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ABSTRACT

This report provides technical and scientific information useful for planning a mass deacidification program and choosing mass treatment processes to preserve library and archival paper-based collections. Aimed at institutions investigating mass deacidification as a preservation alternative, the document explains technical and other related factors that decision makers need to consider, as well as a rationale for considering them. The most conservative path to decision making is advocated, with maintaining the safety of the collections given the highest priority. Basic background information about mass deacidification processes is then offered, and reasons for their development are explored. Ways in which mass deacidification differs from single-item treatment are discussed together with the particular challenges of choosing mass processes. Major emphasis is placed on in-depth analyses of six technical evaluation factors: (1) effectiveness of deacidification procedures; (2) unwanted changes in materials; (3) process engineering; (4) extra benefits from specific processes; (5) toxicity; and (6) environmental impact. Other evaluation issues outlined include unit treatment costs, book and document security, logistical considerations, long-term vendor performance and contracting, observation of facility operation, and liability. Brief explanations of organizational and planning considerations that are of primary importance to the total mass deacidification effort are appended. (SD)

THE COMMISSION ON PRESERVATION AND ACCESS

REPORT

TECHNICAL CONSIDERATIONS IN CHOOSING MASS DEACIDIFICATION PROCESSES

by

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May 1990

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INTRODUCTION

This paper has been developed to provide decision makers with a body of technical and scientific information useful for planning a mass deacidification program and choosing mass treatment processes to preserve library and archival paper-based collections. The main purpose of the publication is to give those institutions which have decided to investigate mass deacidification as a preservation alternative an understanding of the technical and other related factors they need to consider, as well as the rationale for considering them. In taking an objective, evaluation stance, the paper advocates the most conservative path to making decisions, giving the safety of the collections the highest priority. Final decisions regarding the use of mass deacidification remain, of course, with the institutions that serve as the caretakers for the collections requiring preservation. The paper's author, Dr. Peter G. Sparks, served as Director for Preservation at the Library of Congress for eight years before beginning a consulting business in 1989. His education is as a physical chemist.

There are some key, basic assumptions behind the technical evaluation procedures described in this paper:

- To evaluate deacidification processes, an institution must inform vendors regarding what types of information it wants about processes, collect that information from vendors, and devise a fair evaluation process.

- An evaluating institution should not have to do extensive research and development concerning how a process works and interacts with its materials, because it is the responsibility of the process vendors to develop this information. However, libraries and archives should be prepared to do a small amount of independent testing to satisfy themselves regarding some basic results.

- No existing or future mass process will be perfect. The best approach is to look carefully at the merits and drawbacks of each process and make an informed decision with all the facts in hand.

* * *

To assist an institution through the necessary decision steps, this paper first presents some basic background about mass deacidification processes, focusing on reasons for their development and what is known about them from a scientific, technological perspective. There also are discussions of how mass deacidification differs from single-item treatment, and the particular challenges in choosing mass processes. Major emphasis is placed on an in-depth analysis of six technical evaluation factors — the effectiveness of deacidification procedures, unwanted changes in materials, process engineering, extra benefits from specific processes, toxicity, and environmental impact. A subsequent section covers other evaluation issues: unit treatment costs, book and document security, logistical considerations, long-term vendor performance and contracting, observation of facility operation, and liability. Organizational and planning considerations related to technical decisions are included in an appendix.

WHY CONSIDER MASS DEACIDIFICATION

There are at least three compelling reasons to consider mass deacidification technology as an option for preserving certain original materials in local collections and as a vital part of coordinated preservation efforts in the United States.

First, there is the long-observed chemical effect that neutralizing or removing the acid in machine-made paper, coupled with the inclusion of the correct amount of a basic salt in that paper, markedly stabilizes the paper's principal chemical component, cellulose, and prevents the paper from becoming weak and brittle. This stabilization slows down the chain-cutting acid hydrolysis reaction in the giant cellulose molecule, thereby allowing it to retain its chain length and hence the paper's strength for much longer periods of time than it would with acid present. There is also some evidence that the oxidative degradation of cellulose, a lesser effect that also decreases its chain length, is retarded by deacidification. Laboratory aging experiments on deacidified papers and on machine-made alkaline paper have shown that these papers remain flexible and usable for long periods of time compared to their acid paper controls. Accelerated aging techniques predict that acid-free papers with an alkaline reserve in the paper at the 1 to 2 percent level by weight should last three to five times longer than their acidic counterparts. Real-time observations on paper manufactured acid-free and alkaline in the early 1900s by the S.D. Warren paper company have shown little degradation under natural aging conditions.

Important research spanning a good part of this century has developed a sound scientific basis for understanding this stabilization phenomenon, which is the technical reason behind the use of mass deacidification. [Researchers include Edwin Sudermeister at the S.D. Warren paper company; William J. Barrow at the Barrow Research Laboratory; Richard Smith at the University of Chicago; and George Kelly, John Williams, Donald Sebera, and Chandru Shahani at the Library of Congress Research Laboratory, among others.] It is also the basis for efforts to increase the use of alkaline paper in books.

Second, there are enormous and growing library and archival collections in all types of formats that are weakened and brittle. Currently, there are a number of concerted efforts to grapple with the task of transferring the information printed on this brittle paper to secondary preservation formats such as microforms. Deacidification will not help to preserve the information on already brittle paper because its principal utility is to preserve original paper formats that have some strength to start with. It can play a major role, however, in keeping the balance of collections that are on stronger paper from becoming brittle for long periods of time. This is an important contribution to the overall preservation effort because the amount of embrittled paper that must be reformatted is large and will require many years of work and continuing large-scale funding to complete. Moreover, instead of perceiving time as the enemy of preservation efforts, the time gained by deacidification can be used in the future to implement new preservation approaches that are still under development.

Third, for perhaps the first time, there is a preservation technology on the edge of adoption that has the potential to stabilize large quantities of books, manuscripts, maps, and other paper records at a reasonable unit cost. Of course, such an effort will take a great deal of funding, planning, and physical effort, including moving large quantities of items out of and back into a collection. But mass deacidification's high production capability could well result in the treatment of an entire research collection over a period of one or two decades.

WHAT IS KNOWN ABOUT MASS DEACIDIFICATION

There is a considerable amount of general information already known about mass deacidification that can be helpful in understanding how to proceed with evaluating and eventually using these processes. The technical basis for the paper stabilization as accomplished by deacidification is well understood, and this effect has been observed many times.

Laboratory experiments predict a three- to five-fold increase in the useful lifetime of properly deacidified paper having a one to two percent alkaline reserve. Translating this prediction into years of estimated life can be complicated, since papers of different quality will have very different life expectancies to begin with. At two extremes, for example, are a cheap groundwood pulp acidic paper with only a 10-year original lifetime, and a high-quality chemical-pulp acidic paper with 100 years of original lifetime. In these hypothetical cases, the life of the paper with an original 10-year lifetime could be extended to perhaps 30 or 50 years with deacidification. Likewise, the paper with an original 100 years of life might survive for 300 to 500 years with treatment. As has been discovered, actual library and archival collections contain a very broad range of paper strengths and rates of deterioration that in turn yield an equally broad range of stabilized papers after deacidification.

