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MASS DEACIDIFICATION OF LIBRARY COLLECTIONS IN THE CZECH REPUBLIC

Abstract. Authors provide detailed information about the process of preparing books for mass deacidification of library collections in the National Library of the Czech Republic, as well as in other institutions of the Czech Republic. We present the basic principles of deacidification and the requirements for the ideal method of mass deacidification of books. This includes the selection of mass deacidification technology, the preparation of books for deacidification, the methods of testing the quality of deacidification, checking after deacidification, etc. The article is supplemented by a clear diagram of the workflow used for the implementation of mass deacidification of library collections and a list of literature on the topic.

1. Introduction

One of the greatest problems threatening the permanent preservation of modern library collections¹ is the deterioration of the physical paper media. This is caused by the acidity of the paper, which on the basis of a mechanism of hydrolytic reactions in an acidic environment - acid hydrolysis - causes the paper to decay. These degrading reactions threaten the cultural heritage of our country, which is a valuable witness of the period of cultural and national identity building, has incalculable historical, social and artistic value, and contains a wealth of information. Unfortunately, their long-term preservation is greatly affected by their often poor physical condition, as many of them are printed on woody paper causing them to decay (Figs. 1 and 2). The issue is summed up in a quote by *André Malraux*: “*Whoever wants to read the future, must browse the past.*”

The National Library of the Czech Republic (NL CR) administers more than seven million library units, of which approximately 96% represent so-called modern collections, which include books published after 1800. Materials based on cellulose, which is the basic building block of paper fibers, are stable in the neutral to slightly alkaline region. Between 1845 and 1850, the increasing demand for book production led to significant changes in the raw materials used (wood pulp) and in the technology of paper production, leading to significant changes in the chemical structure of the paper and a decrease in its durability due to natural ageing. Paper produced in this way is prone to disintegration due to the formation of acidic substances. Acid hydrolysis breaks

¹In National Library of the Czech Republic collections created after 1800. Books produced after the middle of the 19th century are more problematic in terms of paper acidity. After 1845, there was a fundamental change in the technology of paper production and also a change in the raw materials for paper production. As a result, an internal degradation factor emerged due to the use of pulp with a high content of woody substances. Paper and information carriers produced in this way are doomed to disintegrate due to the acidic substances produced. Acid hydrolysis causes the break down of the macromolecules of cellulose, resulting in the paper losing its mechanical properties - it sometimes falls apart into small pieces. This process can be slowed down by preventive and invasive interventions, but it is necessary to intervene early, while the paper still has some mechanical properties.

down the macromolecules of cellulose, resulting in the paper losing its mechanical properties - it sometimes falls apart into small pieces. This process can be slowed down by preventive and invasive interventions, but it is necessary to intervene early, while the paper still has some mechanical properties. At the same time, the life of paper is affected by a number of degradation factors. These are mainly external factors, including environmental temperature, relative humidity, impurities contained in the environment (e.g. dust particles, air pollutants such as sulphur and nitrogen oxides, ozone ...), light, biological pests (moulds, bacteria, insects), etc. By neutralising the acidic components in the paper - by deacidification and, at the same time, creating an alkaline reserve - the life of the paper can be extended, the decay of the paper can be delayed and the original can be preserved for future generations in good physical condition as a source of information. Due to the huge amount of acidic materials, it is necessary to choose mass deacidification methods. Individually, this amount and volume cannot be handled, and financially, it would be many times more expensive. The National Library of the Czech Republic has been searching for and testing suitable methods of mass deacidification of books and bound periodicals for many years. A survey of the physical condition of the books reveals that a “time bomb” is ticking in the collections. Moreover, many of the books are already at the point of disintegration, with the process is irreversible. In other words, nothing can be done to save the original.



Figure 1. Example of paper decay in library collections due to acid hydrolysis.



Figure 2. Example of the decomposition of newsprint due to acid hydrolysis.

2. The principles of book deacidification

Deacidification technology is an important mass preservation technology that extends the life of paper specimens. It is a well-mapped method of saving library collections threatened by acid hydrolysis. The deacidification process is a chemical treatment process for paper materials. These are technical and technological procedures aimed at eliminating the actual cause of paper degradation or acidity. The acidic substances present in the paper are neutralised or deactivated². By neutralising the acids, their catalytic effect of degradation (as a result of acid hydrolysis) is cancelled and the degradation process of the paper is stopped or at least significantly slowed down or delayed. At the same time, due to mass technology, an “alkaline reserve” in the form of organic compounds (carbonates) containing calcium or magnesium is introduced into the paper. This alkaline reserve creates a “buffer” for the future by neutralising acids formed in the paper as a result of natural ageing, airborne pollutants (sulphur and nitrogen oxides and other degradation products) or absorbed from the external environment. Acid neutralisation is performed using a de-acidifying (neutralising) agent and a carrier medium that introduces the de-acidifying agent into the paper, making the paper more chemically stable and slowing or even stopping paper degradation.

