United States Environmental Protection Agency
Office of the Administrator Science Advisory Board Washington, DC 20460
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June 1987

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Report of the Clean Air Scientific Advisory Committee (CASAC)

Review of the Office of Policy, Planning and Evaluation's Material Damage Assessment

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

June 30, 1987

OFFICE OF
THE ADMINISTRATOR

The Honorable Lee M. Thomas
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Dear Mr. Thomas:

The Material Damage Review Subcommittee of the Clean Air Scientific Advisory Committee (CASAC) has completed its review of several documents pertaining to an analysis of the effects of acid deposition on materials. This review, requested by the Office of Policy, Planning, and Evaluation, focused on the contractor prepared report entitled "A Damage Function Assessment of Building Materials: The Impact of Acid Deposition" (Mathtech, Inc., 1986). The Subcommittee assessed four components of the analysis, namely: degree that the materials inventory is representative of urban areas, physical damage functions relating acid deposition to material damage, economic damage calculations for estimating incremental acid deposition costs, and extrapolation from the case study cities to other major urban areas of the United States.

Generally, the Subcommittee concludes that the 1986 Mathtech report is well done, given the limitations in the available data and the scope of the study, and it represents an improvement over earlier efforts. The report identifies the assumptions and many of the potential omissions, errors, and biases inherent in the work, and tries to account for a range of possible alternatives by furnishing lower and upper damage estimates. Although the researchers have performed competent work in view of the limited resources and research direction, the work reflects continued limitations in knowledge and data bases available to the researchers.

In view of the uncertainties involved, especially in paint damage costs, the Subcommittee believes that the total costs from acid deposition should not be used in the Sulfur Oxides National Ambient Air Quality Standards (NAAQS) rulemaking process. Nevertheless, the conceptual framework and procedures that are used in this report do provide useful information which should be considered. The analyses contained in this report should be considered as complementary to the supply/demand model approach that is now incorporated in the draft Regulatory Impact Analysis (RIA) for Sulfur Oxides.

Thank you for the opportunity to present our views on this important welfare issue. We request that the Agency officially respond to the scientific advice contained in the attached report.

Sincerely,

Morton Lippmann
Chairman
Clean Air Scientific
Advisory Committee

Warren B. Johnson

Warren B. Johnson
Chairman
Material Damage Review
Subcommittee

cc: A. James Barnes
Bruce Jordan
Dick Livingston
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Bill O'Neil
Craig Potter
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SAB-CASAC-87-033

Report of the Clean Air Scientific Advisory Committee
Material Damage Review Subcommittee

ECONOMIC DAMAGE TO BUILDING MATERIALS EXPOSED TO ACID DEPOSITION

June 1987

Science Advisory Board
U.S. Environmental Protection Agency
Washington, DC

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1. EXECUTIVE SUMMARY

This is the report of the Material Damage Review Subcommittee of the Clean Air Scientific Advisory Committee (CASAC). The Subcommittee was formed at the request of the Office of Policy, Planning and Evaluation (OPPE) to review several documents pertaining to an analysis of the effects of acid deposition on materials. These documents are expected to be used in revising the Regulatory Impact Analysis (RIA) associated with the National Ambient Air Quality Standards (NAAQS) for Sulfur Oxides.

The primary review document was the report "A Damage Function Assessment of Building Materials: The Impact of Acid Deposition", prepared in May 1986 by the Mathtech Corporation for OPPE. This report attempts to develop quantitative estimates of the economic damages associated with the exposure of common construction materials to current levels of acid deposition. It also relates to the broader question of uncertainties concerning the magnitude and distributional impacts of the benefits and costs associated with stricter emission control programs.

Generally, the CASAC Material Damage Review Subcommittee concludes that the 1986 Mathtech report is well-executed and documented, given the limitations in the available data and the scope of the study, and it represents an improvement over earlier efforts. The report identifies the assumptions and many of the potential omissions, errors, and biases inherent in the work, and tries to account for a range of possible alternatives by furnishing lower and upper damage estimates. The researchers have performed competent work in view of the limited resources and research direction. Nevertheless, the work reflects continued limitations in knowledge and data bases available to the researchers.

