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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE July 9, 1980

SUBJECT Errata for the April, 1980, First External Review Draft of the EPA Particulate Matter and Sulfur Oxides ($PM/SO_x$) Criteria Document

FROM ECAO, EPA/RTP/N.C.
Lester D. Grant

TO Recipients of the first external review draft (April 1980) of the Particulate Matter and Sulfur Oxides criteria document

PLAINTIFF'S EXHIBIT

SH-3176

The attached materials include corrigenda comments regarding contemplated major text revisions, other lesser corrections (deletions/insertions), and reference clarifications and additions for various chapters of the April, 1980, external review draft of the $PM/SO_x$ criteria document.

The corrigenda comments on chapters 1, 3, and 14 signal major revisions comtemplated for a second external review draft based on comments and other new information obtained since finalization and release of the April external review draft. The lists of errata mainly concern: (1) errors in reference citations and (2) editorial changes intended to clarify textual meaning or errors in technical content. Complete reference lists for chapters 2, 3, 6, 9, and 13, including corrected citations, are provided. There are no comments or errata sheets for chapters 4 or 8.

These errata and descriptions of contemplated changes are being circulated at this time in order to facilitate informed and focused public discussion of EPA's criteria revision efforts. Certainly, additional changes and, possibly, modifications to these contemplated changes may need to be made in response to public comments on the First External Review Draft received by July 31, 1980, and advice received from the Clean Air Scientific Advisory Committee (CASAC) of EPA's Science Advisory Board. Full and adequate opportunity for public comment on any of these contemplated changes or other modifications incorporated in a second external review draft to be made available to the public and CASAC.

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Chapter 1 Introduction, Summary, and Conclusions $SO_x$/PM

Corrigenda

Before listing specific errata (deletions/insertions) for Chapter 1 (Volume I) of the April, 1980, External Review Draft of the EPA criteria document for sulfur oxides and particulate matter, certain general comments should be noted reguarding anticipated revisions in Chapter 1.

First, major revisions planned to be made in later current chapters (2-14) of the document, as indicated in ensuing corrigenda materials, will also be appropriately reflected in revisions to be made in Chapter 1. For example, certain major revisions in the text of Chapter 3 noted in corrigenda comments for that chapter will be appropriately reflected in revision of text in Section 1.3.2 (pg. 1-19 to 1-43). This especially includes introductory materials (4 main points) to be inserted on pg. 3-84 at the start of the discussion of comparison of particulate matter measurement techniques, as noted later in corrigenda comments for Chapter 3. Similarly, revisions noted in those corregenda comments to be made in Chapter 3 regarding the discussions of specific studies comparing COH versus TSP and BS versus TSP measurement results will be appropriately reflected in Chapter 1 revisions.

Other major revisions in Chapter 14, noted in the later corrigenda comments for that chapter, will also be reflected in revisions of Section 1.5.5 (Community Health Observation Studies) of Chapter 1. Of particular importance are major changes to be made in Tables 1-19 to 1-21 (on pg. 1-140 to 1-42) and accompanying text regarding summarization of various expert reviewers' evaluations of key quantitative community health studies. Specific changes in those tables will include the following:

(1) In Table 1-19, deletion of all entries except those for studies by Lawther[13], Glasser and Greenburg[222], Martin and Bradley[11], and Martin[6].

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(2) In Table 1-20, deletion of entries for all studies except those by Greenburg[196], Lawther[52,53], Martin[16], Waller[7], and Van der Lende[74].

(3) In Table 1-21, deletion of entries for all studies except those by Douglas and Waller[90], Lambert and Reid[28], Lunn et al[96,97], Ferris[43], Sawicki[181], Mostardi,[117,258] Shy[215], and Rudnick[182].

Discussion of tables 1-19 to 1-21, in the text on pg. 1-143 to 1-152 is to be revised such that comments on quantitive air quality levels associated with observed health effects will generally be in terms of the original (COH, BS, TSP) particulate matter measurement units employed in specific studies summarized in the table, except for comments on interpretative evaluations by particular expert reviewers that involved "translation" of COH or BS units into TSP units. Further evaluative comments are to be added on whether reasonable interconversions between COH, BS, and TSP measurement units can be made and, if so, in what manner and under what circumstances. The impact of such interconversion or lack of sound bases to do so on interpretation of the epidemiology data base for $SO_x$/PM will then be taken into account in text revisions more specifically delineating key conclusions based on the epidemiology literature.

The implications of those conclusions, and others based on information discussed in Chapters 11, 12, and 13, for development of health criteria for sulfur oxide and particulate matter are to be delineated in an integrative health summary and conclusions chapter still in the process of being prepared for addition to the document. Relevant text summarizing the most salient features of that chapter, once completed. is to be added as the final portion of Chapter 1 (Volume 1).



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Chapter 1 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 1-18 | 3/7 | cyslone | cyclone |
| 1-19 | 2/3 | - | < before: 2.5 μm |
| 1-23 | 1/7 | Parting | Party |
| 1-27 | -- | Note: Table 1-2 is actually Table 1-3 cited in the text, and Table 1-3 is actually Table 1-2 | |
| 1-39 | 1/4 | 10 or, at most, 30 percent | 10 to 30 percent |
| 1-63 | Table 1-6 | Ref. 118 (3 instances) | Replace with Reference 272 |
| 1-64 | " | Ref. 118 (1 instance) | Replace with Reference 272 |
| 1-88 | 3/2,3 | Polyester, acrylic... acid hydrolysis | |
| 1-93 | 1/5,6 | One study...50 percent | One investigator (Lippmann, 1977) calculated that about 10 percent |
| 1-95 | 1/3 | are | may be |
| 1-95 | 1/8,9 | or other agents...conditions. | Period after: ...absence of ammonia. |
| 1-95 | 2/3 | - | (at concentrations $\leq$1 $mg/m^3$ or 5 ppm, respectively) after: alone |
| 1-100 | 1/1 | summarized in Tables 1-8 and 1-9, | of certain studies discussed in Chapter 12, |
| 1-100 | 1/2 | - | at relatively high exposure levels ($\geq$1 $mg/m^3$). after: health effects |
| 1-100 | 1/3 | - | , with relatively few having been observed at concentrations <1 $mg/m^3$. after: dependent |
| 1-100 | 1/10 | $ZnSO_4$ and $(NH_4)_2SO_4$ | $ZnSO_4(NH_4)_2SO_4$ |
| 1-101 | 1/1 | pathophysiological | physiological |

Chapter 1 - $PM/SO_x$ Errata (continued)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 1-101 | 1/3 | and increased flow resistance and compliance, | |
| 1-104 | Table 1-11 | | Table title - line 2: $\leq$ before: 13.1 $mg/m^3$ |
| 1-107 | 2/1 | to 1310 $mg/m^3$ (500 ppm) $SO_2$ | in a 180 liter chamber into which 1310 $mg/m^3$ (500 ppm) $SO_2$ was injected at a rate of 20 ml/min |
| 1-110 | Table 1-13 | Hazucha and Bates, 1975 from "Reference" column, line 8 | |
| 1-110 | Table 1-13 | Significant decrease in FVC, $FEV_{1.0}$, MMFR, MEFR from "Effects" column, lines 6,7 | Significant decrease in MEFR; FVC, $FEV_{1.0}$, MMFR also decreased |
| 1-110 | Table 1-13 | | ; at 1 ppm, one subject experienced 7% increase in flow resistance; another, a 23% decrease after: nasal breathing, "Effects" column, line 17. |
| 1-144 | 1/6 | states | sites |
| 1-145 | 2/1 | study | studies |
| 1-152 | -- | Delete last sentence of footnote "a" for Table 1-24 | |

Chapter 2 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 2-10 | 3/5 | - | ed., after: Dennis |
| 2-26 | 3/9 | - | , undated after: Corp. |
| 2-27 | 2/3 | Instrumentation for Environmental Monitoring, Air, 1972 | Lawrence Berkley Laboratory, 1972 |
| 2-27 | 4/3 | ditto | ditto |
| 2-30 | 1/7 | - | , undated after: Instruments |
| 2-34 | 3/2 | - | a after: 1975 |
| 2-34 | 3/3 | EQS0775001 | EQS-0-775-001 |
| 2-34 | 3/5 | EQS0775002 | EQS-0-775-002 |
| 2-35 | Ref. | - | U.S. Environmental Protection Agency (1979c) |
| 2-50 | Ref. | - | U.S. Environmental Protection Agency (1979c) |
| 2-52 | 1/8 | - | New sentence after: 2-4. "Although only every tenth point is plotted, the statistical analysis pertains to the entire data set." |
| 2-59 | 2/3 | Methods of Air Sampling and Analysis, 1972 | Intersociety, 1972 |
| 2-60 | 2/5 | Brosset and Ferm (1978) | Stevens et al. (1978) |
| 2-61 | 2/3 | (1974) | (1969) |
| 2-63 | 2/5 | 1974, | |
| 2-63 | 3/7 | | 1977 before: 1977a |
| 2-66 | 3/7 | 1973 | 1974 |
| 2-68 | 1/2 | 1975 | 1976 |
| 2-78 | 1/9 | 1977 | 1978 |

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Chapter 2 - $PM/SO_x$ Errata (continued)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 2-87 | 2/12 | Current | An article in Environmental Science and Technology (-, 1978) describes the results for current - |
| 2-87 | 2/14 | Sampler (ES and T Outlook, 1978) have $\sigma_g$ values | Sampler. The $\sigma_g$ values varied |
| 2-90 | - | | New page 2-90a, attached. (Table 2-11) |
| 2-100 | 2/10 | | Threshold Limits Committee before: 1968 |
| 2-111 | 3/4 | Bernard | Barnard |
| 2-120 | 1/8 | 1979 | 1980 |
| 2-120 | 4/2 | new | possible |
| 2-139 | 3/2 | Gooid | Goold |

Note: Completed reference list attached.