There are both liquid and gaseous approaches for the delivery of a deacidification chemical, and under each of these general classes there are several different process variations. Although this rapidly changing field of possibilities may appear to complicate the issue at first, this is a positive situation for the library and archives field, because each institution will have the opportunity to evaluate and select an approach that best suits the needs of its particular collections and budget.

There are at least five different mass deacidification technologies on the market in different stages of development, and two of them have come on the scene only in the last two years. If this pattern continues, there will most likely be several new processes available for consideration in the next ten years to compete with the processes that are adopted first. The need for a long-range procurement strategy to provide for timely reevaluation is apparent.

It has been possible to engineer several technologies successfully from the laboratory bench scale to a pilot plant demonstration level. This is very important, because the fact that a chemical process works in the laboratory does not mean that it will work the same way at the pilot or production levels. Evaluation of the engineering of a process at the pilot plant level is necessary for most industrial processes as they move to production level design. It is even more critical to the careful evaluation procedure of mass deacidification processes because there must be reassurance that they will work at the production level. Also, as much as possible must be known about processes — including their engineering — before committing collections for treatment.

Several technologies with pilot plant facilities have done production runs; in particular, the facility at the National Archives in Canada has extensive operational experience. The experience and data of such facilities can be very valuable in evaluating the day-to-day operations of processes in order to ascertain how they will really work in a production mode.

DIFFERENCES BETWEEN SINGLE-ITEM AND MASS TREATMENT

A great deal of important work goes on in the conservation laboratories that service rare and historically important collections. It is useful to consider the similarities and the inherent differences between the careful single-item treatment approach that has been in use for rare and unique items for the last twenty-five years and the mass treatment approach for large collections being considered in the 1990s. The similarities to be retained — and the unavoidable differences — will shape in important ways the elements of the selection decision for mass processes.

When a conservator considers a single unique paper item for chemical treatment, careful preliminary examination and testing is done to determine to what degree, if any, the paper and/or the design materials on the paper would be changed or damaged by any aspect of the proposed treatment. It is then possible to modify or change the treatment as needed. The process is meticulously controlled and the amount of risk to the item reduced to an acceptable level before proceeding. This very conservative approach, which allows safe decisions to be made for one item or small groups of similar items, is a methodology in which institutions have invested considerable time and money, because it provides a high degree of assurance that original rare and unique holdings will be well preserved. Clearly one of the challenges in approaching mass deacidification is to determine how to proceed in a similarly responsible fashion and be reasonably assured of a positive long-term outcome. Using mass processes to treat books and documents differs from single-item treatment, primarily because mass treatment is inherently more complicated.

First, the number of items to be treated at the same time will be fifty to a thousand times greater. In most research collections, thousands of volumes will have to be treated in a month in order to get the job done in several decades. For instance, if an institution wants to deacidify a collection of two million volumes in twenty years, it will need to treat about 8,300 volumes per month. The ability to exercise careful single-item control will be radically reduced, but the need to exercise a comparable degree of control will still be important to the safety of the collection.

Second, in general, it is not usually economically feasible to do single-item testing prior to mass treating a large collection because of the high numbers of items being treated. Therefore, it will not be possible to detect adverse effects of a process on each item prior to treatment and to adjust for observed problems without incurring much higher costs or reduced production levels. The need for comprehensive test data is still there, but these data will need to be collected before the process is put into use.

Third, the heterogeneous nature of the chemical compounds in most collections greatly increases the possibility of unwanted side effects. Not knowing exactly what inks, dyes, adhesives, binders, or fillers are present in any large batch of items increases the chances of physical or chemical interaction between process chemicals and the chemical materials in the book or document. These effects are unavoidable and should be minimized.

In general, compared to single-item conservation, mass processes will by their very nature lead to higher risks for the books and documents being treated. This risk will always be present and will nearly always be higher than the comparable single-item case, because in mass processes it is impossible to know everything about all the items being treated all of the time. How, then, can mass deacidification be utilized in a responsible way? The answer is, that when evaluating processes, a comprehensive body of scientific and technical information about how mass deacidification actually works in practice is required. Evaluation of this information can lower the risks to the collections during mass treatment and can protect institutions from public liability.

THE CHALLENGES OF CHOOSING MASS PROCESSES

If a library or archive is serious about moving ahead with mass deacidification technology, it must honestly explore the problems inherent in selection of one or more mass deacidification processes.

First, the nature of the decision to be made is highly technical, involving scientific and engineering expertise that is usually not available from staff in most institutions or a part of a current preservation officer's training. The majority of individuals who have had the responsibility for moving decision making forward in libraries or archives have not had either sufficient background themselves or the technical expertise in-house to be able to understand fully what was needed in order to proceed.

Second, experience in actual mass preservation operations has been limited, for many years, to actual production operations that can be observed only in Canada and in Europe. This aspect has improved somewhat in recent years with several pilot facilities in the United States.

Third, there is an aspect of the selection of any mass chemical preservation technology that has a significantly higher risk factor associated with it than do other technical decisions made in libraries and archives. For example, if a library goes about buying a new piece of computer equipment, the worst mistake is that the equipment will not work correctly, and time and money will be wasted. However, an error in judgment in selecting a mass chemical treatment technology could have an irreversible negative impact on the integrity of the very collections that require preservation and possibly on the users of these collections as well. This type of risk management understandably raises the anxiety level of most decision makers.

Fourth, there is a wide variation in the degree of development and information about existing processes, because some of them have been under study for over a decade and some for less than three years. This situation has tended to complicate the selection effort, in that all vendors may not be prepared to respond equally or even at all to the field's request for technical data about their processes. This rapid emergence of new and sometimes under-tested solutions to the acid paper problem has left many a potential user sitting on the bench still looking around the corner for the one and only ideal process that will prove to be the universal solution to the problem. This in turn has delayed selecting the best choices from the currently available group of technologies, so that libraries and archives can get on with the urgent matter of stabilizing their collections.

Fifth, extensive funding and logistical support are required for mass deacidification projects. Even though per-item cost may seem low, the large number of items and time required for mass processes involves the commitment of large sums of money over long periods of time. In addition, the long-term operational support for moving collections to and from a deacidification facility requires a high level of staffing and planning.

In summary, it would appear that lack of progress in the selection of one deacidification process or another centers around these five issues — the technical nature of the decision, limited experience with mass chemical processes, managing higher risk decisions, the variable availability of technical information, and the high, continuing funding levels required — and there may be other issues at work that are not as apparent as these. How, then, can this inertia be overcome? One solution is to develop assistance and assurance in key technical areas for potential users of these technologies, and to chart a path that goes responsibly and directly to the goal of solving problems with acid paper while taking minimal risks with the collections.