3. Survey of the physical condition of library collections

A systematic survey of the library collections has been developed, the results of which are an overview and description of the actual physical condition of individual specimens. Based on the results of such a detailed survey, it is possible to evaluate the types of damage, diagnose their causes and propose possible solutions (repairs, conservation and restoration interventions, storage in protective packaging, deacidification, reformatting). The Department for the Protection of Library Collections annually presents this database as part of its methodological activities. It also trains the staff of those libraries that acquire this database in how to work with electronic forms, but above all, how to conduct a survey of the physical condition of library specimens. Training focused on the description of book bindings according to current terminology, documentation, measurement and evaluation of the physical condition of individual parts (covers, binding elements, appendices, etc.) and the materials themselves is also provided to applicants from institutions using other systems and databases. *Agenda* users are provided with a consultation service, which includes recommendations on the purchase of the necessary equipment from reputable manufacturers. The aforementioned database is not only a suitable tool for the effective selection of specimens for the preservation method of mass de-acidification, but it is also directly linked to another tool developed by the National Library of the Czech Republic, namely the Register of De-acidified Documents. The publicly accessible web interface of the Register of De-acidified Documents (hereinafter referred to as the “Register”) enables library documents to be searched, so that effective planning of the care of library collections can be organised, as well as to make the selection of library items for mass deacidification simpler. The user has the possibility to check whether the selected library units have not yet been de-acidified and whether they can therefore be included in the application for subsidies from the VISK program “Deacidification of library units

² Free acids present in paper.

of which paper acidity has been confirmed by measurement”³ run by the Ministry of Culture of the Czech Republic. The basic data on library units are either obtained from the aforementioned *Agenda*, which stores information from the survey on the physical condition of library units in the collections of cooperating libraries, or in another form of supplied data. In addition to paper acidity values, the Register provides a wide range of information on the physical condition of library collections in the Czech Republic. Filtered records are displayed both in text form and in the form of graphs and timelines. Record filters can be combined and records sorted according to user needs.

So far, this issue has been addressed within the VISK 7 program ("National Program for the Preservation and Digitization of Documents Endangered by Acid Paper Degradation - Kramerius"), which includes activities related to the preservation and accessibility of bohemian documents printed on acid paper, whose existence is threatened by the decay (embrittlement) of the paper carrier. Protective reformatting of endangered periodicals and monographs according to the standards and formats used by the National Digital Library has been underway since 2013. Archival digital copies remain in the possession of the institutions, with access copies deposited in the Kramerius National Digital Library⁴. The Digitization Register is used to keep track of digitized documents. In standard mode, two software tools are available to streamline the selection of documents for deacidification and to help build the knowledge base of de-acidified documents: Collection Survey and Register of De-acidified Document applications, which are linked to each other. Documents for deacidification are selected on the basis of their critical state or low pH value.

4. Preparing books for mass deacidification

The process of preparing large volumes of endangered books for deacidification technology is not simple. The preparation of the books involves many activities, including checking the physical condition of the selected volumes and possible adjustment in the electronic database, checking and supplementing their records in the electronic catalogue of the National Library of the Czech Republic to the level of processed units, selecting and physically handling volumes from the respective depositories, initial measurement of the physical and chemical properties of the books (especially the pH values of the paper), recording these data in tools used to record examined and de-acidified volumes - the *Register of De-acidified Documents* and the *CZBRD Survey of Modern Collections* database, preparing individual volumes for transport to deacidification workplaces, preparing lists and processing exit permits, and many other professional activities. An integral part of the implementation of such a large project includes the responsibility for organising the procurement of a suitable supplier and technology through a public tender, which must be carried out in accordance with applicable legislation and all internal organisational prerequisites for its successful implementation. The whole process of preparing a book for deacidification and the flow of each specimen from the shelf, through the technology and back to the shelf in the depository in the workflow diagram (see Fig. 3). The phases in the preparation and subsequent checking of books can be summarised as follows:

1. Selection from the database
2. Dispatch to the preparation site

³ Public library information services and subsidy program of the Ministry of Culture of the Czech Republic.

⁴ <https://kramerius5.nkp.cz>

3. Checking the books before the process and placing them in cages (see Fig. 4)
4. Transfer to technology
5. Deacidification and conditioning
6. Transport to the NL CR
7. Check after de-acidification
8. Return to the depository

At the same time, a methodology entitled “*Preparation of Modern Library Collections for Mass Deacidification and Quality Control of Deacidification - Selection Criteria and Processing*” has been certified and published for this purpose. The methodology describes in detail the selection of technology for a given library collection, the procedure for processing library collections, and recommends criteria for selecting books suitable for mass deacidification of library or archive collections. It also describes the exact procedure for the preparation and subsequent quality control after deacidification of the books. In this way, everyone who carries out the process does it in a consistent and homogeneous manner and the data and information can then be entered into the *Register of De-acidified Documents*. This process includes research and photographic documentation of the findings and recording of de-acidified books in the *Register of De-acidified Documents*.