We believe that the reported economic damage estimates due to acid deposition in the study region can only be considered suggestions. This is primarily due to the potentially limited reliability and applicability of the paint and mortar damage functions, although other components of the analysis further diminish accuracy.

The Subcommittee's review suggests the final economic estimates are likely (although not certain) to be overstated by the assumptions used in the absence of desired data. As a result, the lower bound estimates appear to have more credence than the best or upper bound estimates. The zinc estimates do appear to be of acceptable reliability, while the more important paint and mortar damage estimates are of very limited reliability.

While the damages are potentially overstated for the materials and regions considered, the omission of several potentially important regions and materials may be an important counterbalancing consideration.

The Subcommittee has the following major findings and recommendations:

- The materials inventory conducted for the four study cities addresses the major structural uses and susceptible materials. The inventory represents a substantial improvement in the data base over previous work. However, it is difficult to judge how representative these four cities are of the 17-state study area. Therefore, the extrapolation from the four study cities to other cities must be considered tentative and uncertain.

- The physical damage functions selected for paint, stone, and mortar are perhaps the most accurate functions available, but are of highly uncertain reliability and may be of limited applicability in this analysis. The damage function for zinc has a higher reliability and lower uncertainty than paint, stone or mortar. While this damage function for zinc appears to relate realistically the damage to remediation scenarios, the damage function for paint, based on erosion, is not necessarily related to remediation measures (e.g., repainting). This is an especially serious shortcoming since paint damage is potentially the most important component of total damage costs from acidic deposition. As a result, the physical damage functions severely limit the confidence one may place in the overall results for use in policy analysis. Due to these uncertainties, the current paint, stone and mortar damage functions should not be used in the RIA.

- Given the data available, the methodology for making economic damage calculations appears reasonable, but given the problems with the damage functions and the many assumptions necessary, there may be significant biases in the total damage costs. More could be done to analyze actual behavioral responses to paint erosion as well as the nature of the costs consumers incur with repainting activities. In addition, important improvements can be made concerning perceptions, behavioral responses, and valuation of damages.

- Overall, the lower end of the cost range is more credible than the upper end of the range. It may be, however, because of the substantial uncertainties involved, that the low end of the range is too high. Thus, the Subcommittee does not endorse any particular estimate as being correct. Rather, we regard the uncertainties as being sufficiently fundamental to warrant further study.

- The 1986 Mathtech analyses represent an alternative approach to materials damage estimation compared to the supply/demand model approach (Mathtech 1982) currently incorporated into the draft RIA. The approaches taken in the two reports are quite different and the results should be considered as complementary to each other.

- The 1986 Mathtech report should be cited in the draft RIA, but should not replace the current economic analysis. Rather, a more thorough comparison of the results of the two efforts should be included as a basis for indicating "plausible" levels of economic damages under alternative sets of restrictive assumptions and available data. The limitations of the analyses should also be acknowledged.

- A substantially improved understanding of the types and levels of damages induced by acid deposition and an improved response by the public is needed.

The Subcommittee also identified a number of other issues and made additional specific comments in Appendix A.

2. INTRODUCTION

On April 21, 1986, the Clean Air Scientific Advisory Committee (CASAC) was briefed by Dr. Thomas Lareau of the Office of Policy, Planning and Evaluation (OPPE) concerning Agency sponsored materials damage analysis. This analysis is intended to be used by the Office of Air Quality Planning and Standards (OAQPS) in preparing the Regulatory Impact Anaylsis (RIA) on the National Ambient Air Quality Standards (NAAQS) for Sulfur Oxides. Dr. Lareau stated that it was the intention of OPPE to request formal CASAC review at a later date.