TECHNICAL EVALUATION FACTORS

The Importance of Technical Evaluation

Preservation professionals have a basic responsibility to understand as much as possible about mass processes before deciding whether they can be used to treat collections. It is up to librarians and archivists to marshal the resources to carry out this task with the care and insight that go into choosing any new preservation method. Evaluating all technical aspects of deacidification processes under consideration is central to making a responsible, low-risk decision.

The total market for deacidification services, assuming the idea catches hold, will be well over one hundred million dollars, and for-profit companies must expect to spend a substantial amount up front in order to win shares of that business. One way in which libraries and archives can simplify their evaluation task is to set out needs clearly so that the vendors of mass processes can make the effort to supply that information. As libraries and archives, we can then do our evaluations, and if some vendors and their processes cannot meet the grade, then so be it. The ones that can will get the rewards of the business, and libraries and archives will meet the goal of stabilizing their collections.

As described in this section, institutions interested in utilizing mass deacidification should collect enough information from vendors for detailed evaluation. It is the vendors' task to supply the information needed in order to be considered viable candidates for contracts and the profits that will come from good products. Responsible vendors are able to provide all the information and support needed to make this decision, because they will understand that libraries and archives do not wish to take undue risks with their most valuable resources. It would be useful for libraries and archives to supply throw-away books and documents to vendors for their testing.

Scientific data generated in laboratories or pilot plant facilities will play a key role in evaluating deacidification processes. It is absolutely necessary to obtain scientific data for evaluation because it is the only sure way to reduce performance to a measurable number and to prove or disprove any technical points. Written claims about how a given process will work are useful reading, but vendors must be required to present proof of those claims with actual laboratory data and to report how these data were obtained. Another point worth mentioning is the need to ask each vendor for technical data measured on the same basis so the results are easily comparable. For example, paper acidity can be measured by several techniques such as a flat-head electrode, hot or cold extraction, or color indicator — each of which may give somewhat different results. It would be best to ask that pH data be measured by only one technique and that this be chosen with some input from the institution's technical evaluation team (see Appendix).

For maximum safety of the collections, however, libraries and archives also should oversee a small amount of testing of treated books and documents during the evaluation period. These test materials should be in the throw-away category and be representative of the collections. This does not have to be a difficult task and can be accomplished either by contracting with an independent testing laboratory for some simple chemical tests or by having these analyses done on the campus by the chemistry department. The measurement of paper pH and alkaline reserve content and the correlation of these data with the different formats would make an interesting undergraduate chemistry major project. The use of pH indicators in this case may be helpful and less labor-intensive than hot and cold extraction methods. The measurement of the degree of enhanced stability in the paper requires more equipment and would have to go to a paper testing laboratory.

Mass deacidification processes employed by libraries and archives must be effective at removing acid from a variety of paper documents and keeping that paper acid-free for long periods of time. They must accomplish this without exposing the document to chemical or physical stress that will cause damage to the item. The vendors must have completely engineered, production-level operating facilities planned on paper, and at least operating pilot-scale facilities capable of demonstrating the process with minimum impact on the environment. Lastly, the work must be done with very low toxicological risk to persons who handle and use the treated documents. Specific technical requirements and scientific information are necessary to determine whether a process can achieve each of the above.

The Effectiveness of Deacidification Procedures

This section presents six areas for determining the effectiveness of any process as a deacidification technology and suggests scientific information that can be required in evaluation. In general, it is the responsibility of libraries and archives to specify the information they want for evaluation and test methods, while it is the responsibility of vendors to supply this information.

1. **The ability of a process to accomplish complete and permanent neutralization of strong and weak acids and acid-forming chemicals, i.e., alum, in the paper of books and documents is a required evaluation issue.** We need the paper to come through treatment without any free acid present in it in order to stop the acid attack on the cellulose. We also need to understand the details of the chemistry behind this reaction. All papers or books treated for purposes of evaluation must be done in an operating facility (minimum pilot scale) and not in a laboratory level apparatus, because the pilot facility will be more representative of the process in a production mode. The following information should be collected by the vendor in order to document the desired neutralization, and it may certainly be augmented:

- We should ask the vendor to supply a description of the process chemistry for the acid neutralization step, including all chemical equations, thermodynamic and kinetic parameters associated with these reactions, and the chemical and physical state of all products and side products produced. These statements should be supported by experimental data from the vendor's laboratory or the scientific literature.

- We will need the vendor to supply before- and after-treatment pH measurements for at least three types of well-characterized acidic test papers, either inserted every tenth page in a typical book or bound in book form of about three hundred pages. The papers should be a high groundwood pulp-content acid newsprint, a high acid-content (pH of 4 or less) mixed groundwood/sulphite sheet, and a good quality chemical pulp acid sheet. Other types of papers may also be useful. All pH measurements should be done by the same technique and accompanied by an explanation of how that measurement was done.

- We should be able to see a graph of the pH value measured at different page locations (every tenth page works well) plotted against the page location for at least one of these test books. This will show how the page pH varied from the beginning to the end of a single book.

- We should ask for data on the pH of a saturated aqueous solution of the alkaline reserve compound to show if it has a value between 6.5 and 8.5.

- A very useful but expensive experiment to require is measurement of the pH of the paper in a set of thirty or forty different untreated acid books (some should have paper in the 3.5 to 4.0 pH range) and then measurement of the after-treatment pH in that set of books. The same measurement can be repeated for another set of thirty or forty books in a completely different treatment run. The resultant data can then be plotted for each run as a distribution curve of the number of books with a given pH value against the pH scale (values 3.5 through

8.5). This analysis can give some reassuring results about a process' ability to reproducibly take a wide distribution of acid-content papers in real documents and bring them all to a narrow, deacidified alkaline pH range determined by the specific alkaline reserve compound in the paper.

2. Deposition of an adequate and uniform amount of alkaline reserve compound in the paper by a process is important in achieving the optimum enhancement of the paper's stability to aging. Once the paper has the optimal amount of alkaline reserve, there appears to be no significant advantage gained by putting in more. We should prove to ourselves that the process under evaluation can, by whatever mechanism it uses, reproducibly deposit an optimum amount of its alkaline reserve compound in the paper itself and do this in a uniform manner in all parts of the book or document. We should understand the method of deposition of the reserve compound, i.e., physical or chemical, and — if the latter — the chemistry behind the reserve formation. Moreover, we also need to address the process' ability to achieve these results simultaneously in many books or documents. Thus we will need to get data from the vendor that address the deposition mechanism, the presence of the reserve at the paper fiber-matrix level in a single sheet, and the uniformity of deposition at three levels: (1) two neighboring sheets in a book or group of documents, (2) a single volume front to back, and (3) the entire set of books or documents from different locations in a treatment chamber. Again we are requiring that all books or documents be treated by the process in a regular run of the operating or pilot facility. We will need at least the following types of information from the vendor in order to examine these issues:

- Data showing the presence and pattern of distribution of the alkaline reserve in the fiber matrix in a sheet of treated paper. The presence of the reserve compound on the surface of the fiber and inside the fiber matrix itself should be documented. The uniformity at this level may not be as important since acidic species (H+ ions) in the fibers can have a certain degree of ionic mobility depending upon the amount of water present. However, the conservative position would be to document the presence of the reserve compound in the fiber matrix and at the same time on the fiber surface because we need the reassurance that the reserve compound is there and not just on the surface of the paper. We need to keep in mind that some papers are more porous than others, and deacidification processes should deposit their alkaline reserves throughout all types of papers. Differences in deposition within the fiber matrix may become apparent between processes for more dense papers. For inorganic reserve compounds the scanning electron microscope [SEM] can be used to collect this information.

