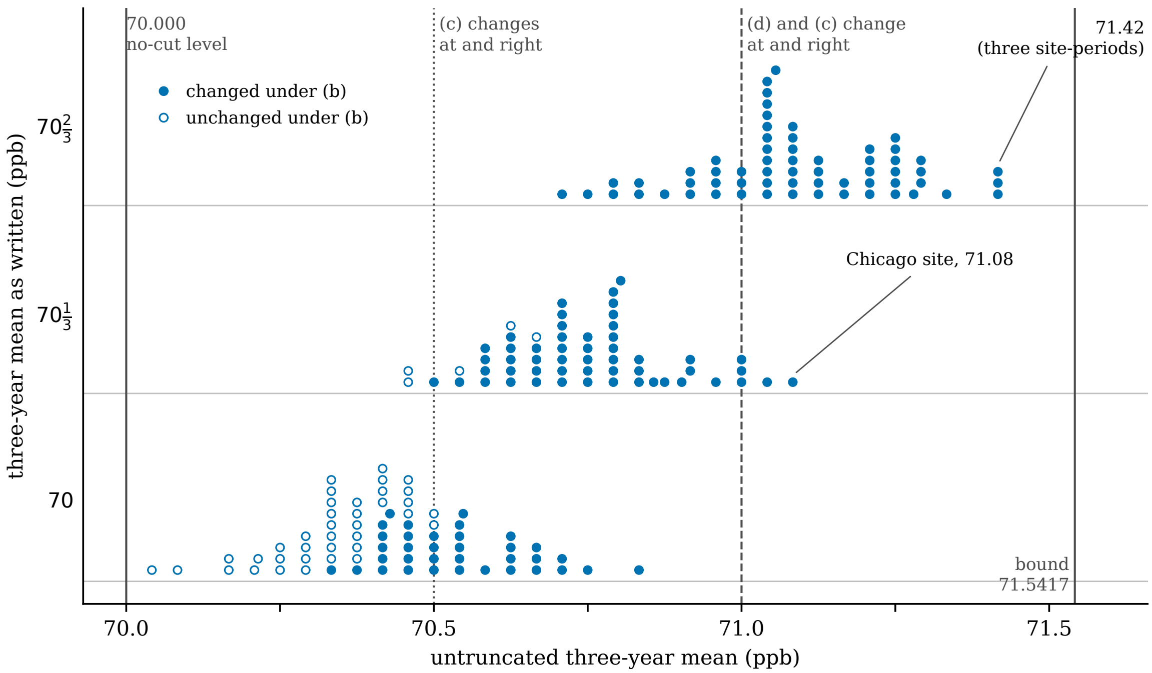

Figure 3: All 190 valid borderline ozone design values of 2020–2025 attain as written, and every one has an untruncated three-year mean above 70.000 ppb; those at or right of the dashed line would have a published value of 0.071 after a single final cut of either kind. Read this as: each mark is one site-period at its three-year mean with the eight-hour averages carried untruncated (post-exclusion series where both series are admissible; Appendix B), arranged in rows by three-year mean as written; the top row holds the 61 values that a final rounding alone would change. Filled marks are values whose determination changes under procedure (b), rounding at both steps; marks at or right of the dotted line are those that change under (c), EPA's 2010 proposal, and marks at or right of the dashed line those that change under (d) as well. Solid lines mark the no-cut level, 70.000 ppb, and the largest untruncated mean that an attaining value can have when the eight-hour truncation leaves its set of valid days unchanged, 71.5417 ppb; the Chicago site (71.08) and the three site-periods at 71.42 are labeled.

Among the 190 valid borderline ozone values of 2020–2025, all of which attain under the regulation as written, the largest untruncated three-year mean is 857/12000 ppm, or 71.42 ppb to two decimals. It occurs at three site-periods, labeled in Fig. 3: Kaufman County, Texas (Site 48-257-0005, 2022–2024), Hunterdon County, New Jersey (2023–2025), and Suffolk County, New York (2023–2025). At the Kaufman County site, for example, the published value is 0.070 ppm, and the untruncated mean of the same reported measurements is 1.42 ppb above the written limit, nearly three times the half ppb by which truncation and rounding differ when applied to the final digit alone. Under each alternative the site violates, with a published value of 0.072 from rounding at both steps and of 0.071 from a single final truncation or rounding of the untruncated mean.

The untruncated mean of an attaining value can exceed the level by at most $37/24 = 1.5417$ ppb for any record whose set of valid days is the same with and without the intermediate truncation, by the following argument. Since an eight-hour average is a multiple of one sixth, one seventh, or one eighth of a part per billion, truncating it discards at most 7/8 of a part per billion. Taking daily maxima, fourth-highest values, and the three-year mean over a fixed set of valid days preserves that bound; hence the untruncated three-year mean exceeds the mean computed as written by at most 7/8 ppb. If a value attains as written, its three-year mean before the final truncation, a mean of three integers, is at most 212/3. The untruncated mean of an attaining value is therefore at most $212/3 + 7/8 = 1717/24 = 71.5417$ ppb, and this value can be reached. The one borderline value whose set of valid days depends on the truncation, that of Hunterdon County in 2023–2025, has an untruncated mean of 71.42 ppb, inside the bound.

The simplest alternative to the written procedure would dispense with the digit conventions altogether: the computed value would be carried through and compared with the limit, with nothing truncated or rounded at any step. Since the truncations can only lower the computed value, removing them also gives the strictest reading of the standard. The effective level would then be 70.000 ppb, whereas under the computation as written a value can attain with an untruncated mean up to 1.5417 ppb above that level.

4.4 Completeness waiver in practice

Appendix U §4(b) and Appendix N waive the full completeness requirements only for violating values. A violating ozone value is valid regardless of completeness; a violating annual $PM_{2.5}$ value needs eleven creditable samples a quarter or, with fewer, a passed minimum-substitution test, and a violating daily $PM_{2.5}$ value a single creditable sample. From the completeness fields of the Design Value Reports, taken as published, we counted how often the waiver operates. In each evaluation period, between 8 and 18 valid ozone violations owe their validity to it (17, 18, 12, and 8 across the four periods, of 210–254 valid violators). No attaining ozone value in any period is valid without complete data, as the one-sided construction of the regulation guarantees. For the annual $PM_{2.5}$ standard the Reports show 2, 13, 7, and 9 valid violators with at least one incomplete quarter in the four periods, of 32–193 valid violators; for the daily standard they show 20, 8, 2, and 3, of 24–87. (Here the 2020–2022 annual period is counted against the $12.0\,\mu g/m^3$ standard then in force and the later three against $9.0\,\mu g/m^3$.)

The finding that no attaining ozone value is valid without complete data has no direct $PM_{2.5}$ counterpart, because Appendix N also lets an attaining value with incomplete quarters qualify as valid through a maximum-substitution test or by discretion, and violating values that fail the minimum-substitution test stay invalid. The waiver's asymmetry is a feature of the regulation as written rather than of how EPA applies it, and has an evident rationale. An observed exceedance is evidence of an exceedance however many other days went unmeasured, whereas a symmetric validity rule would reward the withholding of data. We give these counts to show how often the provision operates, and not as an argument against it.

5 Discussion

In EPA's ozone dockets, environmental and industry commenters have argued over the last digit of the design value, at which truncation and rounding differ by half a part per billion. In the published design values of 2020–2025, about one in three of the borderline determinations, ozone and $PM_{2.5}$ together, depends on the treatment of that digit. Because Appendix U truncates the final digit and Appendix N rounds it, an ozone value can attain and a $PM_{2.5}$ value violate when each exceeds its standard by the same fraction of a reporting increment. However, for ozone the eight-hour and final truncations together affect more determinations than the final truncation alone. With rounding in place of truncation at both steps, 148–149 of the 190 borderline ozone determinations change, against 61 when only the final value is rounded. Appendix U as written also permits a site to attain with an untruncated three-year mean 1.42 ppb above the level, almost three times the half part per billion in dispute.