TABLE 2-11. FRACTIONAL AEROSOL PENETRATION FOR SELECTED SUBSTRATES AS A FUNCTION OF FACE VELOCITY AND PARTICLE SIZE

| FILTER: Gelman Type A, glass fiber | | | | |
|---|---|---|---|---|
| ΔP, cm Hg | 1 | 1.5 | 3 | 10 |
| ∇, cm/sec | 11.2 | 16.9 | 32.7 | 108 |
| $D_p$, μm | PENETRATION | | | |
| 0.035 | <0.0001 | <0.0001 | <0.0001 | 0.0008 |
| 0.10 | <0.0001 | <0.0001 | <0.0001 | 0.00054 |
| 0.30 | <0.0001 | <0.0001 | <0.0001 | <0.00007 |
| 1.0 | <0.0001 | <0.0001 | <0.0001 | <0.00002 |

| FILTER: Ghia S2 37PJ 02, teflon membrane, 2.0 μm pore | | | |
|---|---|---|---|
| ΔP, cm Hg | 1 | 3 | 10 |
| ∇, cm/sec | 23.4 | 64.1 | 187 |
| $D_p$, μm | PENETRATION | | |
| 0.035 | <0.0002 | 0.0011 | 0.0005 |
| 0.10 | <0.00006 | 0.00008 | <0.00024 |
| 0.30 | <0.00007 | <0.00007 | <0.00022 |
| 1.0 | <0.00007 | <0.00009 | <0.00008 |

| FILTER: Whatman No.1, cellulose fiber | | | | |
|---|---|---|---|---|
| ΔP, cm Hg | 1 | 3 | 10 | 30 |
| ∇, cm/sec | 6.1 | 17.4 | 47.6 | 102 |
| $D_p$, μm | PENETRATION | | | |
| 0.035 | 0.56 | 0.52 | 0.34 | 0.058 |
| 0.10 | 0.46 | 0.43 | 0.13 | 0.0071 |
| 0.30 | 0.16 | 0.044 | 0.0049 | 0.00051 |
| 1.0 | 0.019 | 0.034 | 0.0044 | 0.00042 |

Source: Liu et al., 1978

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Chapter 3 Critical Appraisal of Air Quality Measurement Applications Corrigenda

Before listing specific minor errata (insertions/deletions) for text contained in Chapter 3 of the April, 1980, External Review Draft, several major changes to be made in the chapter should be noted. The proposed changes are based in part on additional literature review and comments received since finalization and release of the April, 1980, external review draft of the chapter.

On pg. 3-84, after the first paragraph, new text is to be inserted discussing the fact that difficulties in comparing results from various bodies of epidemiologic literature (e.g., British versus American) on particulate matter health effects arise from differences in specific physical and chemical properties of particulate matter pollution indexed by different measurement techniques employed in such studies. In particular, the following points are to be noted:

(1) The British smoke (BS) sampling technique (widely used in Britain and Europe) mainly collects fine mode particles (<3-5 μm) and, using reflected light, specifically measures degree of reduction of reflectance by the collected particles. BS computed by the degree of reduction in reflectance, although sometimes highly correlated with TSP (r=0.8-0.9) and lead (r=0.8-0.9) as reported by Ball and Hume (1977) and affected by certain other materials (Pedace and Sansone, 1972), is most highly correlated with the amount of graphitic carbon* present (r=.96; Baily and Clayton, 1980). Levels of carbon or other materials affecting reflectance readings can, however, vary independently of the total mass of the collected (mainly fine mode) particles. Thus, estimation of collected particle mass indexed by BS readings is dependent upon calibration of BS readings against standard mass readings (weighing) of collected particle samples typifying

* The term "graphitic carbon" is not meant to imply the three-dimensional structure of graphite, but only to indicate a structure similar to that of carbon black contained in soot.

a given location, allowing for calculation of corresponding mass concentration levels (in $\mu g/m^3$) by taking into account sampling periods and air flow rates. Relationships between BS reflectance readings and mass concentrations ($\mu g/m^3$) for a given location are most accurately determined empirically by reflectance to mass calibrations derived on a site-by-site and, time-specific basis, given the fact that relative mixes of various pollutants sampled could vary on an hour to hour, day to day, or longer-term basis. However, if the relative mix of particulate matter sampled and the percentage of the total collected mass attributable to graphitic carbon and other materials affecting light reflectance remains, similar from time to time or site to site, as empirically demonstrated by representative calibration determinations, then a common standard calibration curve relating mass concentration ($\mu g/m^3$) of particulates collected to reflectance readings may be generally applicable for BS data obtained from thusly calibrated sites shown to fit the standard curve well (Wallin, 1965).

(2) Particulate matter measurements by certain American sampling techniques (e.g., the AISI tape sampler method) which uses light transmittance as the physical property measured (Katz and Sanderson, 1958), are also most strongly affected by graphitic carbon levels present among particulate matter mass collected (mainly fine mode, <5μm size-range). Thus, similar considerations and limitations as described above for the BS method apply to the AISI tape sampler light transmittance method in regard to converting transmittance readings (coefficient of haze units or COHS for the AISI method) to estimates of particulate mass collected. That is, very precise estimates of particulate mass collected or air concentration (in $\mu g/m^3$) require that the transmittance readings (in COHS) be calibrated against representative corresponding sample weights on a site-and time-specific basis.



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However, practical application of the AISI light transmittance method, as in the case of BS measurements, usually precludes other than occasional representative calibrations for a given sampling site due to personnel and other resource limitations. Rather, to the extent that similar relationships of mass to transmittance readings are consistently obtained at a given site through repeated calibrations over time, then use of a standard calibration curve for converting transmittance readings (COHS units) to corresponding particle mass estimates for that site appears to be reasonably well justified.

Analogously, to the extent that a relatively similar mix of pollutants (e.g. graphitic carbon) most strongly affecting light transmittance is represented among the total mass of particulate matter collected at various other sites, it appears reasonable to employ a common standard calibration curve for conversion of transmittance values to estimates of particulate mass collected at those sites by the AISI method, especially if representative calibration data are fit well by the standard curve. Conversely, substantial variations in the pollutant mix, e.g. in the percentage of graphitic carbon represented in the overall particulate mass collected either for the same site at different times or between different sites, should be reflected by notable deviations from the more usually applicable calibration curve and would require generation of another one on a site-and time-specific basis. The likely generalizability of any particular calibration curve for estimation of collected particulate mass concentrations based on light transmittance readings appears, then, to be amenable to empirical testing in terms of: (a) assessment of goodness of fit of data for specific sites to the particular model defining the given calibration curve, and (b) assessment of similarities of chemical composition (including percentage of graphitic carbon and other substances affecting light transmittance) of atmospheric particulate matter sampled at different times at the same site or between different sites.

(3) Since both light reflectance (BS) and transmittance (AISI tape sampler) measurement methods are both most strongly affected by levels of graphitic carbon among the particulate matter mass collected, it might be assumed that results obtained by each method should be readily translatable into equivalent measurement units employed by the other method (i.e., reflectance or darkness index BS readings versus COHS units for the AISI tape sampler), using emperically-derived calibration curves. Similarly, it might be assumed that, if particles of the same size-range are collected and valid curves exist for estimation of particulate matter mass levels based on either light absorption or transmittance readings for a given site, equivalent particulate matter mass or air concentration estimates should be derivable from reflectance or transmittance readings for a given set of BS or COHS data points on a site-and time-specific basis. Those mass concentration estimates, furthermore, would then presumably provide a reasonable basis for comparisons of particulate matter levels in the same size-range from one site or time to another, where atmospheric aerosols of similar chemical composition are sampled. This might be the case, for example, in terms of samples of certain urban aerosols containing similar pollutant mixes derived from relatively similar emission sources, but not obtained from collection sites markedly dominated by different single emission sources. The interconversion (comparability), or lack thereof, of particulate matter mass estimates derived from light reflectance versus light transmittance measurement techniques, therefore, should be empirically testable in terms of goodness of fit of data from a given site or time in relation to curves or equations modeling relationships between results from the two techniques.

The particulate matter measurements (in terms of mass concentrations in $\mu g/m^3$) based on standard light reflectance (BS) or transmittance (AISI tape sampler) methods most often used in community health epidemiology studies might also be expected to approximate fine mode particulate matter mass estimates determined by gravimetric methods, in view of procedures for the former two methods being reported to result mainly in collection of fine mode fraction particles (<3 μm). However, factors influencing estimation of mass from BS reflectance or COH units could be such to result in quantitative mass estimates different from those obtained for fine particulate mass as determined by gravimetric methods.