In July 1986, OPPE formally requested CASAC review of several documents concerning material damage. These documents were the final Mathtech report, "A Damage Function Assessment of Building Materials: The Impact of Acid Deposition" (March 1986), and supporting documents (see Appendix B for full citations) including:

- "Economic Benefits of Reduced Acidic Deposition on Common Building Materials: Methods Assessment"

- "Material Effects Assessment"

- "Economic Damages to Building Materials Exposed to Acidic Deposition"

- "Derivation of Metallic Corrosion Damage Functions for Use in Environmental Assessments"

- "Atmospheric Acid Deposition Damage to Paints"

- "Benefit Analysis of Alternate Secondary NAAQS for Sulfur Dioxide and TSP"

CASAC formed a Subcommittee in July 1986, chaired by Dr. Warren Johnson of the National Center for Atmospheric Research, with the charge (See Appendix C) to review the 1986 Mathtech report and the supporting documents to determine if the methods discussed were scientifically credible and whether the data were appropriate for estimating materials damage from acid deposition in a 17-state area of the United States. In particular, the Agency asked for an assessment of four components of the analysis:

- Materials Inventory - Does the inventory provide a representative sample of the distribution of materials in urban areas that can be used to extrapolate to other urban areas?

- Damage Functions - Do the physical damage functions accurately describe the relation between acid deposition and materials damage?

- Economic Damage Calculations - Are the assumptions about baseline maintenance practices appropriate for estimating incremental acid deposition costs?

- Extrapolation - Is a credible method used for extrapolating from the four case study cities to other major urban areas in the Northeast and North Central United States?

The Subcommittee was also asked to provide its judgment on the following questions:

- Are the analyses useful input for the Sulfur Oxides NAAQS rulemaking process?

- Are these analyses a more credible approach to materials damage estimation than the supply/demand model approach that is currently incorporated into the draft RIA?

The Subcommittee conducted its initial review via the mail. On December 4, 1986, the Subcommittee held a public meeting in Washington, DC to formally discuss the documents with Agency staff, and to obtain comments from the interested public.

3. ASSESSMENT OF THE COMPONENTS OF THE ANALYSIS

A. Materials Inventory

> Does the inventory provide a representative sample of the distribution of materials in urban areas that can be used to extrapolate to other urban areas?

The method used for the inventory in the four urban areas (New Haven, Portland, Pittsburgh, and Cincinnati) is a reasonable approach to take without spending inordinate amounts of time and funds to expand the field survey or baseline portion of the study. However, it is difficult to judge how representative these four communities are of the entire area of the study.

Obviously, many assumptions were made to develop the inventory and it is difficult to determine the degree of bias each may introduce into the results. An in-depth critical analysis of all assumptions used, to see if they introduce bias or only uncertainty, would be useful.

Three major questions are addressed under this heading. The first is the coverage of the inventory with respect to materials and uses. Although the choice of materials is limited, this limit is necessary to fit within the scope of the project. Nevertheless, the inventory covers the major materials used in structures, as well as other susceptible materials. In this respect, the work is a substantial improvement over previous studies.

The second question is whether the sample provides an adequate basis for extrapolating damages for the city in which the sample is taken; that is, does the sample provide an adequte basis for estimating total materials exposed by building group and material for each city? It is difficult to answer this question without examining the details of the sampling design, which are apparently described in Rosenfield (1984).[1] The Mathtech report does include sensitivity analysis of damage estimates based on the standard deviation in each sample city. However, sensitivity analyses would not be expected to uncover fundamental biases in assumptions. The errors in extrapolating to other cities may be considerable.

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[1] Rosenfield, G.H. (1984). "Spatial Sample Design for Building Materials for Use with an Acid Rain Damage Survey." U.S. Geological Survey, Reston, Va. In: R.S. Schmitt and H.J. Smolin, eds. The Changing Role of Computers in Public Agencies. Presented at the annual conference of Urban and Regional Information Systems Assoc. August 1984.

The question of extrapolation outside of the sample cities, that is, to other urban areas, is discussed in Section 3.D. Extrapolation Procedures.

B. Physical Damage Calculations

Do the physical damage functions accurately describe the relation between acid deposition and materials damage?

1) Paint

As identified in the report, paint damage is by far the largest component of total material damage costs. The damage function for paint is based on paint film failure due to erosion measured by weight loss. Peeling, flaking, blistering, soiling and fading are undoubtedly more important forms of paint damage that triggers repainting.