EPA described the downward bias of the repeated truncation in its 2010 proposal, which would have removed that bias by carrying all digits to a single final rounding. Procedure (c) of this paper is the calculation EPA then proposed; the proposal was withdrawn the following year, and EPA has not taken it up in any later ozone rulemaking. Sierra Club's 2022 comment estimated the under-protection from EPA's truncation conventions at up to approximately 1.6 parts per billion. In calculating the largest excess above the level at an attaining site, we took the hourly concentrations as reported, that is, after the truncation that precedes their filing, and varied only the eight-hour and final truncations. Whereas EPA's proposal and Sierra Club's comment describe the size of the downward bias, we identify and count the published determinations that turn on the choice between truncation and rounding.

Our counts are for design values at individual monitoring sites. An area's designation is based on all the sites within its boundary and depends on further steps, among them EPA's concurrence with exceptional-event demonstrations and the drawing of the boundary. None of these steps enters our calculation, and four of the borderline values depend on concurrence decisions on which we take no position. The site-level monitor combinations and the completeness figures were taken from the Design Value Reports as published. The public AirData files are not versioned, and at a few monitors reporting a corrected instrument configuration the published daily means do not follow from the hourly values (Section 3.4). Both facts limit which published values can be reproduced today, and neither alters a determination counted here.

Because only the four most recent evaluation periods are analyzed, the recurrence of borderline sites from one period to the next has been observed over this window only, and a longer history would be needed to characterize persistence. Whether an area's designation is environmentally appropriate is a matter of exposure, health science, and policy on which our results do not bear. Nor do they show either convention to be wrong: truncation and rounding each have defensible rationales, and the choice between them is legislative.

For scale, two figures from the rulemaking record can be set beside the half part per billion at issue. On the instrument side, EPA's stated basis for truncation is that the design value carries an uncertainty of approximately 0.001 ppm (73 FR 16501), the width of the entire truncation-versus-rounding band. On the health side, the 2015 level rests, by the Administrator's own account, primarily on controlled human exposure studies (80 FR 65362), and the pivotal study labeled its arms 60, 70, 80, and 87 ppb; as the rule's own footnotes record, the arm targeted at 70 ppb delivered an actual mean exposure of 72 ppb, and the 60 arm delivered 63 (80 FR 65343, nn. 104-105). The level itself was set as a whole number below 72 ppb, the lowest exposure shown to produce the adverse combination of lung function decrements and respiratory symptoms (80 FR 65363), and CASAC's recommendation, a range "from 70 ppb to 60 ppb," reasons in whole parts per billion throughout. We report these figures for context only: our analysis concerns the arithmetic of the published determinations and does not assess the consequences of either convention.

No sentence in this paper asserts that any convention is wrong or that any area's designation is environmentally inappropriate; which convention should govern a legal boundary is a policy question that arithmetic cannot decide. A calculation such as ours can instead identify the determinations that depend on the choice. EPA could then state, beside each design value in its Design Value Reports, whether the site's status under the standard depends on the treatment of digits, on the inclusive comparison, or on the completeness waiver.

A published list of the convention-dependent determinations would serve the states that write implementation plans, the industries whose permits depend on a designation, and commenters on both sides of the dispute. A commenter may direct the argument at the provision, the eight-hour or the final truncation, on which a particular site's attainment depends. A state may learn in advance which of its attaining sites would change status under a proposal such as that of 2010. The list can be computed from the public AirData files and Design Value Reports as described here; Appendix A gives it for the borderline values of 2020–2025. Counts of this kind could be made wherever a legal status is assigned by comparing a computed statistic with a threshold, as in air quality, water quality, seismic design, and tsunami alerts.

A Borderline site-periods, 2020–2025

Tables A1 and A2 list, for ozone and for $PM_{2.5}$ respectively, every borderline design value of the 2020–2025 evaluation periods that can be calculated from the AirData files and is valid under the completeness rules. Each row gives the AQS site identifier, the county and state as EPA names them, the three-year period, and the attainment status under alternatives examined in the main text. The tables have columns only for the alternatives that change the determination for some but not all of the values listed. Accordingly, Table A1 has no column for the strict comparison, under which every ozone value listed would violate, or for removal of the completeness waiver, which affects none of them. Table A2 also gives the published design value and the status as written.

Procedures (b)–(d) act on the eight-hour ozone averages and are tabulated for ozone only. In a year in which both the post-exclusion and the as-measured AirData daily series reproduce the published fourth-highest value, the ozone entries use the post-exclusion series for that year (Appendix B). A dagger marks the two entries, one under procedure (b) and one under (d), that would violate with the as-measured series instead. The last row of Table A1 and of each panel of Table A2 gives the number of changed determinations in each column.

Table A1: Valid borderline ozone site-periods of the 2020–2025 Design Value Reports (190 site-periods) and the attainment status of each under the alternative digit procedures. Every site-period listed has the published design value 0.070 ppm, which the calculation as written reproduces from the AirData files, and attains; each would violate under a strict comparison, and none is affected by removal of the completeness waiver, so those two columns of Table A2 are omitted here. Final digit: the three-year mean as written, rounded instead of truncated at the last step. (b): rounding at both the eight-hour and the final step. (c): EPA's 2010 proposal, eight-hour averages carried in full and rounded once at the end. (d): eight-hour averages carried in full and truncated once at the end. A, attains; **V**, violates, a change from the status as written. Where both the post-exclusion and the as-measured AirData daily series reproduce a year's published fourth-highest value, entries use the post-exclusion series; † marks the two entries that violate under the as-measured series instead (Appendix B). The last row counts the changed determinations, which are the ozone entries of Tables 2 and 3. County and state names as given by EPA; rows sorted by state, site, and period.

				status under alternative procedure			
AQS site ID	County	State	Period	final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
04-013-4004	Maricopa	Arizona	2023–2025	A	**V**	**V**	A
04-013-4011	Maricopa	Arizona	2020–2022	A	A	**V**	A
04-013-7003	Maricopa	Arizona	2020–2022	A	**V**	**V**	A
04-013-9508	Maricopa	Arizona	2020–2022	**V**	**V**	**V**	**V**
04-013-9508	Maricopa	Arizona	2021–2023	A	**V**	**V**	A
04-019-0021	Pima	Arizona	2022–2024	**V**	**V**	**V**	**V**
04-019-1011	Pima	Arizona	2020–2022	A	A	A	A
04-019-1011	Pima	Arizona	2022–2024	A	A	A	A
04-019-1020	Pima	Arizona	2023–2025	A	**V**	**V**	A
04-019-1028	Pima	Arizona	2020–2022	A	**V**	**V**	A
04-019-1028	Pima	Arizona	2022–2024	**V**	**V**	**V**	A
04-021-3003	Pinal	Arizona	2021–2023	A	**V**	**V**	A
04-021-3003	Pinal	Arizona	2022–2024	**V**	**V**	**V**	**V**

continued on the next page

Table A1: (continued)