(4) Conversion of particulate matter measurement results from either light reflectance (e.g., BS) or transmittance (e.g., AISI tape sampler) methods versus high-volume sampler results (expressed in $\mu g/m^3$ TSP) involve additional considerations beyond those outlined above. First, the high volume sampler has an inlet which is 50% efficient in collecting 25-30 μm sized particles and therefore collects coarse mode particles not sampled by the other two methods as standardly employed. Also, graphitic carbon levels and other materials most strongly affecting light reflectance and transmittance readings and fine mode particulate mass levels (indirectly indexed by the same methods) can vary independently of coarse mode particle levels. They may, therefore, increase or decrease in directions opposite to changes in total suspended particulate (TSP) matter mass. It is thusly not surprising that quite different relationships between particulate matter mass estimates based on BS or COHS readings and TSP levels can exist from site to site or from sampling time to sampling time at the same site.



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Reliable determination or estimation of likely TSP levels present at particular sampling points (times/places) based on corresponding BS or COHS data, then, may only be possible or justifiable within very circumscribed limits and highly dependent upon development of applicable empirically-derived intercomparison models in a fashion analogous to obtaining calibration or interconversion curves for BS and COHS readings discussed above.

On pg. 3-102, immediately before the last paragraph and heading for Section 3.5.5, new text is to be added which notes that three recently reviewed papers (by Ledbetter and Cerepaka, 1980; Swinford and Kolaz, 1980; and Heindryckx, 1975) report on relationships between COH and TSP as determined by comparisons of results obtained from collocated high volume and AISI tape samplers. In each case, for data obtained from sampling site locations as diverse as areas in Texas, Illinois, and Belgium, considerable scatter was found for individual paired observations, suggesting great uncertainty in predicting 24 hour TSP levels from short-term (1 hour) COH readings. It may be possible to improve on the relationships by using seasonal calibrations at each site and nonlinear models calibrated in a manner similar to the ASTM method or the British Standard 1747 Part 2 procedure for smokeshade in order to convert COH readings to units of mass for comparison with TSP data. However, these studies, and other literature cited above in this chapter, all appear to indicate that COH measurements are generally not directly relatable to TSP levels.

On pg. 3-103, immediately before the last paragraph, new text is to be inserted which notes that a typical finding among the various BS/TSP comparison studies cited in the preceeding paragraph is that considerable scatter or variability



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exists for individual paired observations for 24 hour BS and corresponding TSP measurements analyzed in the various studies. However, greater consistency appeared to exist for BS-TSP relationships expressed as long-term (monthly or longer) averages of the paired 24 hour observations; and efforts were made in the different studies to derive equations or models (mainly linear regression) that best fit the observed data obtained from different individual sites, cities and time periods (e.g., winter heating seasons versus summer nonheating seasons).

On pg. 3-116, immediately before the last paragraph, new text is to be inserted noting that neither the Mage (1980)* bounded nonlinear model derived primarily from the annual average (mean) BS-TSP comparison data of Commins and Waller (1967) as summarized by Holland et al. (1979) nor any other presently available model provides a generally reliable basis for interconversion of corresponding individual 24 hour BS-TSP data points, except perhaps at high levels of BS ($\geq$ 500 $\mu g/m^3$). The Mage (1980) and other models such as those discussed in Lee et al. (1972) or Pashel and Egner (1980), however, may provide better ore more reliable fits for BS-TSP monthly or annual average data.

On pg. 3-121, there is to be deleted the last three paragraphs discussing the impact of the use of a sampling flow rate of 0.72 liters per minute by Pashel and Egner (1980). Also to be deleted are Figure 3-13 on pg. 3-122, all text but the last paragraph on pg. 3-123, and Appendix C of Chapter 3. These deletions are based on a personal communication from Pashel and Egner indicating that a 0.72 liter per minute flow rate was erroneously reported in their draft 1980 Atmospheric Environment article; rather, according to their personal communication, a 1.5 l/min. flow rate more typically employed in generating BS data used by British epidemiologists was also used by them in producing the data reported in their 1980 paper.

* Manuscript now in preparation.

Detailed discussion of possible methodological errors in the Pashel and Egner study, starting on pg. 3-118, are to be moved to appendices and only brief summary statements regarding such included in the main text of Chapter 3. Also, on pg. 3-128, the paragraph immediately before the heading for Section 3.5.5.3. is to be entirely deleted and replaced with the following new text: Another possible explanation for the particular pattern of results obtained by Pashel and Egner is suggested by the fact that all of their annual mean data for rural, residential, and commercial sites studied fall on or very near the BNLM (Mage, 1980) model curve in Figure 3-15 on pg. 3-127, whereas data for seven of-eleven industrial sites fall rather far to the right of the BNLM curve. The possibilty exists that high levels of either noncarbonaceous fine-mode particles, coarse mode particles, or both in fugitive dust or stack emissions from nearby industrial sources in the absence of much carbonaceous material from fossil fuel combustion, result in the relatively higher TSP readings (mostly >100 $\mu g/m^3$) obtained at those sites. If such were the case, the data would illustrate a likely general limiting factor in making meaningful comparisons or interconversions between BS and TSP data, even on a long term annual mean basis. That is, whereas the BNLM or other analogous models might fit well BS-TSP comparison readings obtained from sites sampling aerosols dominated by graphitic carbon and other particles from fossil fuel combustion sources, such models would not likely apply in markedly different circumstances, eg. in dry rural areas of the American Southwest or sites strongely affected by fugitive dust from industrial facilities. Especially highly variable BS-TSP relationships can be expected in such situations where large amounts of coarse mode crustal particulate matter or mechanically produced coarse mode particles from anthropogenic activities exists in the air in the



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presence of little fine-mode carbon or other materials from fossil fuel combustion sources.

On pg. 3-141, additional sentences are to be added to the last paragraph, as follows: On the other hand, another possible explanation for the marked divergence of the data set from other published results for BS-TSP comparisons (mainly sampling urban aerosol mixes dominsted by fossil fuel combustion emission products) is that significant amounts of particles from fugitive dust or other emissions from nearby industrial facilities may have contributed to relatively high TSP readings (ca. 100 - 200 $\mu g/m^3$) in the presence of low BS readings ($\leq$ 25 $\mu g/m^3$). Such results would be illustrative of one type of circumstance severely limiting determination of reliable or meaningful relationships between corresponding BS-TSP data points.

Chapter 3 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 3-1 | 2/12 | Higgins and Ferris, 1978 | National Academy of Sciences, 1978a |
| 3-1 | 2/13 | Speizer and Ferris, 1978 | National Academy of Sciences, 1978b |
| 3-25 | 2/2 | dates | was after: which |
| 3-29 | 1/11 | Adams et al., 1971 | - |
| 3-42 | 2/6 | are | as |
| 3-44 | | air (column 4, line 17) | error |
| 3-52 | 3/2 | - | National Survey after: for |
| 3-59 | 3/5 | reflectance | darkness |
| 3-62 | 1/3 | - | Ellison (1968) after: by |
| 3-62 | 2/7 | MckEllison (1964) | Ellison (1968) |
| 3-63 | 3/4 | Page 3-52 | Page 3-57 |
| 3-67 | 1/3 | "period" after: December 15 | , since |
| 3-77 | | (column 4, line 8) Moulds, 1961<br>(Column 5, line 14) 10 cm | Moulds, 1962<br>10 mm |
| 3-82 | 2/12 | | uncorrected after: usage of |
| 3-85 | 1/last | Mck | - |
| 3-89 | | (Entire table heading) | Relationship of coefficient of Haze to Particle Counts ($N\rho$), 0.3 - 2.0μm, Measured in New York City |
| 3-89 | -/last | - | Source: Ingram (1969) |
| 3-91 | 2/7 | $length^2/mass$ | $length^{-2}$-mass |
| 3-93 | 1/3 | can | could |

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Chapter 3 - PM/$SO_x$ Errata (continued)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 3-94 | 2/1 | 1968 | 1978 |
| 3-97 | 2/1 | - | et al. after: Muylle |
| 3-110 | 1/10 | Table 3-8 | Table 3-9 |
| 3-113 | 1/18 | Dalager (1975) | Dalager (1974) |
| 3-116 | 2/4 | one | two |
| 3-121 | 1/3 | R > 50% | R < 50% |
| 3-121 | 3/2 | - | the effect of after: showing |
| 3-128 | 1/1 | sum of $\chi^2$, | chi-square statistic |
| 3-135 | 3/4 | - | sampler after: hi-volume |
| 3-138 | 2/4 | (1972) | (1977) |

Note: List of additional recommended references attached.

Note: Completed reference list attached.

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Chapter 4 $PM/SO_x$

(No errata or revisions at this time.)

Chapter 5 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
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| 5-3 | 3/5 | 23 | 20 |
| 5-20 | ft-nt | $mg/m^3$ | $\mu g/m^3$ |
| 5-20 | ft-nt | | after cumulative: percentage |
| "3-58" | - | Entire page (stray from Ch. 3) (does not apply to all copies) | Pg 5-58 (attached) |
| "3-60" | - | Entire page (stray from Ch. 3) (does not apply to all copies) | Pg 5-60 (attached) |
| 5-99 | legend | | after densities: for nitrogen dioxide |

county having the highest annual average value. It is not possible to determine whether concentrations are more or less uniform across the county or whether they are localized. However, several general impressions are obtained about national TSP conditions. High concentrations can be found in almost every State. Many populated counties have high concentrations (for example, New Jersey-New York City, Pittsburgh, Harrisburg, Chicago, and Los Angeles). Several sparsely populated counties also have high concentrations. Arid regions as well as industrialized counties have high levels.