The authors faced a serious lack of theory or data on the relationship between acid deposition and paint physical damage measures other than erosion. As a result, the erosion function was used to proxy all paint damage functions. This is a highly uncertain and debatable assumption that limits the reliability of the entire analysis. However, if increased acid deposition also increases the rate of peeling and cracking at a rate similar to the erosion of film thickness, and the time chosen to repaint is a function of peeling and cracking (and that time is about the same as for film erosion), the error may be small. If the time to repaint is primarily based upon cracking or peeling rather than film thickness, and if the increased rate of cracking and peeling caused by acidic deposition is lower (or higher) than for film thickness, then the damages will be lower (or higher) than reported. Research is sorely needed to develop relationships between all types of paint damage, acidic deposition and other environmental factors.

2) Mortar

The mortar damages estimated in the report are quite significant. The authors identify the limitations of damage functions and composition information upon which they base their estimates. The stone and mortar damage functions are based upon information that is extremely limited and, at present, of limited reliability. Further, the procedures used suggest these damages may be overstated. From the assumptions used, it takes about 50 years of exposure to current levels of deposition to reduce the repointing service interval by ten years.

It appears that the calculations used have assumed continuous past exposure to current levels, which is probably incorrect and substantially overstates damages. Taking this into consideration would result in reduced current and near-term future damages and/or require discounting procedures as used in the stone analysis. If total past exposure and the current and near-term mortar damages were reduced by half, the total damage numbers for all categories would be reduced by about 20 to 25 percent, which is substantial.

3) Econometric Considerations

There is little discussion in the report of possible econometric problems with the damage functions. For example, could there be an omitted variable problem; i.e., could additional pollutants besides sulfur dioxide (SO_2) and hydrogen ion (H^+) affect damages? Synergistic effects also can occur, e.g., the combined effect of acid rain and road salts. If so, the coefficients on SO_2 and H^+ could be inflated.

Of major concern is the fact that damage functions are all apparently extrapolated from current ambient conditions to some background concentrations (apparently zero for SO_2 and neutral pH for H^+) and are generally linear functions. Is this realistic, since many damage functions for other adverse environmental effects are not linear? In fact, they sometimes show thresholds below which damage is imperceptible. If this is also the case here, the estimated damages may be too high.

C. Economic Damage Calculations

Are the assumptions about baseline maintenance practices appropriate for estimating incremental acid deposition costs?

1) General

Given the data available to the authors and the apparent current lack of understanding of how maintenance decisions are actually made, the economic damage calculations are reasonable. Although the use of critical values (Table 4-5) is an acceptable means of calculating changes in maintenance intervals, it may be a strong simplifying assumption. Overall, the calculations of economic damages are carefully done and rely upon assumptions which, although stringent, do not appear to substantially bias the estimates in either direction.

The benefit estimation approach that is used in this analysis involves the maintenance costs induced by acid deposition. However, optimal maintenance strategies as defined may not be the optimal welfare damage mitigation strategy. For example, if people choose to suffer rather than undertake the maintenance, then benefits are likely to be overestimated. To what extent will individuals and firms suffer unrepaired damage from pollution?

Missing from this analysis is a good discussion of individual behavior as it relates to maintenance. In particular, when will individuals perceive damage and act on repairs, and what repairs will they undertake?

Do these assumed critical loss levels make any sense in terms of actual behavior? How does the type of damage that will occur relate to that found in the earlier studies of critical losses by Haynie and Martin Marietta Environmental Systems?

A field study should be conducted that interviews consumers and firms regarding repair actions. Since the behavioral response is critical to the economic damage calculations, these values should be based on solid information, not assumptions. The most important limitation (and therefore research need) in the economic component of the analysis, is a field study to improve the estimation procedure by determining how building owners perceive relevant damages; how they respond to damage through changes in maintenance intervals, use of different materials, and so on; and how they value damage and response activities.

While the economic analysis can be substantially improved, it is not currently among the major sources of error or bias in the overall assessment.

2) Reasons for Repainting

Painted surfaces are the largest man-made exposed surfaces subject to environmental damage. Therefore, perception, behavioral response, and valuation are highly dependent upon the damage function for paint and the method of calculating costs for damage and/or remediation. The fundamental problem with using the Mathtech damage function as a basis for computing damage costs is that paint erosion may seldom be the basis for decisions to repaint. Mathtech hints on Page 4-13 of their report that erosion is not an appropriate basis for repainting. On Page 2-37 of the 1984 draft Mathtech report "Economic Benefits of Reduced Acidic Deposition on Common Building Materials: Methods Assessment", this is stated more strongly:

> The present damage functions for paint are not adequate to characterize damage definitively. Peeling and cracking of the painted surface are the primary forms of damage that are experienced in the real world. These types of damage are not adequately treated in the existing calculation.