				status under alternative procedure			
AQS site ID	County	State	Period	final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
04-021-7001	Pinal	Arizona	2023–2025	**V**	**V**	**V**	**V**
04-027-8011	Yuma	Arizona	2021–2023	A	**V**	**V**	A
05-035-0005	Crittenden	Arkansas	2020–2022	**V**	**V**	**V**	**V**
05-035-0005	Crittenden	Arkansas	2023–2025	**V**	**V**	**V**	**V**
06-001-0007	Alameda	California	2021–2023	A	A	A	A
06-027-0101	Inyo	California	2022–2024	**V**	**V**	**V**	**V**
06-061-0003	Placer	California	2023–2025	A	A	A	A
06-065-0010	Riverside	California	2022–2024	A	**V**	**V**	A
06-065-0010	Riverside	California	2023–2025	A	**V**	**V**	A
06-065-0016	Riverside	California	2022–2024	A	**V**	**V**	A
06-073-1022	San Diego	California	2020–2022	**V**	**V**	**V**	**V**
08-041-0013	El Paso	Colorado	2022–2024	A	**V**	**V**	A
08-069-0007	Larimer	Colorado	2021–2023	**V**	**V**	**V**	A
08-069-0007	Larimer	Colorado	2023–2025	**V**	**V**	**V**	**V**
09-005-0005	Litchfield	Connecticut	2023–2025	**V**	**V**	**V**	**V**
09-009-0027	New Haven	Connecticut	2020–2022	A	**V**	**V**	A
09-009-0027	New Haven	Connecticut	2021–2023	**V**	**V**	**V**	A
09-009-0027	New Haven	Connecticut	2023–2025	A	**V**	**V**	A
09-013-1001	Tolland	Connecticut	2022–2024	A	A	A	A
13-121-0055	Fulton	Georgia	2021–2023	A	**V**	**V**	A
13-231-9991	Pike	Georgia	2022–2024	A	**V**	A	A
16-001-0017	Ada	Idaho	2020–2022	A	A	A	A
16-001-0017	Ada	Idaho	2021–2023	A	**V**	**V**	A†
17-019-1001	Champaign	Illinois	2022–2024	**V**	**V**	**V**	A
17-019-1001	Champaign	Illinois	2023–2025	A	**V**	**V**	A
17-031-1003	Cook	Illinois	2021–2023	A	**V**	**V**	A
17-031-4007	Cook	Illinois	2020–2022	A	**V**	**V**	**V**
17-043-6001	DuPage	Illinois	2020–2022	A	A	A	A
17-043-6001	DuPage	Illinois	2022–2024	**V**	**V**	**V**	**V**
17-089-0005	Kane	Illinois	2020–2022	A	**V**	**V**	**V**
17-113-2003	McLean	Illinois	2022–2024	A	A	A	A
17-113-2003	McLean	Illinois	2023–2025	A	A	A	A
17-119-0120	Madison	Illinois	2023–2025	A	**V**	**V**	A
17-119-0122	Madison	Illinois	2022–2024	A	A	**V**	A
17-119-0122	Madison	Illinois	2023–2025	A	A	**V**	A
17-119-3007	Madison	Illinois	2020–2022	A	**V**	**V**	A
17-119-3007	Madison	Illinois	2023–2025	A	A	A	A
17-157-0001	Randolph	Illinois	2022–2024	A	**V**	**V**	A
17-163-0010	Saint Clair	Illinois	2021–2023	A	A	A	A
18-003-0002	Allen	Indiana	2022–2024	A	A	A	A
18-011-0001	Boone	Indiana	2023–2025	A	**V**	**V**	A
18-043-0008	Floyd	Indiana	2023–2025	A	**V**	**V**	A

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Table A1: (continued)

AQS site ID	County	State	Period	status under alternative procedure: final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
18-067-0004	Howard	Indiana	2022–2024	A	**V**	**V**	A
18-067-0004	Howard	Indiana	2023–2025	A	**V**	A	A
18-089-2008	Lake	Indiana	2021–2023	**V**	**V**	**V**	**V**
18-089-2008	Lake	Indiana	2022–2024	A	**V**	**V**	A
18-095-0011	Madison	Indiana	2022–2024	A	**V**	A	A
18-097-0057	Marion	Indiana	2021–2023	A	**V**	**V**	A
18-097-0078	Marion	Indiana	2023–2025	A	**V**	**V**	**V**
18-141-0015	St. Joseph	Indiana	2021–2023	A	**V**	**V**	A
18-141-0015	St. Joseph	Indiana	2023–2025	A	**V**	**V**	A
19-045-0021	Clinton	Iowa	2023–2025	A	A	A	A
19-163-0014	Scott	Iowa	2023–2025	A	A	A	A
20-209-0021	Wyandotte	Kansas	2021–2023	A	**V**	**V**	A
20-209-0021	Wyandotte	Kansas	2023–2025	A	**V**	**V**	A
21-015-0008	Boone	Kentucky	2023–2025	A	A	A	A
21-111-0067	Jefferson	Kentucky	2020–2022	**V**	**V**	**V**	A
21-111-0080	Jefferson	Kentucky	2021–2023	**V**	**V**	**V**	**V**
21-111-0080	Jefferson	Kentucky	2022–2024	**V**	**V**	**V**	**V**
21-111-1041	Jefferson	Kentucky	2023–2025	**V**	**V**	**V**	**V**
22-033-0003	East Baton Rouge	Louisiana	2022–2024	A	**V**	**V**	A
22-033-0003	East Baton Rouge	Louisiana	2023–2025	**V**	**V**	**V**	**V**
22-047-0009	Iberville	Louisiana	2022–2024	**V**	**V**	**V**	**V**
22-121-0001	West Baton Rouge	Louisiana	2023–2025	A	**V**	**V**	A
24-005-1007	Baltimore	Maryland	2023–2025	A	**V**	**V**	A
24-025-9001	Harford	Maryland	2022–2024	A	**V**	**V**	A
24-510-5253	Baltimore (City)	Maryland	2022–2024	A	**V**	**V**	A
26-021-0014	Berrien	Michigan	2023–2025	**V**	**V**	**V**	**V**
26-027-0003	Cass	Michigan	2020–2022	A	**V**	A	A
26-027-0003	Cass	Michigan	2021–2023	A	**V**	A	A
26-027-0003	Cass	Michigan	2023–2025	A	**V**	A	A
26-063-0007	Huron	Michigan	2020–2022	A	A	A	A
26-081-0020	Kent	Michigan	2021–2023	A	**V**	**V**	A
26-081-0020	Kent	Michigan	2022–2024	**V**	**V**	**V**	**V**
26-099-1003	Macomb	Michigan	2023–2025	A	A	A	A
26-101-0922	Manistee	Michigan	2021–2023	A	**V**	A	A
26-121-0039	Muskegon	Michigan	2023–2025	**V**	**V**	**V**	**V**
26-125-0001	Oakland	Michigan	2023–2025	A	**V**	**V**	A
26-139-0005	Ottawa	Michigan	2021–2023	**V**	**V**	**V**	A
26-139-0005	Ottawa	Michigan	2022–2024	A	A	A	A
26-147-0005	St. Clair	Michigan	2021–2023	**V**	**V**	**V**	**V**
26-163-0001	Wayne	Michigan	2020–2022	A	A	A	A
26-163-0001	Wayne	Michigan	2021–2023	**V**	**V**	**V**	**V**
28-033-0002	DeSoto	Mississippi	2021–2023	A	**V**	**V**	A

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Table A1: (continued)