The AQCR attainment status for the daily NAAQS is shown in Figure 5-19, which is based on the same 1977 NADB TSP data. The same comment made above applies to the 24-hr measurements. A violation of NAAQS for TSP at one location does not necessarily imply a higher health risk for the entire population of that area. The health implications even for those living near a site in violation are not clear. Populations living in attainment areas but exposed to TSP high in trace metals, for example, might have a high health risk.

A closer look at the site descriptions for stations that recorded violations suggests that the reasons for violation are quite variable. As discussed earlier, it seems clear that industrial sources contribute significantly to TSP levels at many sites. This is not so obvious at other sites, however. Some extremely high concentrations experienced at monitors in Arizona, New Mexico, and elsewhere are most likely associated with surface dust suspended by the wind. Without a careful site inventory or perhaps detailed analysis of TSP chemical and elemental composition, the specific reasons for TSP violations are unknown.

5.2.1.6 Severity of Peak TSP Concentrations--The geographic displays of attainment status are only one way of conveying the extent of the TSP pollution problem. To indicate the severity of TSP ambient exposures, the 90th percentile concen-

tration of the 24-hr measurements was examined for all 4008 sites in the 1977 NADB. The concentrations of TSP and other air pollutants have been widely reported to be log normally distributed (Larsen, 1971). This statistical relationship, however, appears inappropriate at the high and low ends of the distribution (Mage and Ott, 1978). Because the extreme values at the high end are subject to wide scatter, the 95th or 99th percentile was found to be less representative of the severity of high TSP levels. The 90th percentile was therefore chosen as being a more stable indicator. It represents the TSP level that is exceeded on approximately 36 days of the year.

Table 5-16 shows, for each AQCR, the number of TSP monitoring sites whose 90th percentile concentrations were <100, 100-200, 200-260, and >260 $\mu g/m^3$. In Figure 5-20 the AQCR's having at least one monitoring station whose 90th percentile exceeds 260 $\mu g/m^3$ are displayed. AQCR's in Montana, Arizona, and New Mexico have a large number of monitoring sites for a relatively sparse population (approximately twice EPA's minimum requirement). A number of these sites are near smelters. Hence, the high levels do not necessarily imply high population exposure to TSP. In addition, windblown soil contributes to the higher levels in these States. In the Northeast and East, the elevated TSP concentrations reflect the higher density of industrial and urban emissions. In these cases, the high levels (in Pennsylvania, Ohio, New Jersey, New York, Connecticut, and Massachusetts) indicate a larger population exposed to peak TSP concentrations. The high 90th percentile levels in North Dakota, Nebraska, Iowa, and Colorado perhaps reflect an influence of fugitive emissions from agriculture.

Figure 5-21 shows the number of AQCR's whose monitors have their 90th percentile TSP concentration within the various categories. Of the country's 254 AQCR's, only 20 had air quality to the extent that none of their 90th percentiles exceeded 100 $\mu g/m^3$. One hundred and fifty-four AQCR's had 90th percentile values in at



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## Chapter 6 - $PM/SO_x$
## Errata

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| 6-19 | 1/14 | 1979 | 1978a |
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| 6-32 | 2/9 | 1977 | 1978 |
| 6-37 | -/5 | Low, 1971 | Low,1969 |
| 6-42 | 2/2 | 1979 | 1978 |
| 6-42 | 2/4 | 1979 | 1978 |
| 6-42 | 2/14 | Durham et al. 1979 | Durham et al. 1978 |
| 6-46 | 5/5 | 1979 | 1980 |
| 6-47 | 2/10 | 1979 | 1977 |
| 6-48 | 3/2 | 1974 | 1976 |
| 6-52 | 2/4 | 1979 | 1978 |
| 6-52 | 2/12 | 1979 | 1978 |
| 6-53 | -/9 | Slinn et al. (1979) | Slinn et al. (1978) |
| 6-72 | 2/5 | 1975 | 1980 |
| 6-72 | 2/6 | 1975 | 1980 |
| 6-73 | -/6 | White and Roberts (1975) | White and Roberts (1980) |
| 6-74 | -/3 | Lewis and Macias (1979) | Lewis and Macias (1980) |
| 6-87 | 2/4 | Schurmeier | Schiermeier |
| 6-97 | -/3 | 1976 | 1976a |

Note: Completed reference list attached.

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Errata

| Page | Par/Line | Delete | Insert |
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Errata

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| 9-17 | 1/4 | Rosen and Novakov, 1979 | Rosen, et al., 1980 |
| 9-22 | 3/10 | Macias et al., 1975 | Macias and Husar, 1976 |
| 9-25 | ft-nt | Waggoner and Weiss (1979) | Waggoner and Weiss (1980) |
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| 9-48 | -/7 | - | Husar, et al., 1979 after: United States. |
| 9-65 | 3/4 | 7:1 | 7 ± 1 |
| 9-65 | 3/4 | ] after: relative humidity | ] after: ($\mu g/m^3$) |

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Errata

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| 10-9 | 2/7 | Haagen Reed and Ottaz | Haagenrud and Ottar |
| 10-47 | 3/5-6 | sulfate particles. . . . . . . . .by acid hydrolysis | |
| 10-93 | Ref 6 | 1960 after: 1969. | |
| 10-94 | Ref 6 | Evgang | Ergang |
| 10-94 | Ref 6 | | After M. B. Rockel.: Corrosion resistance of stainless steels in the atmosphere - evaluation of the results of weathering tests of up to 10 years duration. |
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Chapter 11 - $PM/SO_x$
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| 11-11 | 1/3 | Hansen, et al., 1974- | Hasen and Ampaya, 1974 after: Nagashi, 1972 |
| 11-34 | Fig. Legend | - | (expressed as fraction of particles entering trachia) after: tracheobronchial (TB) deposition |
| 11-35 | -/1 | George and Breslin, 1976 | George and Breslin, 1967 |
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| 11-51 | 2/8 | 1951 | 1957 |
| 11-60 | 3/3 | Proctor et al. | Proctor and Wagner |
| 11-60 | 3/3 | Proctor and Wagner, 1967; | |
| 11-61 | 4/7 | - | et al., 1971. after: Dadaian |
| 11-62 | 2/11 | Camner et al | Camner and Philipson |
| 11-62 | 2/12 | - | and Davia, after: Thomson |
| 11-82a, b,c,d, | | - | Attached 2½ pages of text and one figure on Respirable Aerosol Sampling at end of chapter. |
| New 11-105 | | - | New page, 11-105 (attached), with 7 additional references. |

Note: List of additional recommended references attached.

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Missing reference page 11-105 from first printing
Chapter 11 - $PM/SO_x$


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| 11-86 | After 8th Ref. | - | Clements, J. A., J. Nellenbogen, and H. J. Trahan. Pulmonary surfactant and evolution of the lungs. Science 169: 603-604, 1970. |
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## 11. RESPIRABLE AEROSOL SAMPLING

A fundamental principle in inhalation toxicology is that it is the deposition of inhaled particulate materials in sensitive regions of the respiratory tract or subsequent transformations and translocations to sensitive organs or cells that leads to potentially deleterious biological responses. Particles (or gases) that deposit neither in sensitive regions of the airways nor in regions conducive to translocation to sensitive organs are cleared with relatively low probability of causing injury or disease (Morrow, 1964). For example, large insoluble particles that deposit almost exclusively in the nose are prevented from reaching the lung during nose breathing and are less likely to lead to injury than smaller particles having appreciable lung deposition.

This principle was early observed in coal mining in Europe; it was found that the air concentration of dust in mines didn't necessarily correlate to the incidence of respiratory disease. However, a meaningful comparison was possible when samples were aerodynamically fractionated to provide a separate measure of the respirable dust levels. This led to the use of "respirable" dust samples in the coal mining industry (Walton, 1954). Further, the repeated practice of collecting respirable dust samples is necessary, since there is variability in the aerodynamic size distribution of dust depending on age and source.

On this basis the principle of "respirable" dust sampling was developed (Lippmann, 1970b). In this context the word "respirable" means broadly "fit to be breathed." The objective is to collect samples that have been purposely biased in favor of the smaller, more respirable sizes. Only the smaller size fraction is measured to yield the "respirable" aerosol concentration. No specific "cut-size" was defined, since it is clear that there is no size for

which all particles smaller are respirable and all larger are not. Instead, weighting functions were defined that simulated the size classification normally afforded by the human naso-pharyngeal deposition during nose breathing. Another factor involved in describing a respirable fraction was the availability of a simple instrument that would provide a practical means for collection of these size-classified samples.

Two weighting functions have been generally used as criteria for respirable dust sampling (Fig. 11-19). The first originated in 1952 when the British Medical Research Council adopted the horizontal elutriator (Walton, 1954) as the respirable dust sampler. Particles that pass the elutriator are collected on a filter or by some other means. The second criteria originated with researchers working for the U. S. Atomic Energy Commission who needed to establish a basis for size classification of radioactive insoluble aerosols; these recommendations came from a meeting held at Los Alamos Scientific Laboratory (LASL), New Mexico, and are commonly referred to as the LASL criteria (Fig. 11-19). A small cyclone separator was chosen as the respirable dust sampler, since massive samples as obtained with the horizontal elutriator were not necessary for analysis of radioactive aerosols. Only the particles that pass the sampler, namely, the smaller size fraction, are collected and used to provide a measure of the respirable aerosol concentration.