- Data showing the presence and uniformity of the alkaline reserve on a single page of a treated book Sampling probably will necessitate dividing several neighboring pages in a treated volume into quarters, one top to bottom and the other edge to spine. Analysis can be done for the amount of reserve compound in each quarter, reported as a percentage by weight of that compound in the piece of paper. The analytical technique used to measure the amount of reserve should be explained. Analysis of these data can give a picture of the uniformity of the alkaline reserve on the pages used.

- Data showing the uniformity of the alkaline reserve in a single book. We should require data from a single treated book of about 300 pages in length that shows the percentage by weight of the alkaline reserve compound measured every ten pages from the beginning to the end of the book. The data should be plotted on a graph as the percentage of alkaline reserve vs. page number.

- Data showing the uniformity of alkaline reserve in a set of volumes treated in the same run taken from different extreme chamber locations. This experiment would require a measurement of the percentage of alkaline reserve in a middle page of the book for a total of at least five books, each of which were treated in different locations of the chamber.

• Data showing the alkaline reserve level required to achieve optimum stability for each of the three test papers mentioned earlier. The experiment to collect these data requires that each type of paper evaluated be treated with a range of alkaline reserve compound using the process. Usually 0.5. 1 , 2, and 3% will suffice for the analysis. Each set of treated papers is put through the accelerated aging regime using 50% RH (relative humidity) and 90° C temperature conditions. MIT fold data are collected at each aging time. From the analysis of this information. the number of days required to get to one-half of the original fold value for each paper tested can be determined. This number is then plotted against the percentage of alkaline reserve in that paper to yield a curve that shows the effect of increasing alkaline reserve in the paper on the paper's stability for the aging conditions used. Each type of paper will have its own curve. which will usually rise to a plateau where the addition of more alkaline reserve will show little improvement in the paper's stability. It is important that the amount of alkaline reserve deposited in the paper, book or document in a production run be high enough to be on the plateau of the stability-response curve described above. If this is not the case for a given process. then paper treated by that process will not have optimum stability characteristics.

3. Deposition of a permanent alkaline reserve compound is essential for a long-lasting deacidification effect. We need to be sure of this permanence, since several processes in the past have failed because the treated paper reverted to an acid pH after a period of time. We should require the following types of information from each vendor:

• Data showing that the compound has negligible volatility at 25° C, which is at the high end of room temperature.

• Data showing that the compound does not undergo hydrolysis or spontaneous decomposition.

• Data showing how the pH of treated paper changes with time under accelerated aging conditions of heat and humidity.

4. How well is the treated paper stabilized under exposure to accelerated aging conditions of heat and humidity? This is the principal benefit in which we are investing our dollars when we buy deacidification. We should expect to see an estimated lifetime increase in the range of three to five times for treated papers with the correct amount of alkaline reserve in them. An acceptable process would demonstrate it can stabilize a variety of papers in this range. The notion that an evaluation procedure must set a minimum value on the enhancement figure is too limiting, because different papers respond differently to different processes. All test papers should be treated in a routine run of the pilot facility. We should ask for the following information from the vendor to evaluate this effect:

• Accelerated aging measurements obtained from the standardized test method used by the Library of Congress research laboratory or the paper industry (modified TAPPI test methods) to estimate how long a paper will last under conditions of controlled heat and relative humidity (RH). The primary measurement should be the MIT fold endurance of samples subjected to accelerated aging conditions. Aging can be either humid (90° C and 50% RH) or dry (100° C and < 5% RH). Although the humid exposure tends to be the most demanding, it is technically better to look at both exposures. Data should be presented by the vendor on at least three types of test papers mentioned earlier, and the alkaline reserve content should be reported for each paper tested. The TAPPI standard test methods (T-453 and T-544) for folding endurance of paper is usually modified to 0.5 kg. tension load, and at least ten replicates should be used per data point. Data should be reported graphically as the log of the average number of folds at break vs. the number of days in the oven, and 98% confidence limits should be shown for each data point.

This is a measurement that is difficult to do correctly without some experience, and it would be better for all concerned if it were done by an independent testing laboratory with some years of experience in paper testing.

5. **Is the process effective in treating different formats such as folios, boxed manuscripts, and maps?** If we want to treat parts of the collections other than books, this is a very important point to evaluate in considerable detail. The approach here is no different from what we do to reassure ourselves about how a process works on books. We need to look at data that show the alkaline reserve levels and document level deposition patterns, but we should not have to look at additional data on pH and accelerated aging because these effects will be there if the reserve is present. Those who want a quick look at pH could use the color indicator technique, where a dilute solution of chlorophenol-red is painted on the page. The yellow [acid] to purple [alkaline] color change shows the presence of alkaline pH. We will also need to readdress every large-scale treatment and logistical issue for each format, including the effect of different containers. We should ask the vendor for the following information to evaluate each format treated in a regular process run:

• Data showing the amount and distribution of alkaline reserve in a single document. For example, in a box of manuscripts this could be a sheet taken from a known location in the box and analyzed for the amount of alkaline reserve compound present in at least four sections of the sheet. These data could also be used to support some of the information needed in the following point.

• Data showing the amount and distribution of the alkaline reserve in sheets in different locations in a group of documents. For example, with boxed manuscripts we would require alkaline reserve analysis, similar to that done in the point above, on a single sheet at the front, middle, and back of the box.

• Data showing the amount and distribution of alkaline reserve between different boxes of documents in extreme treatment chamber locations. For example, with boxed manuscripts we could require analysis of a single sheet from a box at five different chamber locations.

• A plant-level treatment run using the library's or archives' boxes for the different formats in order to evaluate whether the process can effectively treat the documents in their existing containers.

6. Information on a proposed quality-assurance program is essential to evaluating a proposal to treat our collections. We should understand that for any process done on a day-to-day basis, there will be some variation in the results of the treatment. In addition, there could be a major variation in the treatment due to unforeseen circumstances that would produce an out-of-specification batch. It is important to monitor this variation against some acceptable standards of expected quality of treatment that we, the customer, set and the vendor tries to meet. A quality control program attempts to do this routine monitoring of the product's quality. We should ask the vendor to produce the following information:

• A design for a quality control program that would measure important characteristics of a batch of treated materials. *This procedure must take into account the fact that no chemical or physical testing can be done on collection materials and that results would have to be available within several hours of processing treatment in order to be able to release treated materials for shipment.* The use of surrogate test books and documents, which need to be designed by the institution, is recommended.