AQS site ID	County	State	Period	status under alternative procedure			
				final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
29-047-0006	Clay	Missouri	2022–2024	A	**V**	**V**	A
29-099-0019	Jefferson	Missouri	2023–2025	A	A	A	A
29-113-0004	Lincoln	Missouri	2022–2024	A	A	A	A
29-183-1004	Saint Charles	Missouri	2023–2025	A	**V**	A	A
29-189-0005	Saint Louis	Missouri	2023–2025	A	**V**	**V**	A
29-510-0085	St. Louis City	Missouri	2022–2024	A	**V**	**V**	A
32-003-0298	Clark	Nevada	2020–2022	A	A	**V**	A
32-003-0298	Clark	Nevada	2021–2023	A	A	A	A
32-003-0298	Clark	Nevada	2022–2024	**V**	**V**	**V**	A
32-003-0299	Clark	Nevada	2022–2024	A	A	A	A
32-003-0299	Clark	Nevada	2023–2025	A	A	A	A
32-003-1019	Clark	Nevada	2023–2025	**V**	**V**	**V**	**V**
32-003-7772	Clark	Nevada	2023–2025	**V**	**V**	**V**	**V**
32-031-0020	Washoe	Nevada	2020–2022	A	**V**	**V**	A
34-003-0006	Bergen	New Jersey	2021–2023	A	A	A	A
34-003-0006	Bergen	New Jersey	2022–2024	**V**	**V**	**V**	**V**
34-015-0002	Gloucester	New Jersey	2021–2023	A	**V**	**V**	A
34-019-0001	Hunterdon	New Jersey	2023–2025	**V**	**V**	**V**	**V**
34-023-0011	Middlesex	New Jersey	2023–2025	**V**	**V**	**V**	**V**
34-025-0005	Monmouth	New Jersey	2021–2023	A	A[†]	A	A
34-029-0006	Ocean	New Jersey	2021–2023	A	**V**	A	A
34-031-5001	Passaic	New Jersey	2023–2025	A	A	A	A
35-001-0023	Bernalillo	New Mexico	2023–2025	**V**	**V**	**V**	A
35-013-0020	Dona Ana	New Mexico	2021–2023	**V**	**V**	**V**	A
35-013-0020	Dona Ana	New Mexico	2022–2024	A	**V**	**V**	A
35-013-0023	Dona Ana	New Mexico	2023–2025	A	**V**	**V**	A
35-043-1001	Sandoval	New Mexico	2020–2022	A	A	A	A
35-045-0018	San Juan	New Mexico	2020–2022	A	A	A	A
35-045-0018	San Juan	New Mexico	2021–2023	A	A	A	A
36-005-0110	Bronx	New York	2023–2025	**V**	**V**	**V**	A
36-005-0133	Bronx	New York	2021–2023	A	**V**	**V**	A
36-061-0135	New York	New York	2020–2022	A	A	A	A
36-081-0124	Queens	New York	2020–2022	**V**	**V**	**V**	**V**
36-103-0002	Suffolk	New York	2023–2025	**V**	**V**	**V**	**V**
36-103-0009	Suffolk	New York	2020–2022	A	**V**	**V**	A
39-007-1001	Ashtabula	Ohio	2021–2023	A	A	A	A
39-035-0034	Cuyahoga	Ohio	2023–2025	A	A	A	A
39-061-0006	Hamilton	Ohio	2021–2023	**V**	**V**	**V**	**V**
39-061-0010	Hamilton	Ohio	2022–2024	A	**V**	**V**	A
39-061-0010	Hamilton	Ohio	2023–2025	A	A	A	A
39-061-0040	Hamilton	Ohio	2021–2023	A	**V**	**V**	A
39-085-0003	Lake	Ohio	2023–2025	A	**V**	**V**	A

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Table A1: (continued)

				status under alternative procedure			
AQS site ID	County	State	Period	final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
39-113-0037	Montgomery	Ohio	2023–2025	**V**	**V**	**V**	**V**
39-165-0007	Warren	Ohio	2021–2023	**V**	**V**	**V**	A
40-017-0101	Canadian	Oklahoma	2021–2023	**V**	**V**	**V**	**V**
40-017-0101	Canadian	Oklahoma	2023–2025	A	**V**	**V**	A
40-031-0651	Comanche	Oklahoma	2022–2024	**V**	**V**	**V**	**V**
40-109-1037	Oklahoma	Oklahoma	2020–2022	A	**V**	**V**	A
40-109-1037	Oklahoma	Oklahoma	2023–2025	**V**	**V**	**V**	**V**
40-115-9004	Ottawa	Oklahoma	2021–2023	A	**V**	**V**	A
40-143-1127	Tulsa	Oklahoma	2021–2023	**V**	**V**	**V**	**V**
40-143-1127	Tulsa	Oklahoma	2023–2025	A	**V**	**V**	A
42-101-0024	Philadelphia	Pennsylvania	2020–2022	A	**V**	**V**	A
42-101-0024	Philadelphia	Pennsylvania	2021–2023	**V**	**V**	**V**	**V**
42-101-0024	Philadelphia	Pennsylvania	2022–2024	A	**V**	**V**	A
42-101-0048	Philadelphia	Pennsylvania	2021–2023	A	**V**	**V**	A
42-101-0048	Philadelphia	Pennsylvania	2022–2024	**V**	**V**	**V**	**V**
47-157-0021	Shelby	Tennessee	2023–2025	A	A	A	A
47-165-0007	Sumner	Tennessee	2022–2024	A	**V**	**V**	A
48-027-1045	Bell	Texas	2021–2023	A	A	A	A
48-029-0059	Bexar	Texas	2022–2024	A	**V**	**V**	A
48-029-0059	Bexar	Texas	2023–2025	A	**V**	**V**	A
48-039-1016	Brazoria	Texas	2021–2023	A	**V**	**V**	**V**
48-039-1016	Brazoria	Texas	2022–2024	**V**	**V**	**V**	**V**
48-141-0044	El Paso	Texas	2022–2024	A	**V**	A	A
48-141-0055	El Paso	Texas	2022–2024	A	**V**	**V**	A
48-141-0057	El Paso	Texas	2021–2023	**V**	**V**	**V**	**V**
48-141-0057	El Paso	Texas	2023–2025	A	**V**	A	A
48-141-0058	El Paso	Texas	2020–2022	A	**V**	**V**	A
48-141-0058	El Paso	Texas	2023–2025	**V**	**V**	**V**	**V**
48-167-1034	Galveston	Texas	2020–2022	A	**V**	**V**	**V**
48-201-0047	Harris	Texas	2020–2022	A	**V**	**V**	A
48-201-0066	Harris	Texas	2020–2022	A	**V**	A	A
48-201-1015	Harris	Texas	2021–2023	A	**V**	**V**	A
48-201-1050	Harris	Texas	2022–2024	**V**	**V**	**V**	**V**
48-257-0005	Kaufman	Texas	2022–2024	**V**	**V**	**V**	**V**
48-367-0081	Parker	Texas	2020–2022	A	**V**	A	A
48-479-0016	Webb	Texas	2023–2025	A	**V**	**V**	A
49-035-3015	Salt Lake	Utah	2023–2025	A	A	**V**	A
49-045-0004	Tooele	Utah	2022–2024	**V**	**V**	**V**	**V**
49-047-2003	Uintah	Utah	2022–2024	**V**	**V**	**V**	**V**
49-049-5010	Utah	Utah	2020–2022	**V**	**V**	**V**	A
49-057-1003	Weber	Utah	2023–2025	A	**V**	**V**	A
53-033-0023	King	Washington	2020–2022	**V**	**V**	**V**	A

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Table A1: (continued)

AQS site ID	County	State	Period	status under alternative procedure: final digit rounded	(b) round both	(c) carry, round	(d) carry, truncate
55-021-0015	Columbia	Wisconsin	2023–2025	A	**V**	**V**	A
55-027-0001	Dodge	Wisconsin	2021–2023	A	**V**	**V**	A
55-029-0004	Door	Wisconsin	2023–2025	A	**V**	**V**	A
55-079-0068	Milwaukee	Wisconsin	2022–2024	**V**	**V**	**V**	**V**
55-105-0030	Rock	Wisconsin	2022–2024	**V**	**V**	**V**	**V**
55-105-0030	Rock	Wisconsin	2023–2025	**V**	**V**	**V**	**V**
55-117-0009	Sheboygan	Wisconsin	2021–2023	A	**V**	**V**	A
55-117-0009	Sheboygan	Wisconsin	2022–2024	**V**	**V**	**V**	A
55-117-0009	Sheboygan	Wisconsin	2023–2025	A	A	A	A
changed determinations, of 190				61	148	140	52