Neither the BMRC nor the LASL criteria for respirable aerosol sampling agrees exactly with the ICRP Task Group recommendations concerning naso-pharyngeal deposition but tend to include more of the particles which are less than 7 μm in aerodynamic diameter. This is probably fortuitous, since it tends to compensate for aerosols deposited in the deep lung in a combination of mouth and nose breathing. Hence, the 3 μm particles that are more

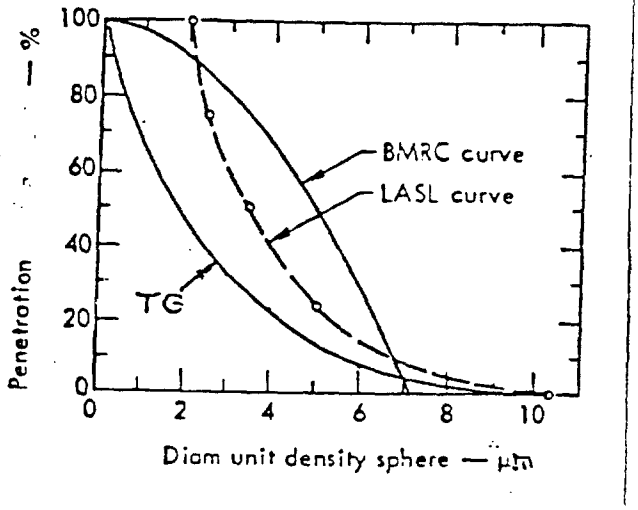


FIGURE ~~20~~ 11-19

Respirable aerosol sampling criteria for penetration of repirable aerosols through a size-classifier to provide for collection of particles that have the greatest potential for pulmonary deposition if inhaled (from Raabe,1979).

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efficiently deposited in the pulmonary region during mouth breathing (Fig. 11-10) than during nose breathing (Fig. 11-3) are weighted more than would be justified by the ICRP Task Group nose breathing models.

It is important to note that the "respirable" dust sample is thus not intended to be a measure of the lung deposition but only a measure of aerosol concentration for particles that are the primary candidates for lung deposition. Clearly, the respirable dust sample is only biologically relevant for aerosols whose upper respiratory deposition is not expected to be of major health impact. Soluble aerosols of toxic substances can enter the blood directly from the nasal mucosa or the gastrointestinal tract during clearance from the nose, and the deposition of particles as large as 100 μm or even larger in the nose may be the primary hazard for such aerosols.

Chapter 12 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 12-7 | | | Revised Table 12-1 |
| 12-8 | -/1 | Kikigawa and Sizuka | Kikigawa and Iizuka |
| 12-16 | 4/2-3 | Sentence: Mice....lifetimes. | Mice were exposed over their lifetimes in a 180 liter chamber into which 500 ppm $SO_2$ was injected at a rate of 20 ml/min for 5 minutes, 5 days/week.[67] |
| 12-17 | Col. 1 & 2 | 1310 500 | (See Text) |
| 12-17 | Col. 3 line 6 | 300 days | lifetime |
| 12-20 | Col.1 | 1310 $mg/m^3$ (500 ppm) $SO_2$ | (See Text) |
| 12-21 | | First column, 8th line: $Ong/m^3$ | 0 $mg/m^3$ |
| 12-51 | | Original page | New page, with revisions for the 7th compound: $Fe_2O_3$. |
| 12-52 | | Original page | New page, with revisions for first entry: Open hearth dust. |
| 12-72 | 2/10 | 100 $\mu g/m^3$ | 0.1 $mg/m^3$ |
| 12-80 | 4/5 | head only | head-only |
| 12-91 | 2/21 | alterations, thus | alterations. Thus |
| 12-93 | 3/6<br>3/7 | | comma after: diameter)<br>comma after: time |
| 12-98 | 1/14 | regimes | regimens |
| 12-100 | 3/8-9 | ozone exposed | ozone-exposed |
| 12-102 | Col. 1 | (see Table 12-15) | (see Table 12-14) |
| 12-105 | Col. 4 -/15 | beating | beat |

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Chapter 12 - $PM/SO_x$
Errata (cont.)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 12-105 | Col 5 | Gardner et al.[154] | Gardner et al.[145] |
| 12-115 | 2/1, 2 | Peacock and Spence. . . . . for two years. | Peacock and Spence (1967)[327] exposed LX strain mice, over their lifetimes, in a 180 liter chamber into which $SO_2$ at a concentration of 500 ppm (1310 $\mu g/m^3$) was injected at a rate of 20 ml/min for 5 minutes, 5 days/week. |
| 12-117 | 2/6 | Ref. 392 | Ref. 292 |
| 12-124 | 2/2 | absorption and | |
| 12-124 | 2/3 | is | |
| 12-124 | 2/4 | | is retained somewhere in the respiratory system. after: amount |
| 12-125 | 2/12,13 | In a different study . . . . . .(500 ppm) $SO_2$ | In a different study, mice were exposed over their lifetimes in a 180 liter chamber into which $SO_2$ at a concentration of 500 ppm, (1310 $\mu g/m^3$) was injected at a rate of 20 ml/min for 5 minutes, 5 days/week. |
| 12-129 | 2/8 | initiating | irritating |
| 12-130 | 1/10 | | comma after: volume |
| 12-151 | Ref. 233 | L. Whittenberger | J. L. Whittenberger |

Note: List of additional recommended references attached.

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TABLE 12-1. POTENTIAL MUTAGENIC EFFECTS OF $SO_2$/BISULFITE

| Concentration $SO_2$ | Bisulfite | Organism | End Point | Response | Comments | Reference |
|---|---|---|---|---|---|---|
| | 0.9 M $HSO_3^-$ pH 5.0 | Phage T4-R11 System | GC→AT or deamination of cysocine | + | | Summers and Drake[200] |
| | 3 M $HSO_3^-$ pH 5-6 | Phage T4-R11 System | deamination of cytocine | ± | Poor dose response | Hayatsu and Miura[201] Iida et al.[202] |
| | 1 M $HSO_3^-$ pH 5.2 | E. coli K12 & K15 | GC→AT or deamination of cytocine | + | | Mukai et al.[203] |
| | $5 \times 10^{-3}$ M $HSO_3^-$ pH 3.6 | S. cerevisiae | Point Mutation | + | | Dorange and Dupuy[204] |
| | 0.04 or 0.08 M | D. melanogaster | Point Mutation | - | May not be bioavailable | Valencia et al.[205] |
| 1310 mg/m$^3$ (500 ppm) | | Hela cells (Human) | Cytotoxicity | + | | Thompson and Pace[207] |
| 13.1 - 105 mg/m$^3$ (5 - 40 ppm x 3 min) | | Mouse fibroblasts & Peritoneal macrophages | | | | Nulsen et al.[208] |



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TABLE 12-8 (continued).

| Compound | Concentration $mg/m^3$ | Particle size, μm, MMD** | Resistance cm $H_2O$/ml/sec % difference from control | Compliance ml/cm $H_2O$ % difference from control | Reference |
|---|---|---|---|---|---|
| $Na_2SO_4$ | 0.90 | 0.11 | +2 | -7 | 130 |
| $ZnSO_4$ | 0.91 | 1.4 | +41* | | 123,170 |
| $ZnSO_4 \cdot (NH_4)_2SO_4$ | 0.25 | 0.29 | +22* | | 123,173 |
| | 0.50 | 0.29 | +40* | | 123 |
| | 1.10 | 0.29 | +81* | | 123,170 |
| | 1.80 | 0.29 | +129* | | 64,123 |
| | 1.50 | 0.51 | +43* | | 123,173 |
| | 2.48 | 0.51 | +68* | | 123 |
| | 1.40 | 0.74 | +29* | | 64,123,173 |
| | 1.10 | 1.4 | +6 | | 123,173 |
| | 3.60 | 1.4 | +32* | | 123 |
| $CuSO_4$ | 0.43 | 0.11 | +9 | -11* | 130 |
| | 2.05 | 0.13 | +25* | -15* | 130 |
| | 2.41 | 0.33 | +14* | -11* | 130 |
| $NaVO_4$ | 0.70 | | +7[a] | | 96 |
| $FeSO_4$ | 1.00 | | +2[a] | | 96 |
| $Fe_2O_3$ (2hr) | 11.70 | 0.076 (GMD) | -9[a] | | 96,124 |
| | 21.00 | 0.076 (GMD) | 0[a] | | 96,124 |
| $MnCl_2$ | 1.00 | | +4[a] | | 96 |
| $MnO_2$ | 9.70 | | -6[a] | | 96 |
| $MnSO_4$ | 4.00 | | -1[a] | | 170 |



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TABLE 12-8 (continued)

| Compound | Concentration $mg/m^3$ | Particle size, μm, MMD | Resistance cm $H_2O$/ml/sec % difference from control | Compliance ml/cm $H_2O$ % difference from control | Reference |
|---|---|---|---|---|---|
| Open hearth | 0.16 | 0.037 (GMD) | +11[a] | 0 | 96,124 |
| dust | 7.00 | 0.037 (GMD) | +6[a] | -16 | 96,124 |
| Activated carbon | 8.70 | | -3[a] | | 96 |
| Spectographic carbon | 2.00 | | +7[a] | | 96 |
| | 8.00 | | +17[a] | | 96 |

*$p < 0.05$

[a]Statistics not done

**Diameters are provided as mass median diameter (MMD) unless specified as geometric median diameter by count (GMD).



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Additional References Recommended for Consideration in Chapter 12

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Costa, D. L., and M. O. Amdur. Respiratory responses of guinea pigs to oil mists. Am. Indust. Hyg. Assoc. J. 40(8):673-679, 1979.