• The vendor's plan for how the analytical work for quality control would be accomplished. For example, would a facility be set up at the plant or would the samples be sent out to a service laboratory? How would this test laboratory be staffed? How would the data be reviewed prior to return shipment? Will the library or archive want to review data or double-check quality control every two or three months?

• The vendor's plan for how it would deal with batches of treated materials that do not meet specifications.

Unwanted Changes

This section discusses the types of interaction that the chemistry and/or the engineering of the process may have that could cause unwanted changes in the materials found in library and archival books and documents. It is highly probable that most mass processes will cause some observable changes in the materials they treat. This is to be expected for reasons mentioned earlier, but we need to understand just what the changes are and the magnitude of their effect. On the one hand, several small negative cosmetic effects may be quite an acceptable trade-off when we consider all the positive merits of the total treatment. On the other hand, some negative effects may not be acceptable and may become a basis for grading one process over another. It is the vendors' responsibility to do the testing discussed below and to submit the results to the potential customer. The library or archive may want to require additional testing on certain types of materials, and should be willing to give the vendors representative materials to treat.

1. **Chemical compatibility with materials commonly used in the manufacture of paper, covers, and bindings of books and other documents needs to be investigated.** These effects may be studied using laboratory apparatus as well as plant-treated materials, as long as the chemicals and the conditions are the same. The technical advisory group should be brought in on this decision to identify what materials should be exposed to a process'chemistry and which analytical techniques are recommended to follow any changes. The following materials would represent a minimum set for such an evaluation: cellulose, lignin, gelatin, starch, polyvinyl acetate, polyvinyl alcohol, polyethylene, polypropylene, nitrocellulose, and optical brighteners. Several of the analytical techniques that have been used in the past include. Fourier transform infrared (FTIR) spectroscopy, x-ray fluorescence (XRF), blue reflectance, molecular weight by viscosity, and magic angle nuclear magnetic resonance. These techniques measure fundamental properties of the material under study and allow before- and after-exposure comparisons in order to detect changes. Other techniques may also be applicable.

2. **Compatibility with materials such as inks, dyes, and colorants used to put text, designs, or other information on library or archival materials should be examined.** These effects can also be studied in a laboratory, although it would also be useful to run standard colors through the plant if this were feasible. We should require data from vendors that show to what degree the color or dye in question changes as a result of going through the treatment process. Controls of untreated material will be needed for comparison. There are a number of analytical approaches to measuring color change. The technical advisory group should consider which method to require and which colors, dyes, and inks to put on the list for testing. A number of colors used in fine arts materials have been identified in the museum conservation field, and these as well as modern color printing and writing inks need to be investigated.

3. **The effect of the process on the brightness of the papers used in library documents can be easily measured using the standard blue reflectance test.** We should require data obtained by this test on several test papers to tell us if the papers' normal loss of optical properties is markedly changed by the treatment. Keep in mind that the appearance of papers does change when they are aged and that what we are looking for here is additional effects. The treated and control papers are aged in the oven under standard conditions of temperature and humidity for periods of up to 40 to 60 days. Samples are pulled every few days and their reflectance measured. Reflectance measurement data are plotted on a graph for the treated and the control sample versus days in the oven.

4. The effect of the process on the degree of photosensitivity of the treated paper needs to be evaluated. The compounds used as alkaline reserves in deacidification processes have the potential to change the sensitivity of cellulose in paper to high-energy ultraviolet (UV) radiation. Because cellulose in paper is rather sensitive to ultraviolet radiation, we have gone to considerable lengths to shield our paper documents from high levels of this harmful radiation. Thus, most documents are not exposed to high levels of UV in libraries and archives, and we might question why we should be concerned about this effect. The reason is that the overall safety of the collections is important and we must know if the UV stability of the paper is greatly affected by treatment so we can be especially careful in exhibit situations where UV radiation can be a problem.

We should require data that characterize this effect for several test papers, one of which has a high degree of good cellulose. We need to require two experiments. The first involves exposing treated paper and untreated controls to a measured amount of UV radiation for a period of time under fixed conditions of humidity and temperature. These samples are then tested for fold endurance and the fold values plotted as a function of hours of UV exposure. In addition, the second experiment would involve taking the UV-exposed paper samples and subjecting them to additional humid aging conditions [90° C, 50% RH]. These papers would be tested for their fold endurance at different oven times and plotted in the normal way. Analysis of these data will tell if the process has an effect on the photodegradation of cellulose in these papers.

5. The strength of the paper should not be weakened significantly by the treatment. The effect of the process on the initial strength of the paper can be measured by comparing the average MIT fold value of treated vs. untreated control before the samples are aged. Since these data are normally collected in accelerated aging experiments, we should ask vendors to supply the zero exposure time fold values for several types of paper that were treated by the production level process, including the untreated controls.

6. The effect of a process on book cover materials in terms of any chemical or physical effect on the thin polymeric cover layer needs to be observed for a variety of different book cover materials. In addition, the effect of the process on leather should also be observed. The way to do this is to systematically select representative samples of covers and put them through the production process while retaining a section of untreated cover for comparison. There may be some correlation with these observations and those done on more pure materials under the compatibility testing. It is unlikely that any process will be 100% benign to all cover materials. The expectation is that some interaction will be observed with a small percentage of covers because of the large variation in cover materials from various parts of the world. The issue to be addressed in the evaluation is what can we live with and what constitutes a need for cover replacement and its extra cost. The latter can become a factor in grading one process lower than another.

7. What cosmetic changes in the document can be observed after treatment? This is an area of evaluation that requires direct observation of treated books and documents that we have selected to go through a process. It is different but related to the observations in the last section and most likely can be done concurrently. The changes that might occur will be less dramatic and may not constitute actual material damage to the document. Nevertheless, these changes need to be identified and considered, because they may cause problems in the future. Examples could be the deposition of colored materials on the surfaces of the cover or on a page in the text block, distortion of the boards, a change in the flexibility of the binding, and the cockling of large paper documents due to loss of water. We will probably observe some of these effects for most processes, and this is to be expected, considering their chemistry and engineering. We must evaluate these effects to determine whether or not they are something to be concerned about. For example, some dimensional changes can be reversible on storage as water is readsorbed. It would be useful to require vendors to disclose what they know in this regard, as well as to do observations on a range of materials that we submit for treatment.