Table A2: Valid borderline $PM_{2.5}$ site-periods of the 2020–2025 Design Value Reports, annual standard (75 site-periods, upper panel) and daily standard (39, lower panel), with the attainment status of each as written and under three alternatives. All four periods are evaluated against the current levels of 9.0 and 35 μg/m^3; the 2020–2022 annual values were published under the earlier 12.0 μg/m^3 level, so their entries give the status under the current level and not the determinations then in force. Design value: as published, in μg/m^3, reproduced from the AirData daily files. As written: Appendix N, final digit rounded, attainment at or below the level. Final digit: the same mean truncated instead of rounded. Strict (the comparison $<$ column of Table 2): attainment only below the level. No waiver (the symmetric completeness column of Table 2): a violating value held to the data completeness required of an attaining one. A, attains; V, violates; n.d., no valid determination; bold marks a change from the status as written. Validity is re-evaluated under each alternative from the completeness figures of the Reports: a value that attains only under the alternative must have three years valid under Appendix N §4.1(b) or §4.2(b) (a year with an incomplete quarter remaining valid if its own annual mean or 98th percentile exceeds the level) or pass the maximum-value substitution test (§4.1(c)(ii), §4.2(c)(i)). * marks the two entries for which neither holds, so that the alternative gives no valid determination without the Administrator's approval of the incomplete data (§4.1(d), §4.2(d)); ** marks the one entry whose validity under truncation depends on whether the annual mean of its incomplete year, which lies between 9.05 and 9.10 μg/m^3, is itself rounded (valid) or truncated (no valid determination) in the test of §4.1(b). Procedures (b)–(d) of Table A1 act on the eight-hour ozone averages and have no counterpart here. The last row of each panel counts the changes, which are the $PM_{2.5}$ entries of Table 2. Rows sorted by state, site, and period.

AQS site ID	County	State	Period	design value (μg/m^3)	status: as written	final digit truncated	strict	no waiver
Annual standard, level 9.0 μg/m^3								
01-113-0003	Russell	Alabama	2022–2024	9.1	V	**A**	V	V
06-009-0001	Calaveras	California	2020–2022	9.0	A	A	**V**	A
06-019-2009	Fresno	California	2020–2022	9.1	V	**A**	V	V

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Table A2: (continued)

AQS site ID	County	State	Period	design value (μg/m^3)	status: as written	status: final digit truncated	status: strict	status: no waiver
06-025-1003	Imperial	California	2020–2022	9.0	A	A	**V**	A
06-071-0306	San Bernardino	California	2021–2023	9.0	A	A	**V**	A
06-073-1022	San Diego	California	2021–2023	9.1	V	**A**	V	V
06-073-1022	San Diego	California	2023–2025	9.0	A	A	**V**	A
13-095-0007	Dougherty	Georgia	2021–2023	9.0	A	A	**V**	A
13-095-0007	Dougherty	Georgia	2023–2025	9.0	A	A	**V**	A
13-121-0039	Fulton	Georgia	2022–2024	9.0	A	A	**V**	A
13-135-0002	Gwinnett	Georgia	2022–2024	9.1	V	**A**	V	V
13-185-0003	Lowndes	Georgia	2022–2024	9.0	A	A	**V**	A
13-295-0004	Walker	Georgia	2022–2024	9.0	A	A	**V**	A
16-027-0010	Canyon	Idaho	2022–2024	9.1	V	**A**	V	V
17-031-0022	Cook	Illinois	2020–2022	9.1	V	**n.d.***	V	**n.d.**
17-031-0022	Cook	Illinois	2022–2024	9.0	A	A	**V**	A
17-031-0057	Cook	Illinois	2022–2024	9.0	A	A	**V**	A
17-031-3301	Cook	Illinois	2022–2024	9.1	V	**A**	V	V
17-031-4007	Cook	Illinois	2020–2022	9.1	V	**A**	V	V
17-089-0007	Kane	Illinois	2020–2022	9.1	V	**A**	V	V
17-089-0124	Kane	Illinois	2022–2024	9.1	V	**A**	V	V
17-113-2003	McLean	Illinois	2021–2023	9.0	A	A	**V**	A
17-119-0120	Madison	Illinois	2020–2022	9.1	V	**A**	V	V
17-201-0118	Winnebago	Illinois	2020–2022	9.1	V	**A**	V	V
17-201-0118	Winnebago	Illinois	2021–2023	9.0	A	A	**V**	A
18-089-0031	Lake	Indiana	2023–2025	9.1	V	**A****	V	V
18-089-0034	Lake	Indiana	2022–2024	9.0	A	A	**V**	A
18-089-0034	Lake	Indiana	2023–2025	9.1	V	**A**	V	V
18-089-0036	Lake	Indiana	2023–2025	9.1	V	**A**	V	V
18-127-0024	Porter	Indiana	2021–2023	9.0	A	A	**V**	A
18-163-0016	Vanderburgh	Indiana	2021–2023	9.1	V	**A**	V	V
18-163-0021	Vanderburgh	Indiana	2022–2024	9.0	A	A	**V**	A
18-167-0018	Vigo	Indiana	2023–2025	9.0	A	A	**V**	A
21-059-0005	Daviess	Kentucky	2020–2022	9.0	A	A	**V**	A
22-033-0009	East Baton Rouge	Louisiana	2022–2024	9.0	A	A	**V**	A
22-121-0001	West Baton Rouge	Louisiana	2021–2023	9.1	V	**A**	V	V
22-121-0001	West Baton Rouge	Louisiana	2023–2025	9.0	A	A	**V**	A
26-163-0001	Wayne	Michigan	2020–2022	9.0	A	A	**V**	A
27-053-0963	Hennepin	Minnesota	2023–2025	9.0	A	A	**V**	A
27-123-0868	Ramsey	Minnesota	2021–2023	9.0	A	A	**V**	A
28-033-0002	DeSoto	Mississippi	2023–2025	9.0	A	A	**V**	A
28-047-0008	Harrison	Mississippi	2020–2022	9.1	V	**A**	V	V
29-021-0005	Buchanan	Missouri	2023–2025	9.0	A	A	**V**	A
29-510-0085	St. Louis City	Missouri	2023–2025	9.0	A	A	**V**	A
29-510-0094	St. Louis City	Missouri	2021–2023	9.0	A	A	**V**	A

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Table A2: (continued)