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Chapter 13 - $PM/SO_x$
Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 13-5 | Col. 4 8th Ref | Odor Threshold, 1968 | Arthur D. Little, Inc. 1968 |
| 13-5 | Col. 4 6th Ref | Holmes, 1954 | Holmes, 1915 (see Greenwald, 1954) |
| 13-5 | Col. 4 11th Ref | Bushtueva et al., 1960 | Bushtueva, 1962 |
| 13-9 | 2/1 | Bushtueva et al. (1960) | Bushtueva (1962) |
| 13-11 | -/16 | | In "Effects" column entry for Frank et al., 1962, after ... nasal breathing:; at 1 ppm, one subject experienced 7% increase in flow resistance, another a 23% decrease |
| 13-12 | -/10 | In "Reference" column: Hazucha and Bates, 1975 | |
| 13-12 | -/11 | In "Effects" column: Significant decrease in FVC, $FEV_{1.0}$, MMFR, MEFR | Significant decrease in MEFR; FVC, $FEV_{1.0}$, MMFR also decreased |
| 13-13 | Col. 7 2nd Ref | Wolff et al., 1975b | Wolff et al., 1977 |
| 13-13 | -/2 | | In "Effects" column entry for Jaeger et al., after ... 30 minutes:; 3 subjects incurred delayed effects and required medication. |
| 13-16 | 2/11 | Lawther and Bond 1955 | Lawther 1955 |
| 13-22 | 3/1 | 1975b | 1977 |
| 13-23 | 2/1 | 1975b | 1977 |
| 13-26 | 3/4 | - | ; EPA before estimate |
| 13-26 | 4/2 | - | ; EPA before estimate |

Chapter 13 - PM/$SO_x$ Errata (cont.)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 13-27 | Col. 6 | Koenig, 1979 | Koenig et al., 1979 |
| | 7th Ref | | |
| | 8th Ref | Koenig, 1979 | Koenig et al., 1979 |
| 13-28 | 2/3 | - | ; EPA before estimate |
| 13-28 | 2/12 | - | EPA before estimate |
| 13-31 | 2/7 | - | 1973 after: Hazucha |
| 13-38 | 2/4 | estimated | EPA estimate of |
| 13-38 | 2/5 | estimated | EPA estimate of |
| 13-40 | 1/16 | 1968 | 1978 |

Note: Completed reference list attached.

Note: List of additional recommended references attached.

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Additional References Recommended for Consideration in Chapter 13

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## Chapter 14. Epidemiology Studies Corrigenda

Before listing specific minor errata (insertions/deletions) for text contained in Chapter 14 of the April 1980, External Review Draft, several general comments should be noted regarding planned reorganization and certain other major changes to be made in the chapter. The chapter reorganization and other changes are based in part on comments received both from within and outside EPA and further technical information obtained since finalization and release of the April, 1980, external review version of the chapter.

In regard to reorganization of the chapter, the present introduction (Section 14.1) discussing general epidemiology methodology considerations and the discussion of air quality measurement considerations (Section 14.2) are to be retained, with certain specific revisions noted later. Similarly, much of the later discussion of caveats and limits contained in Section 14.6 is to be retained, again with certain revisions as noted later. The materials between the above sections (dealing with evaluation of specific studies), however, is to be reorganized using the following format:

14.3 - Acute Exposure Effects
- 14.3.1 - Mortality
- 14.3.2 - Morbidity
  - Adults
  - Children

14.4 - Chronic Exposure Effects
- 14.4.1 - Mortality
- 14.4.2 - Morbidity
  - Adults
  - Children

Resequencing of the discussion of specific studies in the above manner both: (1) better matches the presentation format followed for summary text and tables later in Chapter 14 and in Volume I; and (2) better organizes discussion of technical data related to development of health criteria for short-term (24-hour) or long term (annual average) ambient air quality standards, respectively. Text on

the bottom of pg. 14-14 is, therefore, to be revised to reflect the reorganization of subsequent materials in Section 14.3 and 14.4, and to indicate that a new Section 14.5 will contain integrative summary and interpretation discussion materials of the type dealt with under the present Section 14.6.

Also, at the end of Section 14.1, following the above revisons of text at the bottom of Pg. 14-14, new text to be inserted is to note that certain criteria are to be followed, generally, in the selection of specific studies to be discussed in detail under new Section 14.3 and 14.4. The criteria to be employed in narrowing down the detailed discussion to potentially key studies are as follows:

1. The studies have been peer-reviewed and published or are "in press" to be published, such that final versions of the published reports are (or can be made) publically available. Also, the results or analyses contained in the published reports represent completed analyses of data, rather than "preliminary" analyses subject to change before publication in "final" form.

2. The published information is sufficient to allow for reasonably clear evaluation of the methodology employed in collection and analysis of data leading to the results reported (or such information is satisfactorily alternatively obtained or clarified).

3. Evidence exists for major confounding factors having been appropriately controlled for or taken into account in the published analyses, e.g. especially temperature in studies of acute effects and smoking, race, and socioeconomic status in chronic exposure studies.

4. The published results, together with any alternatively obtained information, appear to provide a reasonably clear potential basis by which to define quantitative dose-effect or dose-response relationships for health effects associated with sulfur oxides and particulate matter. Emphasis is to be placed on studies yielding information on effects associated with exposures below 1000 $\mu g/m^3$ (24 hour average) that are most germane for present criteria development purposes.

In addition to detailed discussion of studies meeting all of the above criteria, certain other studies failing to meet one or more of the criteria may also be considered or reviewed, based on their findings likely providing important information bearing on the overall assessment of epidemiologic evidence of significance for present purposes.

Following the above modifications of introductory materials in Section 14.1, the next section (14.2) on air quality measurement considerations is to be expanded to include summary statements derived from Chapter 3 discussions of intercomparisons between estimates of particulate matter levels obtained by various measurement techniques. Thus, immediately before the start of Section 14.3 at the bottom of Pg. 14-34, there is to be inserted a relatively brief summary discussion concerning the main conclusions derived from Chapter 3 regarding intercomparisons of particulate matter measurement data obtained by means of high-volume (TSP) sampling, British smoke (BS), and other (e.g., the AISI) particulate measurement techniques. Note will be made of the difficulties and limitations inherent in making such intercomparisons and, based on this, the particulate matter measurement results employed in particular studies discussed in Sections 14.3 and 14.4 are to be expressed there only in terms of units appropriate for the specific measurement methodology employed (e.g., in CoH units or $\mu g/m^3$ of either BS or TSP). Only following summarization of study results in terms of such original measurement units are discussions of any potential interconversions between measurement units to be included as part of later summary and conclusions materials in Section 14.5 and elsewhere (e.g., Volume I).

No attempt will be made here to list myriad changes in sequencing of text materials now under Sections 14.3 to 14.5 of the April, 1980, External Review Draft necessary to accomplish the reorganization of materials into the new Sections 14.3 and 14.4 listed under the revised format outlined above. Rather, only certain planned substantive content revisions (mainly large text deletions) of existing materials in Sections 14.3 to 14.5 of the April draft are summarized below before presentation of more detailed lesser errata corrections for the Chapter.

On pg. 14-47, Table 14-7 is to be deleted along with revisions and reduction in text at the bottom of pg. 14-46 and top of pg. 14-48, discussing the Osaka and Rotterdam studies. The revisions are to note that the Biersteker[315] and Watanabe[100] studies report data or information on quantitative dose-effect relationships, but insufficient information was reported to allow for evaluation of the adequacy of study design (especially in regard to adjustments made for temperature effects).

On pg. 14-51 to 14-52, the discussion of multiple regression studies by Hodgson,[158] Buechley,[159,160] Lebowitz,[170] and Lebowitz et al.[171] is to be shortened considerably. Note is to be made that these studies provide mainly qualitative data on associations between sulfur oxides ($SO_x$) or particulate matter (PM) and observed mortality effects but generally do not provide clear data on quantitative levels of $SO_x$ or PM likely associated with such effects, with the exception of the Beuchley studies[159, 160] finding significant increases in mortality when 24 hour mean $SO_2$ levels exceeded approximately 500$\mu g/m^3$.

On pg. 14-56, 14-58, 14-59, the extensive quotation of material from Holland et al.[301] concerning the Martin studies[6,11] is to be deleted. Also the rest of the text on pg. 14-59 is to be deleted, along with the text concerning the detailed additional analysis of mortality effects observed in the Martin studies[6,11] that runs from pg. 14-60 to 14-65. Similarly, the rest of the text on 14-65-and 14-66 (top) on further analysis of the 1975 London and 1975 Pittsburgh episodes is to be deleted. The available reports or discussions of the 1975 London episodes do not allow for more detailed analyses of the type indicated on pg. 14-65; and the available report by Riggan et al. (1977)[341] on the Pittsburgh episode contains information only on preliminary analyses that remain to be more definitively completed, peer-reviewed and published.