8. Does the process impart a significant level of new odor to the treated document? All books and documents have a distinctive odor of their own. We have all noticed this when we walk into the stacks and smell that nice old book odor we associate with a library. It is not particularly objectionable because we are used to it. The smell of our old book friends in the stacks comes from very, very small amounts of chemicals that are constantly evaporating from the paper and inks, and our noses are so sensitive that we can detect them. Deacidification processes involve the use of many chemicals and the formation of other chemical compounds that can impart a variety of new odors to treated paper. This issue may seem relatively minor when we consider one document, but think about ten thousand treated books coming back into poorly ventilated stack areas each week or month. In this context a significant off-gassing of any mildly objectionable odor will be a big problem. We must be sure that any process that we use does not leave an odor-generating compound in the paper that will cause an odor problem in the library or archives when the books return. Many odors can be dissipated in a relatively short period of time under the right conditions, so most problems should be solvable before the books or documents leave the treatment facility. A good approach to evaluating odor in a treated document is to have an "odor panel" of three or four persons who sniff the item in question and rank the odor on a preset scale against a control.

9. What are the effects of the process on microfiche (silver and diazo) and on photographic prints? We need to observe these effects because these materials often are placed in books and in manuscript collections. This can easily be accomplished by giving vendors some examples of each and asking that they be run through the process. Visual inspection of the treated sample in comparison with a similar untreated control will tell if there is a problem. Before and after density readings on the fiche may be useful.

10. Does any aspect of the treatment process impose any pretesting or preselection of documents? These extra steps can affect the work flow in such a way as to increase costs and/or limit production. We need to analyze carefully what is imposed just by the process prior to treatment, whether this is either preselection alone or preselection followed by pretesting. Preselection involves an item-level decision that will remove or identify specific items from the shelf before that group of materials is sent for deacidification. This step is needed when we know in advance that an item requires special handling to be treated or may not be able to be treated at all. Preselection and pretesting require item-level selection followed by a specific test procedure, usually, to tell if the item can go through the process or not. The latter can be labor intensive and costly for large deacidification programs, while for small programs pretesting is not as limiting. It is reasonable to expect that a certain amount of preselection or pretesting will be required for any process and simply represents a cost element to be evaluated. We should require a vendor to disclose all known process-driven preselection and pretesting requirements, so that we can use this information in the evaluation.

Process Engineering

Because of their relatively recent development, most mass deacidification operations are not yet standardized, as are other preservation techniques such as microfilming. In nearly all cases, mass deacidification is conducted at this time in a pilot — rather than full production — stage. But libraries and archives are contracting for a full production capability, rather than a pilot project.

Taking a chemical process from the laboratory stage to an operational pilot plant and then to a production-level facility is a relatively complicated and expensive task, but one that is done many times by the chemical industry every year. The know how to do this exists for any deacidification process that has been invented to date. Such an effort, of course, takes development capital, and it is the responsibility of the company selling the process to make this investment.

We should be evaluating a process based on at least its engineering design at the pilot-plant level and, better yet, at the production plant level. Although this area of evaluation is probably the least understood by libraries and archives, it is nevertheless in our best interests to ask vendors about their process engineering for two reasons. The first relates directly to the safety of the collections that will be exposed to the pressures, temperatures, mechanical movement and other potential hazards generated by the treatment equipment. A careful preservation approach to the selection of any process to treat our most valuable resources requires that we fully understand what is happening and what could happen to our property when it is being treated. The preservation community has always maintained this level of knowledge about other treatment approaches, and we must insist on it with mass deacidification because the risks are greater.

The second reason is related to the library and archival fields' need to protect themselves in the procurement of long-term and expensive service contracts. The bottom line is that we must make a reasonable independent judgment that companies offering mass processes at a production level really have done the requisite engineering and have actual plans for constructing facilities that will support their ability to offer us continuing production-level mass deacidification services. If vendors have done their homework, this will be obvious in a day or two of review with their engineers. The effort spent in evaluating the engineering will add a dimension of reality to the evaluation process with many benefits down the line, when our ability to produce results will be very dependent on vendors' abilities to build and operate treatment facilities.

By doing this, we minimize our risks about whether processes will really work at the production level, and we see how serious vendors are in putting up facilities that will produce the treatment volume we need. We need several pieces of information in order to evaluate process engineering, and we should be willing to maintain the confidential nature of this information.

1. **We should look at the full engineering design package for an operating facility at a specified level of production.** This would include design information in enough detail to allow for an evaluation of its feasibility, safety, suitability for treating books and documents, and construction. The institution's technical evaluation team, which should include a chemical engineer, can set out more detailed requirements for this part of the evaluation. The requirements should include, at a minimum, the following:

- A process description, including temperature and pressure profiles and a basis for the design scale-up to a production facility.

- A safety review of the facility design using HAZOP — a standard chemical inventory safety review approach — or an equivalent procedure and a worst-case process failure analysis.

- Layouts of shipping, receiving, and document storage facilities including environmental control levels.

- Detailed drawings of materials-handling devices for books and any other formats we want to treat.

2. **We should require an operational run of the pilot or production facility,** in which the technical evaluation team would be present to observe the process work. Attention should be paid to the procedures for storing and handling the books and to how the process is controlled with respect to book temperature and any physical stresses on the books or documents.

Extra Benefits

Mass deacidification processes usually differ from each other in terms of their chemistry and in the engineering approaches used to get the active chemical agent into the paper. These differences can lead to extra benefits for a specific process that the others may or may not share. Most vendors will make a variety of claims about what their process can do. This is to be expected, and these claims should be accompanied by a complete set of scientific data that will support them. We also need to satisfy ourselves that these benefits will be useful to our own preservation programs.

We need to be realistic about adding extra technical benefits to the process requirements. Just because one process has a useful extra benefit due to its specific chemistry doesn't mean that it is realistic to require that same benefit of all other processes before they can be considered. Additional technical benefits, no matter how attractive they may seem at first glance, cannot always be added to another chemical system without complicating the situation and possibly losing something in return.

The extra benefits usually fall into two general categories: 1) specific technical effects such as mold control, insecticidal activity, paper strengthening, and inhibition of oxidative degradation, and 2) handling or processing advantages that will make the task easier and possibly less costly. To assign proper significance to them, we should know as much about these extra benefits as we know about the principal parts of the process. In some cases, such as strengthening of paper, considerable thought will need to be given to the approach to evaluating technical performance, because there is no general understanding in the field about what is needed.

This brings us to the question of what should we ask for in evaluating a process that claims to have extra benefits. First, we should handle technical benefits just like any other technical issue and require scientific data that support the claim. Second, a cost-benefit analysis should be used to evaluate an extra benefit that makes the process more costly. Third, with claims of handling or processing advantages we will need some documentation to back up the specific claim. This documentation could be based on visual observation at an operating facility using a trial run of throw away materials. In any case, we should take the time to actually see it work.