					status			
AQS site ID	County	State	Period	design value (μg/m^3)	as written	final digit truncated	strict	no waiver
34-007-0002	Camden	New Jersey	2020–2022	9.1	V	**A**	V	V
34-039-0004	Union	New Jersey	2020–2022	9.0	A	A	**V**	A
37-057-0002	Davidson	North Carolina	2023–2025	9.1	V	**A**	V	V
39-017-0015	Butler	Ohio	2022–2024	9.1	V	**A**	V	V
39-017-0019	Butler	Ohio	2023–2025	9.0	A	A	**V**	A
39-049-0034	Franklin	Ohio	2021–2023	9.0	A	A	**V**	A
39-095-1003	Lucas	Ohio	2022–2024	9.1	V	**A**	V	V
39-113-0038	Montgomery	Ohio	2021–2023	9.0	A	A	**V**	A
40-071-0604	Kay	Oklahoma	2021–2023	9.0	A	A	**V**	A
40-109-0097	Oklahoma	Oklahoma	2021–2023	9.1	V	**A**	V	V
41-033-0114	Josephine	Oregon	2022–2024	9.0	A	A	**V**	A
42-003-0002	Allegheny	Pennsylvania	2020–2022	9.1	V	**A**	V	V
42-043-0401	Dauphin	Pennsylvania	2023–2025	9.0	A	A	**V**	A
42-045-0002	Delaware	Pennsylvania	2020–2022	9.1	V	**A**	V	V
42-071-0012	Lancaster	Pennsylvania	2023–2025	9.0	A	A	**V**	A
42-101-0055	Philadelphia	Pennsylvania	2022–2024	9.0	A	A	**V**	A
42-101-0075	Philadelphia	Pennsylvania	2020–2022	9.1	V	**A**	V	V
42-125-0005	Washington	Pennsylvania	2021–2023	9.0	A	A	**V**	A
47-037-0040	Davidson	Tennessee	2020–2022	9.1	V	**A**	V	V
47-093-1013	Knox	Tennessee	2020–2022	9.0	A	A	**V**	A
48-013-1090	Atascosa	Texas	2021–2023	9.0	A	A	**V**	A
48-013-1090	Atascosa	Texas	2023–2025	9.1	V	**A**	V	V
48-029-0032	Bexar	Texas	2022–2024	9.0	A	A	**V**	A
48-029-0032	Bexar	Texas	2023–2025	9.1	V	**A**	V	V
48-141-0044	El Paso	Texas	2021–2023	9.0	A	A	**V**	A
48-439-1002	Tarrant	Texas	2023–2025	9.0	A	A	**V**	A
48-453-0014	Travis	Texas	2022–2024	9.1	V	**A**	V	V
53-011-0024	Clark	Washington	2020–2022	9.1	V	**A**	V	V
54-003-0003	Berkeley	West Virginia	2021–2023	9.1	V	**A**	V	V
55-133-0027	Waukesha	Wisconsin	2021–2023	9.1	V	**A**	V	V
changed determinations, of 75						33	42	1
Daily standard, level 35 μg/m^3								
02-090-0040	Fairbanks North Star	Alaska	2023–2025	35	A	A	**V**	A
06-013-0002	Contra Costa	California	2020–2022	35	A	A	**V**	A
06-019-5001	Fresno	California	2021–2023	36	V	**A**	V	V
06-029-0018	Kern	California	2020–2022	35	A	A	**V**	A
06-031-1004	Kings	California	2023–2025	35	A	A	**V**	A
06-037-0002	Los Angeles	California	2020–2022	36	V	**n.d.***	V	**n.d.**
06-037-1302	Los Angeles	California	2023–2025	35	A	A	**V**	A
06-037-1602	Los Angeles	California	2023–2025	35	A	A	**V**	A
06-039-2010	Madera	California	2021–2023	35	A	A	**V**	A

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Table A2: (continued)

					status			
AQS site ID	County	State	Period	design value ($\mu g/m^3$)	as written	final digit truncated	strict	no waiver
06-047-2510	Merced	California	2021–2023	35	A	A	**V**	A
06-065-8005	Riverside	California	2020–2022	36	V	**A**	V	V
06-071-0027	San Bernardino	California	2023–2025	35	A	A	**V**	A
06-071-2002	San Bernardino	California	2022–2024	35	A	A	**V**	A
06-085-0005	Santa Clara	California	2020–2022	36	V	**A**	V	V
06-103-0007	Tehama	California	2021–2023	35	A	A	**V**	A
06-107-2003	Tulare	California	2023–2025	35	A	A	**V**	A
16-027-0010	Canyon	Idaho	2022–2024	35	A	A	**V**	A
16-079-0017	Shoshone	Idaho	2021–2023	36	V	**A**	V	V
27-005-2013	Becker	Minnesota	2023–2025	35	A	A	**V**	A
27-021-3410	Cass	Minnesota	2023–2025	36	V	**A**	V	V
27-037-0470	Dakota	Minnesota	2023–2025	36	V	**A**	V	V
27-053-0963	Hennepin	Minnesota	2023–2025	36	V	**A**	V	**n.d.**
27-123-0871	Ramsey	Minnesota	2023–2025	36	V	**A**	V	V
30-029-0049	Flathead	Montana	2020–2022	35	A	A	**V**	A
30-029-0049	Flathead	Montana	2021–2023	36	V	**A**	V	V
38-007-0002	Billings	North Dakota	2023–2025	35	A	A	**V**	A
38-025-0004	Dunn	North Dakota	2021–2023	35	A	A	**V**	A
38-025-0004	Dunn	North Dakota	2022–2024	35	A	A	**V**	A
38-065-0002	Oliver	North Dakota	2022–2024	36	V	**A**	V	V
38-101-0003	Ward	North Dakota	2022–2024	35	A	A	**V**	A
41-013-0100	Crook	Oregon	2022–2024	35	A	A	**V**	A
41-013-0100	Crook	Oregon	2023–2025	35	A	A	**V**	A
41-033-0114	Josephine	Oregon	2022–2024	36	V	**A**	V	V
41-033-0114	Josephine	Oregon	2023–2025	35	A	A	**V**	A
49-035-4002	Salt Lake	Utah	2020–2022	35	A	A	**V**	A
53-047-0013	Okanogan	Washington	2022–2024	36	V	**A**	V	V
53-061-0020	Snohomish	Washington	2022–2024	35	A	A	**V**	A
53-061-1007	Snohomish	Washington	2020–2022	36	V	**A**	V	V
55-009-0005	Brown	Wisconsin	2023–2025	35	A	A	**V**	A
changed determinations, of 39						14	25	2

B Calculation details

Several ozone counts in Table 3 are printed as ranges because, for years with exceptional-event exclusions, the AirData files contain two daily series, with and without the excluded data. This appendix describes the choice between the two series and its effects, the published daily values that do not follow from the published hourly concentrations, and the comparisons and test cases with which we assessed our implementation.

B.1 Exceptional-event series and the count ranges

For each ozone site and each year with exclusions, we use whichever of the post-exclusion and as-measured daily series gives the fourth-highest daily maximum listed in the Design Value Report. At twelve of the recalculated ozone site-periods there is a year in which the two series differ and both reproduce the Report's fourth-highest value. For those years we use the post-exclusion series and print each count that depends on the choice as a range whose other end is the count obtained with the as-measured series. Using the as-measured series instead changes the value calculated under some procedure at four of the 190 valid borderline ozone site-periods and the determination at two. One is Monmouth County, New Jersey, 2021–2023, whose three-year mean before the final step under (b), rounding at both steps, is 211/3000 ppm with the post-exclusion and 212/3000 ppm with the as-measured series; the other is Ada County, Idaho, 2021–2023, under (d), one final truncation. Neither the values under (a), as written, nor the 61 determinations that change at the final digit alone, nor the 140 that change under (c), EPA's 2010 proposal, depend on the choice.

The daily data entering the borderline ozone calculations contain 270 maxima from days only partly excluded as exceptional events. Because the hours EPA concurred in excluding are not public, such a day's maximum under procedures (b)–(d) is undetermined, and we carry it as an interval between its smallest and largest possible values. Of the site-periods whose daily data contain partly excluded days, only two use such a day in the design-value calculation (only one if the as-measured series is taken), and in both cases the two ends of the interval give the same design value and determination.

B.2 Daily values not reproduced from hourly data

We calculated 543,000-odd ozone and $PM_{2.5}$ daily values at the borderline sites from the AQS hourly concentrations; 99.5–99.7% of them reproduce the published value, and the rest are of three kinds. For 704 ozone and 33 $PM_{2.5}$ values, part of the day was excluded as an exceptional event; the AirData files identify the hours submitted for exclusion but not the subset EPA concurred in excluding. A further 480 ozone values are December 31 maxima. In the AirData daily files these maxima are formed from hours of the same calendar year only, whereas by the letter of Appendix U the late eight-hour periods of a day include hours of the next day. Recalculating these 480 maxima by the letter changes no determination. The remaining 566 $PM_{2.5}$ values, 562 of them at monitors reporting “corrected” Teledyne T640 data, have a published daily mean that is not the mean of the published hourly concentrations under any digit treatment the regulation allows.