This point is further emphasized in a survey conducted in 1968 by Better Homes and Gardens on residential painting practice.[2] In the section of the report on this survey dealing with the respondents' most

2 "Residential Paint Markets, 1968." A study of consumers by Better Homes and Gardens, conducted in cooperation with the National Paint, Varnish, and Lacquer Association, Washington, DC.

recent exterior painting activity, a table is presented giving the reasons for the most recent repainting. Of 1,106 total replies, 41 percent listed the predominant reason to repaint was that the old paint was blistering and peeling. The second and third reasons, at 20 percent each, were to protect the undersurface, and because the previous paint was flat and drab. Erosion might be involved to a limited degree in only two of the six specific reasons given.

From the above discussion, it appears that costs for acidic deposition to paint are probably overstated. Further, it is likely that damage costs for other construction materials are also incorrect because of faulty assumptions about the nature of the damage and response in the form of maintenance practice to remedy the damage. For example, some households repaint prior to the required need to change color or to prepare a house for resale. In these cases, the incremental damage for air pollution would be zero.

3) Behavior

If additional resoures were available, the Subcommittee would urge the following changes: First, a better understanding is needed of the behavioral response to paint erosion. When will consumers undertake repainting due to erosion and what is the incremental effect of acid deposition on these decisions? A second set of concerns pertain to unrepaired damage. For consumers who eventually do repaint, what is the value of the aesthetic loss from erosion before repainting? In addition, some individuals may choose not to repaint at all and simply incur the unrepaired damage, which will be less costly than the price of repainting.

A third class of concerns pertain to the economic cost of repainting. Even with only modest additional effort, we could get a better estimate of this cost. What fraction of households hire painters for exterior work, and what is the rate they will pay? For consumers who do their own repainting the calculation is more uncertain. The commercial cost sets an upper bound on the painting cost, but how far below this amount one should calculate is not clear. Consider a worker who earns $10/hour who faces commercial rates of $20/hour. He will choose to repaint even if he greatly dislikes doing so, provided that the disutility per hour of painting has a value less than $20. If he likes to paint, this value may be below his market wage of $10/hour. A "neutral" but probably incorrect assumption would use the worker's wage rate as the painting labor cost if it were below the cost charged by professional painters, and would use the professional painters' wage otherwise.

4) Costs of Repainting

Once the decision has been made to repaint a house, the question of cost arises. Various figures are cited in the report, such as $1 per square foot (Page 5-6), the unit maintenance cost (Table 5-2), and data from various studies (Table 5-15). Does this information pertain to interior painting, exterior painting, or both? We believe that more work can be done in this area of the report.

For overall unit painting costs, the assumption is that these costs should be reduced by 20 percent to account for painting done by homeowners. This assumption may lead to an underestimation of damages for two reasons. First, while the report cites evidence that 50 percent of all architectural paint is sold to non-professionals who do the painting themselves, do-it-yourself activity seems much higher for interior painting. Do-it-yourself painting of exteriors may be less than the 50 percent assumed in the report. Second, the report bases its estimate of the labor cost of do-it-yourself painting on the assumption that home owners' wages are the same as those of professional painters. The relevant market wage is the average wage of that class of workers owning their own homes, which may be higher. Substantial literature exists on estimating the opportunity cost of household leisure time. Some references to this literature might be used to justify the assumption that the opportunity cost of leisure time is 50 percent of the relevant wage.