Toxicity

It is very important to have toxicological information on processes, because we must be assured from a socially-responsible viewpoint that the chemicals used do not represent a health risk to workers in the plant, and from our own institution's moral and legal standpoint that the residues left in the books as an alkaline reserve present a low toxicity risk to persons who handle and use the treated documents The amount of chemical deposited in a single book may be small, but when a large collection is treated, many tens of thousands of pounds of the alkaline reserve compound will be stored inside the books. Depending on its nature, this compound could become airborne and enter the body through the nose; it could be transmitted by the fingers to sensitive skin areas and to the eyes, and it could enter the body through the mouth. There will be a reluctance on the part of some vendors to supply toxicity information because if the research is not in the literature it will be time-consuming and costly to obtain. However, the bottom line is that we must not, under any circumstances, go forward with large-scale treatment of a collection until the toxicity risks are adequately understood. The long-term legal and moral issues are significant, and the library and archival field should not expose itself unduly in this arena when some time and research will give us the answers to move forward with minimal risk. The public view on toxicity issues in the 1980s was one of more and more concern for the responsible use of chemicals, and we can expect these views to be even stronger in the 1990s. A review should be done of existing OSHA and EPA guidelines on chemicals that remain in the documents.

The type of toxicity testing information that we should be looking for will at a minimum include animal exposure studies on acute oral toxicity, dermal irritation, and eye irritation; it will also address issues involving the inhalation of particulates or evaporating chemicals and the effect that these materials could have on the body functions of humans. The advice of a professional toxicology consultant should be sought in deciding on exactly what to require; however, the body function studies could include the operation of lung and pulmonary diseases; kinetic distribution studies, male and female reproductive toxicology; multi-generation genetic effects; immune system effects; and acute, sub-chronic, and chronic carcinogenic studies. These studies are usually done on specially bred test animals, like the Fisher 544 rat, and it takes at least a year to complete the short-term work and up to thirty months to complete the chronic investigations. For some chemical compounds these studies may already be in the literature; for others they will need to be done. The interpretation of the results of any toxicity studies will require the assistance of a professional toxicologist who specializes in risk-assessment analysis.

Potential toxicity effects in libraries and archives should be focused on the alkaline reserve compound and to what extent it is coming out of the treated paper. The amount of this compound coming off the paper — when the book is being used by a reader (i.e., turning the pages) and when the book is sitting on the shelves in the stack areas — needs to be measured. The use and storage situations can be simulated in the laboratory and the appropriate data collected. This latter information can then be correlated with the toxicity testing done on animals to determine the extent of toxicological risk to which an employee or user is exposed. We should be thinking primarily about the long-term exposure issue, because some staff who work with the books throughout their careers, i.e., for three to four decades, will be exposed to some amount of the alkaline reserve chemical left in the paper. We want to be able to demonstrate that their level of exposure to the chemical in the paper is very low and that careful laboratory studies have shown that exposure at this level in test animals represents no significant risk to their health.

Environmental Impact

It is socially responsible for the library and archival field to choose deacidification technologies that will not pollute the environment with undesirable chemicals. In addition, it is also to our advantage to use technologies that will not be restricted in the future by obvious trends in environmental legislation or by current federal and state environmental laws. If plants cannot be operated because of environmental pollution problems, we certainly will not get our books treated. Vendors should be required to submit an environmental assessment of the process, most probably a report by an independent engineer that would identify the waste products and describe the disposal and treatment of these wastes in order to meet the latest federal, state and local standards. In addition, an environmental risk assessment should be required for the location of the production facility. This document is more complicated and costly and may have to be submitted at a later date, but in any case it should be made available as soon as possible and prior to any final commitment to use a process.

OTHER EVALUATION FACTORS

Unit Treatment Costs

The cost of deacidifying a book has been projected for several processes over the last five years at between $3.50 and $5.00. This number does not usually include the cost of handling the materials in the institution or transporting them to and from the treatment facility, and the factor of profit for a deacidification contractor has not been carefully explored. It is likely that, when all is said and done, a more realistic unit cost in 1991 or 1992 dollars will fall between $5 and $10. Cost obviously enters into the choice of one process over another, and it is important to understand how the unit cost is calculated. We should require vendors to submit unit cost calculations that clearly separate their operating costs from their profit and to provide detail on the operating costs. The reason for this is that we need to have a complete understanding of how all charges are arrived at and what factors will affect those costs. The calculation should be prepared for at least two levels of treatment load that correspond to the minimum and the maximum number of items that would be sent in a given year. Book handling costs need to be estimated and built into the basic treatment cost. in order to see the real total cost for using a specific process.

Book and Document Security

Security issues need to be addressed at the treatment facility and, if need be, in the transportation of materials from the institution to the facility and back. The responsibility for security at the facility will normally be with the vendor for large off-site operations. Responsibility for security during transit may rest with either the institution or the vendor. Whatever the case for a specific program, we should ask the vendors to submit plans for how they would address security at their facility and, if needed, during transit. This should include both plans for perimeter security and special security procedures for materials of high value or at risk for theft. An institution needs to decide what handling restrictions it wants to impose on vendors and give them this information so their security plans can take it into account. For example, direct handling of books and documents by vendor personnel at a treatment facility could be off limits. The plans submitted should become the basis for another aspect of the complete evaluation of a process proposal.

Logistical Considerations

As we start to plan the details of mass deacidification programs, we rapidly begin to see the critical importance of moving thousands of items efficiently in relatively short periods of time. Decisions that seem simple to implement in the abstract can cause significant delays and higher costs in getting materials ready for shipment to a treatment facility and eventually back into the stacks.

Materials handling requirements that are imposed by treatment processes must be completely disclosed by vendors and the impact of these requirements on the deacidification program evaluated. For example, the containers that the books or documents are stored in during shipment and treatment are very important because labor will be involved in getting the items into and out of those containers. How much time is required to load a container, who will do this, where will it be done, who will pay for this labor, are the books safe in the containers — these are all questions that must be addressed and that should become factors in the evaluation of a group of processes.

The extension of the above arguments to formats other than books is very important if we plan to treat other types of materials. It will be necessary to study the procedures and packing requirements for boxes of manuscripts, maps, or folios in order to evaluate how processes will handle these materials.

Long-term Vendor Performance

This issue must be considered because all vendors are not equal in their ability to follow through on completing a project for which they may submit a proposal. Here we are trying to protect ourselves from the difficult case of a defaulting vendor and the substantial time and dollars wasted in terminating a contract and moving on to another vendor. We should evaluate this aspect up-front in the process by having a separate, non-technical part of the procedure. Vendors can submit information on how they would manage and finance the long-term effort (1-5 years) of supplying the deacidification service, along with information on the financial stability and management of their companies. This information would become a part of the total evaluation.

Long-term Contracting

Libraries and archives are most likely to buy deacidification services for periods exceeding ten years and probably for upwards of twenty years. We need to think about the implications of this period of time in an approach to choosing and contracting for these services, so that acceptable processes will always be there for preservation programs. What if a first contractor goes out of business? How will we bring along other processes or other vendors to operate the same process? How will we make allowances for new deacidification technology developments that may replace the current processes in the follow-on contracts? Answers to these questions can have an impact on the evaluation and selection of initial deacidification service vendors. For example, it may be wiser to have two vendors with the same or different acceptable processes in order to maximize chances of keeping the program going in the long run at competitive pricing. What if we see a very promising process during the evaluation/selection procedure, but the process is not developed well enough to compete effectively this time around? Do we reject this process outright and discourage further work, or do we find a way to encourage its further development so we can keep as many options open in the future as possible? Some time spent on discussing these types of issues in the beginning of a program will pay dividends later.