On pg. 14-70 to 14-71, table 14-16 on qualitative mortality studies is to be moved to the appendices and referred to in Chapter 14 text only briefly, in summary terms. Also, certain studies, such as those by Buck and Brown[199] Wicken and Buck,[19] Burn and Pemberton, [20] are to be added to qualitative studies listed in Table 14-16. Comments on the Winkelstein studies[21-23] and analyses presented on pg. 14-73 to 14-81 would be especially valuable in order to resolve whether to retain such detailed discussion of these results as important quantitative findings or whether to simply list the Winkelstein results in a table of qualitative findings.

On pg. 14-90, the summary table (14-21) is to be revised to show the 24 hour particulate levels at which mortality effects were observed only in terms of the original units ($\mu g/m^3$ BS; CoH units) in which such data were reported (and not possible comparable TSP units). On pg. 14-91, Table 14.22 is to be deleted.

On pg. 14-93 to 14-95, the Table (14.23) on qualitative studies of air pollution and acute respiratory disease is to be moved to the Appendices and only brief summary statements regarding the table kept in the main text of Chapter 14. Comments on studies by Finklea et al.[177,122,123] are to be deleted from the table.

On pg. 14-96 and 14-97, text revisions are to be made that note the exclusion from discussion in the April draft of studies carried out as part of the EPA "CHESS" program. Also, in that connection, explanatory text will be inserted stating that: (1) The manner in which CHESS program study results were reported and interpreted in summary form in early 1970 publications and in more detail in the 1974 "Sulfur Oxides Monograph" raised questions regarding possible inconsistencies in data collection and analyses, as well as interpretation of the reported results;



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(2) Of particular concern were questions regarding the adequacy of air quality data measurements (for TSP and $SO_2$, as well as other pollutants) upon which key quantitative conclusions were based regarding possible air pollution-health effects relationships; (3) Many of the outstanding questions regarding the CHESS studies remain to be clearly resolved and, until such time that they are, the potential usefulness of such studies is extremely limited in terms of yielding well-defined information on air pollution-health effects relationships as they might pertain to development of health effects criteria; (4) Based on the above considerations, CHESS program data sets and analyses will not be further discussed in criteria document drafts, unless questions regarding accuracy of specific data sets and their analyses have been satisfactorily resolved and reports on them adequately peer reviewed.

On pg. 14-102, the last sentence on the page is to be amended to note that, since measurements of air pollution and pulmonary function reported in the Stebbings et al.[82] study and the Stebbings and Fogelman[216] study were not initiated until after the peak of the 1975 Pittsburgh episode, it is impossible to clearly relate any health effects observed in those studies to specific $SO_2$ or PM levels. Consequently, the rest of the detailed discussion of the Stebbings[82,216] studies on pg. 14-103 and top, pg. 14-104, is to be deleted.

Also, on pg. 14-105 and 14-106, all text dealing with the Stebbings and Hayes[190] report on a 1971-1972 New York "CHESS" Program panel study is to be deleted, as per statements made earlier concerning exclusion from discussion of CHESS Program studies due to unresolved questions regarding their reported results and interpretations. Similarly, the detailed text discussing the French et al.[306] New York ARD "CHESS" Program study is to be deleted from top, pg. 14-109 to top, pg. 14-133, including Tables 14-24 to 14-26 on pg. 14-110 to 14-112.



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On pg. 14-107 to 14-109, the discussion of the studies[71, 205-210] by McCarroll and associates is to be shortened (and reference to quantitative estimates of pollutant levels associated with observed health effects deleted). Consideration will be given to including brief summaries of those studies in an appropriate table of qualitative studies.

On pg. 14-113, the detailed discussion of the Kalpalzanov et al.[63] study is to be deleted and its results only briefly summarized in an appropriate table of qualitative studies.

On pg. 14-115 to 14-116, the discussions of the Kevany[15] and Heinman[54] and Sterling [72,73] studies are to be deleted; the results of each are to be summarized in an appropriate table of qualitative studies.

The discussion of the Fletcher et al.[274] and Angel et al.[69] studies on pg. 14-117, is to be moved to the new Section 14.4 on chronic exposure effects, rather than remaining under the text on acute effects as presently situated. Note will be made of difficulties in estimating quantitative levels of $SO_x$ or PM associated with observed health effects, and other problems, which argue for these studies to be included as part of an appropriate table of qualitative studies.

The text on the Verma et al.[65] study (bottom, pg. 14-120; top, 14-121) is to be deleted and that study only mentioned briefly in an appropriate table of qualitative studies. Also, on pg. 14-121, the discussion of the "Ministry of Pensions" study[62] is to be moved to the new Section 14.4 on chronic effects; note will be made of problems with air monitoring data used in that study and other methodological problems which mitigate against useful quantitative information being extracted for present criteria development purposes.



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On pg. 14-123, the Shephard et al.[327, 328] discussion is to be deleted and the Lebowitz et al.[180] study results (including top pg. 14-124) briefly summarized in a table of qualitative studies.

Table 14-29, on pg. 14-125 is to be revised as follows: (1) particulate matter measurement data will be expressed only in terms of BS or TSP as originally reported, with a column being added for BS in the table headings along side the TSP ($\mu g/m^3$) heading; (2) "qualitative" studies will be deleted from the table, including those by McCarroll et al.,[205,206] Cassell et al.,[208, 209] Greenburg et al.,[196] Stebbings et al.,[216] Stebbings and Hayes,[190] Heimann,[54] and British Ministry of Pensions.[62]

On pg. 14-131 to 14-134, certain of the studies included in Table 14-30 as yielding qualitative information on air pollution-health effects might be appropriately deleted, except for ones providing data specifically elucidating associations between health effects and $SO_x$ or PM. Comments on which studies should be retained as meeting such criteria, and which should be deleted as useless for present purposes, would be helpful.

The extensive discussion of the Irwig et al.[98] and Melia et al.[(new ref. #342)] reports on the British school children study, on pg. 14-139 to 14-149 (top), is to be deleted. Essentially no reference in the main body of Chapter 14 is to be made to either the Irwig et al. or Melia et al. reports in view of the preliminary nature of the analyses alluded to in the referenced papers and the lack of any peer-reviewed published reports on "final" or completed analyses of the British school children study.

On pg. 14-151 (top), the discussion of the study by Tsunetoshi et al.[38] is to be deleted and the results briefly summarized in a qualitative studies table.



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Similarly, the Suzuki et al.[183] study discussion on pg. 14-151 (bottom) is to be deleted and that study summarized in a qualitative studies table, as is also the case for the Toyama et al.,[312,317] Tani[319] and Yoshii[319] studies on pg. 14-152.

On pg. 14-152 to 14-158, all text is to be deleted regarding discussion of the EPA "CHESS" studies reported by Chapman et al.[212] for Utah "CRD" and Chicago "CRD" prevalence rate data sets. Also, on pg. 14-158 (bottom) and 14-159 (top) discussion of the Yoshida et al.[176] is to be deleted and results of that study briefly summarized in a qualitative studies table.

Comments focusing on the discussion and interpretation of the studies by Rudnick[182] and Douglas and Waller[90] on pg. 14-159 to 14-163 would be highly useful, as would comments on the Lunn et al.[96, 97] studies discussed on pg. 14-163 to 14-165. Rudnick[182], Douglas and Waller[90], and Lunn et al.[96,97] appear to to provide at least some reasonably well-defined air quality data by which quantitative health effects - $SO_x$/PM air pollution relationships might be delineated (they have been interpreted by leading experts in such a manner). This, together with otherwise apparently sound methodological features, argue for these studies being strongly considered as potential key studies in arriving at final conclusions regarding the epidemiology data base for $SO_x$ and PM.

On pg. 14-165 to 14-177, all text is to be deleted regarding discussion of CHESS studies reported by Hammer et al.[214] and French et al.[306] (on New York "LRD" data), French et al.[306] (on Utah "LRD" data), and Hammer[113,257] (on Southeast or Birmingham vs. Charlotte "LRD" data). This is in keeping with statements presented earlier regarding exclusion of CHESS studies from consideration in view of questions that remain to be resolved concerning data collection, analyses and interpretation of results for CHESS Program studies. Of all the various CHESS



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studies to be deleted at this time, the Hammer[113, 257] "Southeast LRD" study appears to provide the most extensive and thorough data analyses potentially leading to reliable quantitative estimates of air pollution ($SO_x$/PM)-health effects relationships. Also, there appears to be a reasonable possiblity of resolving questions concerning the Hammer study[113,257] within the time frame of finalization of the present document. Comments on that study would, therefore, be helpful in determining its possible future consideration for inclusion in the criteria document as a potentially key quantitative study.

Comments focused on the Van der Lende et al. studies[74-77] discussed on pg. 14-178 would also be quite useful, in view of its having been interpreted by a number of experts as yielding important information on quantitative health effects - air pollution ($SO_x$/PM) relationships. Similarly, comments would be useful on the Becklake[33] and Manfreda et al.[85] studies as potentially finding lack of evidence of health effects at $SO_2$ and TSP levels around 100 $\mu g/m^3$ or less, as discussed on pg. 14-178 and 14-179.

On pg. 14-179 (bottom) and pg. 14-180 (top), the discussion of the Kagawa et al.[218, 264] studies is to be deleted and, at most, briefly summarized within a qualitative studies table. The same applies for the Zapletal et. al[87] study discussed at the top of pg. 14-180.