5) Silicate-Base Paint

The analysis of damages to painted surfaces is based on the assumption that carbonate-base paint will be replaced with silicate-base paint. But based on the discussion of the advantages of silicate-base paints, a substantial fraction of surfaces initially painted with carbonate-base paint would be repainted with silicate-base paint, in any case, independently of acid deposition. Thus, the added cost of silicate-base paints estimated on page 5-10 of the Mathtech report ($42 million) is not relevant if silicate-base paint would be the paint of choice in any case, that it, independent of resistance to pollution. If this is valid, then damages to painted surfaces are overestimated in this report. The report examines the sensitivity of damage estimated to assumptions about the percentage split between the two types of paint. It does not examine the sensitivity to changes in the split as carbonate-base paint surfaces are repainted with silicate-base paints.

The report indicates that silicate-base paints are more expensive, which is misleading. They are more expensive per gallon but not per year, unless one only wants paint to last three years.

6) Stone Buildings

The damage estimate to stone buildings is based on an estimate of replacement costs of about $20 per square foot. The basis of this estimate is uncertain. Does this refer to the cost of replacing stone facings only? If so, it may be inappropriate to apply this number to many of the stone buildings in the inventory. The stone in most residences and many smaller commercial and public buildings is an integral part of the load bearing external walls. Replacement of that stone may involve tearing down and replacing the structure.

D. Extrapolation Procedures

> Is a credible method used for extrapolating from the four case study cities to other major urban areas in the Northeast and North Central United States?

1) General

Given the data available, the section on Extrapolation Procedures in the report seems to provide plausible procedures for other cities in the 17-state area. The reasonableness of the results are conditioned upon the acceptance of the calculated physical and economic damages for the case-study cities. Because it is an extrapolation, rather than a repetition of the earlier approach to all 113 cities, the estimates are necessarily imperfect.

To improve the readers' confidence in the extrapolations, it would be helpful if the authors could take three case-study cities to extrapolate to the fourth city. For example, could the experiences of the three other cities be used to project the Portland experience, and how well would this projection compare with what was actually found?

2) The Mix of Cities

This analysis extrapolates the experiences in New Haven, Portland, Pittsburgh, and Cincinnati. How were these cities chosen? Is there any indication that they provide a reliable basis for extrapolating to other cities? What about large cities, such as New York, Boston, and Philadelphia? Having a reasonable range is important given the fact that economic damages to materials vary by a factor of almost 100 from the estimate for Portland to the estimate for Pittsburgh. Even on a per-capita basis, the discrepancy is almost a factor of seven, which suggests that a good mix of cities is very important to provide a reliable basis for comparison. Thus, more justification should be given for the four cities chosen.

3) Materials Use by Region

The data from the sample cities varies substantially in materials use by region. The four-city sample does not provide an adequate basis for understanding this variation across the whole geographic area and range of city sizes covered by the extrapolation. Given the importance in the overall estimates of large urban areas, this is a shortcoming of the report.

A key part of the sample is the extrapolation of wall area by material and building type to five census divisions. The Mathtech report states on page 6-4 that this was based on sample data from the case study inventory and from Department of Energy materials distribution information. However, without having reviewed Lipfert (1985),[3] it is difficult for the Subcommittee to fully evaluate the data of the extrapolation procedures adequately.

4. ADDITIONAL ISSUES

A. Use of Results in the Rulemaking Process

> Are the analyses useful input for the SO_2 NAAQS rulemaking process?

The calculations for the four sample cities show the potential for significant damages to exterior materials. The extrapolation estimates show the possibility that area-wide damages in this category, when combined with estimates of damage in other categories, may be comparable in magnitude to control costs. This comparison might suggest that this work is useful input to the secondary National Ambient Air Quality Standards for SO_2; however, in view of the great uncertainty in paint damage costs, the total costs from acidic deposition should not be used as part of any rulemaking.

A better understanding of the types of damage induced by acidic deposition, and the response of the public to this damage, is needed before the economic estimates derived from such studies can be considered free of extensive uncertainties and biases. Given the substantial uncertainties involved, the Subcommittee urges that EPA consider additional work in areas where it is feasible to improve our knowledge (e.g., economic damages).

B. A More Credible Approach

> Do these analyses represent a more credible approach to materials damage estimation than the supply/demand model approach (Mathtech 1982) that is currently incorporated into the draft RIA?

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[3] Lipfert, F.V. (1985). Report in preparation by Brookhaven National Laboratory.