B.3 Comparisons and test cases

The 281 comparisons between our implementation and the independently written one, over the stratified sample of twenty-five site-periods, were as follows. For a site-period that can be recalculated, thirteen quantities were compared, and for one that cannot, five to seven (the Report's entries and the reason the value cannot be recalculated). Three of the thirteen are entries of the Design Value Report (the per-year statistics, the design value, and the validity status). The rest are the first two of those entries as calculated, the mean before the final truncation or rounding, whether the published value is reproduced, and the determination as written and under each alternative at the final step.

Our statements of the five conventions on which most determinations turn (the final truncation, the inclusive comparison, half-up rounding, the percentile rank, and the completeness waiver) were compared word for word with the CFR text, with no discrepancy. In 41 synthetic test cases with hand-computed answers (constructed boundary values, deliberately corrupted daily records, and completeness-waiver cases in both directions) the implementation gave the expected result each time. The determinations counted in Table 2 agree with those formed from the Design Value Reports' annual statistics at each of the 304 site-periods, and so does each determination's dependence on the final digit and on the inclusive comparison.

C Data-handling provisions of 40 CFR Part 50

Table C1 lists the 59 data-handling provisions of 40 CFR Part 50 (eCFR text of 16 July 2026). Each row is a clause of Appendix U, N, K, or H, or of §§50.6–50.20, that fixes a reported digit, a divisor, a completeness requirement, a substitution, or the comparison with a level. A paragraph with several such clauses has one row per clause. Only the Appendix U and N provisions and the ozone and $PM_{2.5}$ comparison clauses enter our calculations.

Table C1: The 59 data-handling provisions of Appendices U, N, K, and H to 40 CFR Part 50 and of the comparison clauses of §§50.6–50.20 (eCFR text of 16 July 2026), grouped by appendix and numbered consecutively. A filled circle in column (A) marks the 36 provisions whose change alone can move some achievable design value across the level of a standard. A dagger in column (B) marks a provision whose text does not state the operative reading. Four questions are left open in this way; the first, whether an average of collocated-monitor values is truncated again, is common to Appendix U (row 19) and Appendix N (row 37) and is the only one that enters the ozone and $PM_{2.5}$ calculations. The section (§), table, and equation numbers in each row are those of the appendix or CFR part named in the group heading; phrases in quotation marks are verbatim regulatory text.

No.	Provision	Rule	(A)	(B)
Comparison of the statistic with the level of the standard, 40 CFR §§50.6–50.20				
1	§50.6(a)	PM_{10}: the standards are attained when the expected number of days per calendar year with a 24-hour average above 150 μg/m^3, determined under Appendix K, is equal to or less than one.	•	
2	§50.9(a)	One-hour ozone: the standard is attained when the expected number of days per calendar year with a maximum hourly average above 0.12 ppm is equal to or less than 1, determined under Appendix H.	•	
3	§50.19(b), (d)	Ozone (8-hour): the standard is met when the 3-year average of the annual fourth-highest daily maximum 8-hour average is less than or equal to 0.070 ppm, determined under Appendix U.	•	
4	§50.20(b); also §§50.18(b), 50.13(b)	Annual $PM_{2.5}$: the standard is met when the annual mean, determined under Appendix N, is less than or equal to 9.0 μg/m^3 (the earlier annual standards, 12.0 and 15.0 μg/m^3, use the same wording).	•	
5	§50.20(c); also §§50.18(c), 50.13(c)	24-hour $PM_{2.5}$: the standard is met when the 98th percentile 24-hour concentration, determined under Appendix N, is less than or equal to 35 μg/m^3.	•	
6	§50.10(b)	Ozone (8-hour, 1997 standard): the standards are met when the average of the annual fourth-highest daily maximum 8-hour average is less than or equal to 0.08 ppm, determined under Appendix I.		
Appendix U to Part 50 (2015 ozone standard)				
7	§3(a)	Hourly averages are reported in ppm to the third decimal place; additional digits are truncated.	•	
8	§3(b)	An 8-hour average is valid if at least 6 of its hourly values are available; with 6 or 7 hours the divisor is 6 or 7.		

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Table C1, continued

No.	Provision	Rule	(A)	(B)
9	§3(b)	With 5 or fewer hours an 8-hour average is valid only if it is greater than the level after zero is substituted for the missing hours, equivalently if the available hourly concentrations sum to more than 0.567 ppm.	•	
10	§3(b)	The 8-hour averages are reported to three decimal places; additional digits are truncated.	•	
11	§3(b), §1(b)	Hours approved under §50.14 as affected by exceptional events are counted as missing in the 8-hour averages.		
12	§3(c)	The daily maximum is the highest of the 17 consecutive 8-hour averages that begin between 7:00 a.m. and 11:00 p.m.; the later 8-hour periods extend into the following day.		
13	§3(d)	A daily maximum is valid if at least 13 of the 17 averages are valid, or, with fewer than 13, if it is greater than the level; hours excluded as exceptional events still count toward the 13.	•	
14	§3(e)	The design value is the annual fourth-highest daily maximum averaged over three years, reported to three decimal places with additional digits truncated.	•	
15	§1(c), §3(e)	The annual fourth-highest value is the fourth-highest daily maximum of the year, taken over days valid under §3(d) only.		
16	§4(b)	A design value greater than the level is always valid; a design value less than or equal to the level requires valid daily maxima for at least 90% of ozone-season days on average over the 3-year period and at least 75% in each year.	•	
17	§4(c)	Missing days may be counted toward completeness when meteorological or ambient data show that conditions were not conducive to concentrations above the level, subject to Regional Administrator approval.		
18	§4(d), Examples 1–2	Worked examples: a 3-year average of 0.065666 ppm is truncated to 0.065 ppm and meets the standard; 0.073333 ppm is truncated to 0.073 ppm and fails to meet it even though completeness is less than 75% in one year and less than 90% over the 3-year period.	•	
19	§2(b)(ii)	When the primary monitor lacks a valid hour, the value from a secondary monitor is substituted; with more than one secondary monitor their hourly values are averaged. Whether the averaged value is truncated again under §3(a) is not stated.	•	†
20	§2(c)	Data from two nearby sites may be combined into a single site data record with Regional Administrator approval, on the basis of qualitative factors listed in the clause.		
21	§3(c)	Daily maxima are determined for each day with monitoring data, including days outside the ozone monitoring season.		
Appendix N to Part 50 ($PM_{2.5}$ standards)				
22	§3.0(b)	Concentrations are reported to at least one decimal place; digits to the right of the tenths place are truncated (by AQS if more decimals are reported).	•	
23	§3.0(c)	A 24-hour average is valid if at least 75 percent of the hourly values (18 hourly values) are available; with fewer than 24 hours the divisor is the number of available hours.		
24	§3.0(c)	A day with seven or more missing hours is also valid if, with zero substituted for the missing hours, the 24-hour average is greater than the level (the text states this condition as greater than or equal to 35.5 $\mu g/m^3$).	•	
25	§4.3(a)	Annual design values are rounded to the nearest tenth of a $\mu g/m^3$ (decimals "x.x5 and greater are rounded up"); intermediate calculations are not rounded.	•	
26	§4.3(b)	Twenty-four-hour design values are rounded to the nearest 1 $\mu g/m^3$ (0.5 and greater rounded up).	•	