Comments would be especially valuable regarding the discussions on pg. 14-180 to 14-186 regarding the studies by: Holland et al;[101,102] Bennett et al.[103]; Colley and Reid[112]; Ferris[115]; Mostardi and Leonard[177]; Mostardi and Martell[258]; and Shy et al.[215] (Cincinnati school children pulmonary function study). At least some of these studies appear to provide potentially useful information by which quantitative health effects - air pollution ($SO_x$/PM) relationships might

be defined, whereas others may be sufficiently flawed methodologically (e.g. in failure to control for smoking, etc.) so as to be rendered essentially useless for present criteria development purposes.

On pg. 14-186 to 14-188, all of the text is to be deleted regarding the "CHESS" studies reported on by Shy et al.[215] (New York pulmonary function data) and Chapman et al.[213] (Birmingham and Charlotte pulmonary function data).

Comments would be useful regarding the Neri et al.[34,35] studies, discussed on pg. 14-189, as well as the other studies discussed on pg. 14-190 to 14-195. However, the discussion of Irwig et al.[98] results, on pg. 14-193 (bottom), is to be entirely deleted in view of the "preliminary" nature of the results thus far reported.

On pg. 14-196 to 14-197, Table 14-40 is to be revised, including: (1) addition of a column heading for BS ($\mu g/m^3$) along side TSP ($\mu g/m^3$) and listing of particulate matter measurement data under only one of the columns according to the original form or units reported for a given study; and (2) deletion of CHESS Program studies (Goldberg et al.,[109] House et al.,[108] Nelson et al.,[114] Hammer,[113,257] Shy et al.,[215] Chapman et al.[213]) and qualitative studies (Kerrebijn et al.,[99] Yoshida et al.,[176]) consistent with deletions in text noted above. The present Summary and Conclusions section (14.6) of Chapter 14, starting on pg. 14-199, is to be designated as Section 14.5 under the proposed chapter reorganization format outlined on the first two pages of the present materials. Reflecting the planned format change, the first paragraph on pg. 14-199 is to be appropriately revised to note under points (3) and

(4) that acute and chronic exposure effects discussions appear under Sections 14.3 and 14.4, respectively, of the newly reorganized chapter. Point (5) at the end of the first paragraph is to be deleted.

On pg. 14-200, the last part of the last sentence of the first paragraph (text starting with "--not for the purpose...") is to be deleted as unnecessary. The next paragraph on pg. 14-200 is to be revised to make reference to Table 14-41 as summarizing the results of key studies discussed earlier in the chapter as providing valid information on quantitative relationships between acute exposures to sulfur oxides or particulate matter and mortality and morbility health effects. Reference is also to be made to Table 14-42 as containing similar summarization of key quantitative studies concerning chronic exposure effects.

Table 14-41, on pg. 14-201 and 14-202, is to be revised as follows: (1) additional column headings for COH and BS measurement results in $\mu g/m^3$ are to be provided along side the TSP ($\mu g/m^3$) heading; (2) results for particulate matter measurements will be entered under one of the three (BS; COH; TSP) columns only, as per the original units or form reported for a given study; and (3) numerous deletions of entries from the revised table are to be made. Such deletions are to include: (a) the first four sets of entries designated as being for British, Dutch, Japanese, and USA studies under episodic mortality; and (b) the morbidity study entries for Stebbings and Hayes,[190] McCarroll et al.,[163] Cassell et al.,[208,209] and Stebbings and Fogleman.[216]



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On pg. 14-203, changes analogous to the first two types listed above for Table 14-41 are to also be made in Table 14-42. Entries are to be deleted from Table 14-42 for studies by Winkelstein,[188] Zeidberg and colleagues,[16-18] Hammer et al.,[214] Goldberg et al.,[109] House et al.,[108] Nelson et al.,[114] Hammer,[113,257], Shy et al.,[215] and Chapman et al.[213]

From pg. 14-205 to pg. 14-208 (top, before heading for Section 14.6.2), all text for present Section 14.6.1.1 is to be deleted. The text under Section 14.6.2 (pg. 14-208 to 14-214), however, is to remain, as is the text under Section 14.6.3 (pg. 14-215 to pg. 14-251).

On pg. 14-245, Figure 14-8 is to be deleted and the differences between evaluations of key studies between Holland et al.[301], WHO[312] and other reviewers briefly discussed only in new text inserted on pg. 12-244. Study results for the Osaka (1962), Rotterdam (1960's), France (1973), Tokyo (1970), and Southeast USA (1969-71) entries in the figure will not be discussed. The mistaken data entry for "Chicago-(1972)" in the figure actually refers to Mostardi's[177,258] studies in Ohio (1972), and the entry in the key to the right for Apling et al., Waller (1977-78) London is for Apling et al.; Weatherly and Waller (1977-78) London. Discussion of differences in the reviewers' evaluations of study results will note where the particular review "translated" original estimates of health effects-associated particulate matter levels associated with health effects from original COH or BS units to approximate corresponding TSP levels.

Lastly, at the end of Chapter 14, copies of summary tables now appearing only in Volume I of the document (as Tables 1-19 to 1-22) are to be inserted to summarize the evaluations of different reviews for key quantitative studies.



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The tables will be the same as present Tables 1-19, 1-20, and 1-21, except for those modifications discussed for those tables earlier, under present corrigenda materials for Chapter 1. Appropriate text will also be inserted to discuss the reviewers' evaluations summarized in the tables and definite statements made regarding which studies appear to be generally viewed as being valid and conclusions that can appropriately be drawn based on those study results.



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# Chapter 14 - $PM/SO_x$
## Errata

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 14-4 | 2/1 | Note: The "Lowrance (1976)" reference cited is listed as reference #343 on attached completed reference list. | |
| 14-16 | 2/4 | Note: The "WSL (1967)" reference cited is listed as reference #344 on attached completed reference list. | |
| 14-16 | 6/1 | Note: The "WSL (1967)" reference cited is listed as reference #344 on attached completed reference list. | |
| 14-16 | 7/3 | Note: The "WSL (1967)" reference cited is listed as reference #344 on attached completed reference list. | |
| 14-17 | Fig 14-1 | Note: The "WSL (1967)" reference cited is listed as reference #344 on attached completed reference list. | |
| 14-18 | 2/9 | Note: The WSL Instruction Manual (1966) is listed as reference #345 on attached completed reference list. | |
| 14-21 | 3/10 | Holland et al. (1979) | Holland et al. (1979)[301] |
| 14-26 | 2/11 | | [62] after: of Pensions" |
| 14-26 | 2/11 | | [90] after: Douglas and Waller |
| 14-28 | 2/8 | | [107] after: (IR) |
| | 4/5 | | [107] after: (IR) |
| | 4/11 | | [107] after: (IR) |
| 14-29 | ft.nt C | | [107] after: IR |
| 14-30 | 1/3 | | [107] after: IR |
| 14-31 | 1/3 | | [107] after: IR |
| 14-31 | 2/5 | | average before: flow rate |
| 14-31 | 2/5 | measured value | calculated concentration |
| 14-34 | 3/4 | 10 or, at most, 30 percent. | 10 to 30 percent. |
| 14-50 | 3/1 | References 185, 186 | - |

Chapter 14 - $PM/SO_x$ Errata (continued)

| Page | Par/Line | Delete | Insert |
|---|---|---|---|
| 14-51 | 1/3 | Reference 185 | Reference 184 |
| | 1/6 | associations .....in | changes in associations between decreasing |
| | 1/7 | decreasing .....span. | recorded mortality rates over the 1963-1972 time span. |
| 14-127 | 1/12 | | [247] after: Goldsmith |
| | 1/12 | | [246] after: Speizer |
| 14-214 | 2/11 | Thoraic Society | Thoracic Society |
| | 2/13 | | containing an epidemiology evaluation chapter by Higgins and Ferris (1978)[307] |
| | 2/14 | | containing an epidemiology evaluation chapter by Speizer and Ferris (1978)[308] |
| 14-226 | 2/2 | Ferris[214a] | Ferris[314a] |
| 14-227 | 2/9 | and particulalte | any particulate |
| 14-237 | - | last sentence of footnote "a" for Table 14-52 | |

Note: See attached changes for Chapter 14 reference list.

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Changes to References for Chapter 14 - $PM/SO_x$

Certain Chapter 14 reference numbers represent studies deleted from earlier drafts of Chapter 14 or designate studies now to be deleted in keeping with changes in text noted earlier in Chapter 14 corrigenda comments. Thus, the following Chapter 14 reference numbers should be disregarded: 98; 108-111; 113-117; 120-124; 190; 212-214; 314; 342.

References for studies cited in Chapter 14 but not listed in the original reference list, as noted in earlier corrigenda comments or text errata listings, are as follows:

342. Melia, R. J. W., C. duV. Florey, and A. V. Swan. The effect of atmospheric smoke and sulfur dioxide on respiratory illness among British schoolchildren: A preliminary report. Paper given at the VIIth International Scientific Meeting of the International Epidemiological Association, Puerto Rico, 1977.

343. Lawrence, W. W. Of acceptable risk, science and determination of safety. Los Altos, William Kaufman, 1976.

344. Warren Spring Laboratory. The Investigation of Atmospheric Pollution 1958-1966. Thirty-second report. Her Majesty's Stationary Office, London, 1967.

345. Warren Spring Laboratory. National Survey of Smoke and Sulfur Dioxide, Instruction Manual. Warren Spring Laboratory, Stevenage, England, 1966.