There is no simple answer to this question due to the substantial differences in method, data, geographic coverage, and coverage of economic sectors and activities between this report and the earlier document (Mathtech 1982). Also the two reports analyze the effects of air pollution that is measured differently. Thus, these reports are not alternative measures of the same economic phenomenon, and are therefore not directly comparable.

The principles that underlie the present report are more easily grasped than the method of indirect estimation developed for the 1982 Mathtech document. Yet the methods used in this latest report are conceptually correct only under restrictive assumptions concerning the absence of material substitution, direct utility losses, etc. The 1982 report derives estimating techniques from conceptually correct economic models of behavior. The magnitude of the biases introduced by the restrictive assumptions in the 1986 report are unknown.

The geographical coverage of the two reports is also quite different. The 1982 report is national in scope while the 1986 report covers only urban areas within the Northeastern part of the United States. In the 1982 report, separate estimates were developed for the household sector and for the commercial/industrial sectors. For the household sector, the 1982 report covered all cleaning and maintenance activities and related losses in utility and welfare, including those involving interior soiling, etc. However the estimates were derived implicitly from data on differences in household expenditure patterns across areas that differed according to air pollution levels. The present report focuses only on exterior damages to residences and related structures, ignoring losses in utility, damages to residential interiors, and increased costs due to mitigating activities. On the other hand, the present report is based on quantitative data on the effects of pollution on materials.

As for the commercial/industrial sector, the 1982 report covered only a limited number of industrial sectors, but it included all forms of costs-increasing damages due to pollution, rather than just damages to exterior structures. The present report includes all commercial/industrial structures but is limited to exterior structural damages in urban areas.

The two reports should be considered complementary to each other. The present report emphasizes the physical mechanisms by which pollution causes damages, while the 1982 report focuses on the behavioral responses of economic agents to these effects. The behavioral approach therefore encompasses a wider range of effects and responses than those explicitly modeled in the physical mechanisms method. However, the approach focusing on behavioral responses yields results that are linked more directly to the underlying changes in welfare or utility which the studies are attempting to measure.

The present approach identifies real physical mechanisms by which pollution affects individuals. The 1982 report shows that individuals appear to perceive these effects and respond in economically meaningful ways which can be interpreted as reflecting losses in economic well-being. The Subcommittee believes that the results and limitations of both studies should be included in any assessment of the economic implications of physical damages due to air pollution.

APPENDIX A

APPENDIX A

ADDITIONAL SPECIFIC COMMENTS

1. Although the report lists many of the omissions, errors, and possible biases that have not been addressed, it does little to indicate which are more important than others. This may give the perhaps false impression that these limitations approximately net out. Any evidence on the relative magnitude of the errors, omissions, and biases would increase the usefulness of the overall data.

2. A subsection in either section 1 or section 5 should list all the biases used in the methodology and make an informed guess as to whether the net effect of all the biases is to underestimate or to overestimate the total economic damages from acid deposition. Since some damages are purposely omitted, e.g. infrastructure systems, it would help to provide some guidance as to whether these omitted damages are of the same order of magnitude as those which are estimated.

3. Section 1 provides a useful overview and summary of the entire report. The limitations subsection in this section (and in Sections 4 and 6) help put the accuracy and coverage of the estimates in perspective. Page 1-6 does not explain why national estimates of damages are not provided, given that the NAAQS are national. If it is true that damages are negligible outside the 17-state region, the report should say so clearly and document this finding.

4. Page 1-8 does not explain why the damages to infrastructure systems were not estimated. Does this introduce a serious bias? Why was this class of damages omitted?

5. The distinction between regional and local SO_2 sources on Page 1-11 is not clearly explained and should be for expositional purposes.

6. The last suggestion for future research on Page 1-19 (calculate confidence intervals) is the logical next task and would provide a useful extension to the estimates in this report, especially the ranges of estimates reported. The ranges are useful, but they are not a substitute for confidence intervals, as the authors are careful to explain.

7. The recommendations for future research could include the effects on art objects, since it is difficult to assess costs of this type of damage. One potentially significant underestimate: could values for works of art that cannot be repaired or replaced to be equivalent to the original pieces? Aside from irreplaceable works of art, the procedures may be resulting in a "mild" upward bias in the estimates.