Observation of Facility Operation

There is nothing like seeing a process work with our own eyes. We should take the time to have our technical evaluation team visit treatment facilities and watch how they work on various formats that we supply. Observe how the books and documents are loaded and how they look when they come out of the treatment chambers. Watch how the crews operate the facilities. Are the operating procedures in printed manuals and are they followed? Are plant safety procedures visibly posted and followed? A great deal can be learned about processes when we see them used to treat some of our own materials, and this knowledge can build confidence in the processes or raise questions that need to be answered. In all cases we must see processes work on at least a pilot scale, and this event should be a required part of the evaluation procedure.

Liability

As we get closer to signing a contract, the lawyers will start to become involved in the "legal boiler plate," which will raise the issue of who is liable for the materials being deacidified. Vendor company lawyers will attempt to free companies from any liability for the collections when they are being treated in order to eliminate the possibility of future litigation or at least to decrease their exposure. The latter option may take the form of a limit on the dollar amount they will be liable for in any suit brought by the library or archives for damaging its property. This in turn may limit the number of items they will want to treat at the same time or for that matter treat at all. Clearly this issue should be moved forward into the evaluation area and not left to be negotiated afterwards, when it could easily cause us to want to find different vendors.

Marginal Treatment Performance

No mass treatment process will perfectly treat all materials that we want to deacidify. There will be a small percentage of books and documents that cannot be successfully treated for one reason or another. As part of the evaluation procedure we should look at the cost of trade-offs surrounding those items that will have to be treated by another approach. Vendors should be required to disclose known areas of difficult treatment. This type of analysis could become an additional factor for ranking one process over another.

IN CONCLUSION

For all who are involved in planning for mass deacidification, a basic understanding of the responsibilities and roles of their institution — and the responsibilities of the vendors — is essential. Key decision makers also need to know the basic chemistry and scientific principles that underlie mass deacidification processes and the tests that should be performed to assure scientific validity. Even with a solid comprehension of the technical and other evaluation factors that need to be considered, decision makers may continue to wonder if their institution will be able to move along this multi-faceted decision path. The answer to this question should be a confident "yes" — coupled with the realization that time, effort and funds will be required to do the job.

As it turns out, the decision-making process is no different from that used previously for choices of automated systems, building designs, or retrospective conversion projects: Gather available relevant information, analyze that information, and make the best possible decision based on that information. Although no existing or future mass process will be perfect, it is entirely possible to look carefully at the merits and drawbacks of each process and make an informed decision with all the facts in hand. If decision makers assemble a useful body of data and test results, pull together a knowledgeable technical evaluation team, and follow a logical evaluation procedure, they will be able to identify a choice — or as is most likely — several choices.

As stated in the introduction, the guidance provided in this paper has evolved from a scientific stance advocating the most conservative path to making decisions and giving the safety of the collections the highest priority. Final decisions regarding the use of mass deacidification remain with those institutions that serve as the caretakers for the collections requiring preservation.

APPENDIX
ORGANIZATIONAL AND PLANNING CONSIDERATIONS

This paper is concerned primarily with technical evaluation. However, as an institution evaluates five or more highly technical mass chemical treatment processes, it also will be engaged in a number of other activities to prepare for sustaining a mass preservation program for at least a decade. The following organizational and planning considerations are mentioned to call attention to their primary importance to the total mass deacidification effort. Other resources should be contacted for more information and specific guidance in each of these areas. For example, the Association of Research Libraries is publishing a paper by Karen Turko (July 1990) that discusses the management decisions that have to be taken in terms of collection evaluation, selection of materials, materials handling, and financial issues.

- **Obtain commitment from many levels of the institution** to the mass deacidification program — essential because of the program's size and duration. Ideally, this commitment will run from the top to the bottom of the organization, since many areas of operations will be affected. It is not unlike the commitments made many years ago to do long-term microfilming projects, but the impact on reader services and collections management personnel for those collections receiving mass treatment will be greater.
- **Identify sources of funding** for the program well in advance. It is very likely that more funds will be needed in the first two or three years of operation: Contractual commitments to get the work done in the beginning may have to span several years in order to enable vendors to begin offering the service on a truly low-cost, production basis. This aspect should improve as the service side of this industry becomes more mature with many institutions buying the service.
- **Plan and implement a well-coordinated public information program** about the mass deacidification program. Define all groups affected directly by the program as well as those who should be informed for political or professional reasons.
- **Decide how to select collections** for deacidification, and the order in which collections will be treated. The decision whether to treat all new acquisitions before shelving also can be addressed as a part of this task.
- **Consider the impact of the deacidification program** on regular operations and plan how to minimize these impacts. The monthly movement of thousands of books and documents can have a major effect on staff and users. Plan to give employees and users advance notice when collections will move and when they will return.
- **Determine the possibilities to optimize ongoing preservation activities.** Take advantage of opportunities created when large segments of the collection are examined prior to treatment and when materials come back into the institution afterward. Would it make sense, for example, to complete all rebinding of a class of the book collection before it is treated? What about relabeling, identification of brittle paper, and minor repairs?
- **Decide what to do about the brittle materials** in collections chosen for deacidification. This is a very practical decision that can augment a filming program (if the numbers are not too high) and save considerable reshelving expense. Weak papers do not receive nearly as much benefit from deacidification as do stronger papers. The trade-offs here are the cost of treatment for some level of benefit and the cost of reshelving the volume if it is left on the shelf. It would be wise to remove all "basket case" brittle paper before deacidification, because it will probably be damaged by handling and other physical stress.

- **Develop a well-defined set of performance requirements** for the mass deacidification program. Such requirements are needed in procurements of the size being contemplated, i.e., a large portion of a research collection. These requirements should reflect what is wanted from processes to treat the collections and should allow only processes that can deliver the wanted elements to be considered for further evaluation. Going through this exercise for the collection will help the institution understand what it wants from a process and will make the selection more straightforward. Involving a knowledgeable purchasing officer at the beginning will make things go more smoothly at the end.

- **Evaluate logistical support facilities and materials handling capabilities.** Moving thousands of books and other materials to external or internal treatment centers will require staff, elevators, staging areas, and secure loading dock space. In addition, the number of book trucks for moving volumes or boxes of items from collection areas should be determined and enough made available to support the project. Additional staffing needs must also be considered.

- **Start early to plan for a technical and scientific evaluation team**, because this group can be of great assistance in deciding on approaches to collecting information as well as evaluating the technical merit of that information. Useful advice can come from a paper chemist or physical-organic chemist with a background in stabilization of cellulose and the testing of paper, as well as a chemical engineer who has specialized in process design and the practical aspects of building and operating production units. A scientist who specializes in toxicology of materials also will be useful. Although there are only a limited number of scientists who have preservation experience, there are many persons located in universities and industrial laboratories who could be of assistance.