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Table C1, continued

No.	Provision	Rule	(A)	(B)
27	§1.0(c)	The quarterly data capture rate is creditable samples divided by scheduled samples, multiplied by 100 and rounded to the nearest integer.	•	
28	§4.1(b)	A year is complete when all four quarters have at least 75 percent capture; a year with at least 11 creditable samples in each quarter is also valid if the resulting annual design value, rounded under §4.3, is greater than the level.	•	
29	§4.1(c)(i)	With deficient quarters, an annual design value above the level is valid if it remains greater than the level after the lowest reported daily value of the quarter is substituted for the missing samples. This minimum quarterly value substitution test is permitted only with at least 30 days of data across the matching quarters of the three years.		
30	§4.1(c)(ii)	An annual design value equal to or below the level is valid if it remains at or below the level after each deficient quarter is filled to 100 percent with its highest reported daily value, excluding approved exceptional-event data; each deficient quarter needs at least 50 percent capture.		
31	§4.2(b)	For the 24-hour design value a year is valid notwithstanding incomplete quarters, with as few as one creditable sample in the year, if the resulting value, rounded under §4.3, is greater than the level.	•	
32	§4.1(d), §4.2(d)	An incomplete design value may also be considered valid with the approval of, or at the initiative of, the Administrator, on the basis of qualitative factors listed in the clause.		
33	§4.4(b)	The annual mean is the sum of the quarterly means divided by the number of quarters with at least one daily value (Equation 2).	•	
34	§1.0(c), §4.5(a)	Extra (non-creditable) samples enter the means and may be selected as the 98th percentile value, but only the creditable count determines how deep in the sorted list the percentile lies.	•	
35	§4.5(a), Table 1	The annual 98th percentile is the n-th highest daily value, with n read from Table 1 by the annual creditable sample count ($n = 1$ for 1–50 samples, 2 for 51–100, and so on to 8 for 351–366).	•	
36	§4.5(b), §4.4(c)	Both design values are 3-year averages of the annual statistics (Equations 3 and 4), carried unrounded until §4.3.		
37	§3.0(d)(2)	When the primary monitor lacks a valid daily value, a collocated monitor's value is used; with more than one collocated value their average is used. Whether the average is truncated again to one decimal place is not stated.	•	†
38	§3.0(a)	Data "not certified by the reporting organization" may nevertheless be used once the deadline for certification has passed if EPA judges them complete and accurate.		
39	§1.0(c)	A make-up sample is creditable if taken before the next required sampling day or exactly one week after the missed day.		
40	§3.0(e)	Samples from a collocated continuous FEM/ARM monitor that samples more often than the primary FRM monitor are always considered scheduled and hence creditable.	•	
41	§3.0(d)(3)	Data from two nearby sites may be combined if the Regional Administrator determines that the measured concentrations do not differ substantially.		
Appendix K to Part 50 (PM_{10} standards)				
42	§1.0(b)	An exceedance is a daily value above the 24-hour level after rounding to the nearest $10\,\mu g/m^3$ (values ending in 5 or greater rounded up).	•	
43	§2.1(b)	The expected exceedance rate is compared with one per year after rounding to the nearest tenth (0.05 and greater rounded up; a rate of 1.05 becomes 1.1, the lowest rate for nonattainment).	•	

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Table C1, continued

No.	Provision	Rule	(A)	(B)
44	§2.3(a)	A minimum of 75 percent of scheduled samples per quarter is required. How this percentage is rounded is not stated (Appendix N, by contrast, rounds its capture rate to the nearest integer).	•	†
45	§2.3(c)	The 75 percent requirement does not apply when fewer data suffice to establish nonattainment unambiguously.		
46	§2.3(d)	A 24-hour average is valid with at least 75 percent of hourly values (18 hourly values); a day with 7 or more missing hours also counts if, with zero substituted, its average exceeds the level after rounding to the nearest $10\,\mu g/m^3$.	•	
47	§3.1(a)	Observed exceedances in a quarter are scaled for missing days by the ratio of days in the quarter to days with data (Equation 1).	•	
48	§3.1(b)	The estimated exceedances for a quarter are rounded to the nearest hundredth (0.005 and greater rounded up).	•	
49	§3.1(d)	The estimated exceedances for a year are rounded to one decimal place; the expected number of exceedances is their average over the most recent 3 or more representative years, again rounded to one decimal place (0.05 and greater rounded up).	•	
50	§3.1(f)	The missing-data correction is not required for the quarter of a first observed exceedance if it was the only exceedance that quarter, everyday sampling follows for 4 calendar quarters, and 75 percent capture is achieved.	•	
51	§3.0(a)(2), §3.0(b)	With two or more collocated monitors the daily value is their average; data from two nearby sites may be combined with Regional Administrator approval.		
52	§3.2(a)–(b)	When sampling occurs on days beyond the systematic schedule, exceedances are estimated by strata, one stratum per scheduled sampling day (Equation 3).		
53	§2.3(b), §2.4(a)	More than 3 representative years may be used, and adjustments for unusual events by statistical models or historical data are allowed subject to Regional Administrator approval.		
Appendix H to Part 50 (one-hour ozone standard)				
54	§1	An exceedance is a daily maximum hourly average greater than the level. The appendix states no digit convention for this comparison; the operative reading appears only in the *Guideline for Interpretation of Ozone Air Quality Standards* that the appendix references.	•	†
55	§3	A daily maximum is valid if 75 percent of the hours from 9:01 a.m. to 9:00 p.m. were measured or if the highest hour is greater than the level.	•	
56	§3	A missing daily maximum may be assumed below the level if the valid maxima on the preceding and following days do not exceed 75 percent of the level.		
57	§3	The estimated exceedances for the year are the observed exceedances scaled for missing days, rounded to one decimal place. The rounding clause reads “fractional parts equal to 0.05 round up” and, as written, does not cover parts greater than 0.05.	•	†
58	§3	A site with two or more observed exceedances in each year does not meet the standard, and the incomplete-sampling procedure is unnecessary.		
59	§3	The number of required monitoring days is the total number of days in the year unless the Regional Administrator has granted a waiver under 40 CFR Part 58.		

Data availability

All data used are public. The measurements are the AQS AirData pre-generated daily-summary and hourly files (retrieved in July 2026); the published design values, validity status and completeness fields are EPA's Design Value Reports for the evaluation periods 2020–2022 through 2023–2025; the regulatory text is the eCFR text of 40 CFR Part 50 as of 16 July 2026. Appendix A lists every valid borderline site-period with its status under each alternative examined. Because EPA regenerates the AirData files from its current database, a reproducibility package that preserves the computation is posted at `https://bootloops.ai/files/airquality/airquality-record.tar.gz` (about 41 MB), with its file-by-file digests in the accompanying `airquality-record.MANIFEST.sha256` and the digest of the archive itself in `airquality-record.RECORD.json`. It contains (i) the SHA-256 digests of the thirteen hourly and twelve daily AirData year files, the eight Design Value Report workbooks and the eCFR text, each as retrieved, with a retrieval ledger, and the workbooks and regulatory text themselves; (ii) the code that builds the borderline cohort from the Reports, computes design values from the daily and from the hourly files, applies procedures (a)–(d) of Eq. (2) to every ozone site-period in the Reports, and re-evaluates validity under each alternative, together with the table of conventions adopted where the regulation is silent; (iii) the extracted hourly and daily records of every site counted in Sections 4.1 and 4.2 and the exceptional-event series adopted for each site and year; (iv) a table with one row per borderline site-period and year giving the number of valid days and the annual fourth-highest daily maximum under each procedure as exact rationals, and every machine-readable result from which the numbers in this paper are read; (v) two independent reimplementations of the design-value chain and their outputs, and planted tests of provisions of Appendix U as implemented, including the eight-hour periods with fewer than six valid hours, periods that cross midnight into the following year, event-flagged hours, the daily validity waiver, and a constructed three-year record that attains under (a) and violates under (b) and (c). The hourly ozone records of every monitor in the four Reports, as retrieved, are posted beside the package as one file per year (`hourly_o3_2020–2026_all-monitors.csv.gz`; about 31 MB for each full year and a small file for the January 2026 hours that complete the last eight-hour periods of 2025), with the archived daily rows (`daily_o3_all-monitors.json.gz`) and their own digest list, so that the sweep over all site-periods can be repeated without reference to EPA's current files.

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