8. Section 2 provides a competent summary of benefit estimation and a description of the methodology used in the report. Figure 2-8 is quite useful. Although the decision to allow only one reaction to acid deposition, for example, additional maintenance provides a reasonable approximation, two additional implications of this assumption might usefully be explained. First, this behavioral response assumes that there is no trade-off involved in selecting the maintenance interval, i.e., consumers chose the same level of building quality no matter how expensive the maintenance becomes to keep up that level of quality. Obviously, this is a strong assumption. Second, the approach assumes that maintenance is sufficiently frequent to avoid any damage to the underlying materials, e.g., wood siding, bricks.

9. The reasons for the zero entries in the materials inventory probably should be documented, perhaps in an appendix.

10. Page 4-36 shows substantial differences between the estimates of Haynie and Martin Marietta Environmental Systems concerning initial paint thickness and critical loss. However, the sensitivity analysis conducted at the end of Section 5 does not include sensitivity to variations in these key assumptions.

11. There is uncertainty in how the upper and lower bound estimates were derived. The report lists, for example, several factors that could either increase or decrease the paint estimates. These possible errors appear to be multiplicative. This is important to the determination of the spread of reasonable numbers and should be more completely documented.

12. The source of the data in Section 5 used for regional adjustments to cost and price indices is not described.

13. Without access to Lipfert's report, it is not possible to evaluate the regressions used on Pages 6-8 and 6-16 for the commercial/industrial category.

14. Tables in Section 6 refer to the Northeastern Census Division. Is it not the New England Census Division?

15. Why was Michigan, especially Detroit, excluded from the extrapolation?

16. Because the Pittsburgh extrapolation contained the poorest performance of the four test cities, and 50 percent of the damages occur in the three largest metropolitan areas, more data should be gathered in these three areas. Approximating the building counts through regression equations is the assumption which we question most. This component of the extrapolation is likely to be a major source of error for large cities.

APPENDIX B

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CITATIONS OF REVIEW DOCUMENTS

1. "A Damage Function Assessment of Building Materials: The Impact of Acid Deposition." Mathtech, Inc. May 1986. Final Report.

2. "Economic Benefits of Reduced Acidic Deposition on Common Building Materials: Methods Assessment." Mathtech, Inc. June 1984. Draft Final Report.

3. "Material Effects Assessment." Draft of the materials section of the 1985 NAPAP Assessment (unpublished) (National Acid Precipitation Assessment Program).

4. "Economic Damages to Building Materials Exposed to Acid Deposition." T.J. Lareau et al.

5. "Derivation of Metallic Corrosion Damage Functions for Use in Environmental Assessments." Brookhaven National Laboratory. April 1985.

6. "Atmospheric Acid Deposition Damage to Paints." Fred Haynie. U.S. EPA Report EPA/600/M-85/019. January 1986.

7. "Benefit Analysis of Alternative Secondary NAAQS for Sulfur Dioxide and TSP." Volume I. U.S. EPA Report EPA-450/5-83-001a. August 1982.

APPENDIX C

APPENDIX C

CHARGE TO THE CASAC MATERIAL DAMAGE REVIEW SUBCOMMITTEE

The Mathtech report (1986), together with the supporting documents are to be reviewed to determine whether the methods are credible and whether the data are appropriate for estimating materials damage from acid deposition in a 17-state area of the United States.

The following components of the analysis are to be assessed:

- Materials Inventory - Does the inventory provide a representative sample of the distribution of materials in urban areas that can be used to extrapolate to other urban areas?

- Damage Functions - Do the physical damage functions accurately describe the relation between acid deposition and materials damage?

- Economic Damage Calculations - Are the assumptions about baseline maintenance practices appropriate for estimating incremental acid deposition costs?

- Extrapolation - Is a credible method used for extrapolating the four case study cities to other major urban areas in the Northeast and North Central United States?

Based on these assessments:

- Are the analyses useful input for the SO_2 NAAQS rulemaking process?

- Do these analyses represent a more credible approach to materials damage estimation than the supply/demand model approach (Mathtech 1982) that is currently incorporated into the draft Regulatory Impact Analysis (RIA)?