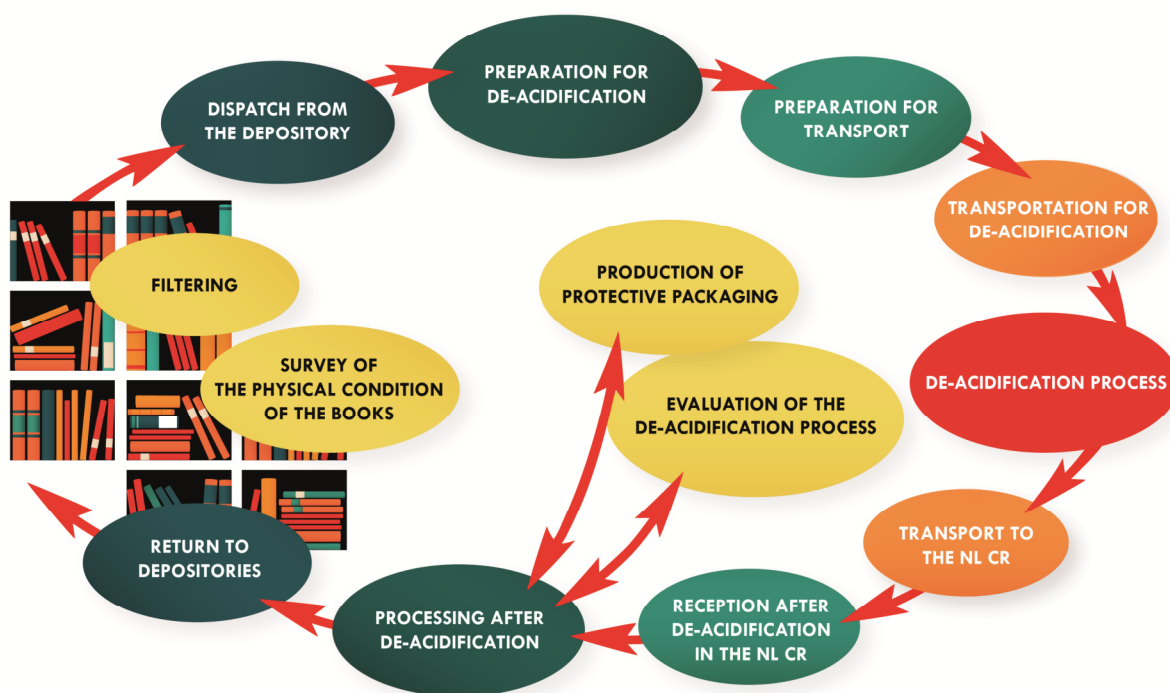


Figure 3. Workflow diagram for the implementation of mass deacidification of library collections.



Figure 4. Selection of books and their placement in cages for PaperSave Swiss deacidification technology.

5. Testing and selection of mass deacidification methods

The specialist workplaces of the National Library of the Czech Republic and the National Archives have been testing various deacidification technologies for several decades. At the same time, over the course of several years, they have consistently undertaken the implementation of partial projects funded by the VISK 7 and now VISK 4⁵ program run by the Ministry of Culture. These programs are focused on deacidification itself and testing the quality of deacidification of critically endangered volumes. Over a period of almost ten years of testing, NLCR researchers have become familiar with most of the technologies currently available on the market - Bookkeeper, PaperSave, PaperSave Swiss and ZFB:2. However, all technologies and workflows have their limitations, which is borne out by the fact that none of these technologies are available in the Czech Republic. This not only concerns functional limits, but also financial or quantitative restraints that make it virtually impossible to de-acidify all bonds that are at risk of physical disintegration.

For the implementation of de-acidification, it was necessary to select and choose a suitable deacidification technology and an experienced business partner to ensure the transport logistics and the deacidification process itself. From long-term measurements carried out within the specialist workplaces of the National Library of the Czech Republic, PaperSave Swiss® mass deacidification technology was selected as the most effective in the relevant period. This technology uses magnesium and titanium

⁵ VISK 4, or the National Program for the Protection of Library Collections, was launched in 2022 as a new sub-program of the VISK (Public Information Services for Libraries) program, focusing on the protection of library collections. The new program was created on the basis of the results of a questionnaire survey conducted into the needs of libraries in the Czech Republic, as well as the discussions of a working group on the *Concept for the Development of Libraries in the Czech Republic*, specifically priority number 4, i.e. the permanent preservation of traditional cultural documents. The aim is to ensure the long-term protection of physical documents stored in library collections against degrading influences in the network of libraries in the Czech Republic. The program proposes the use of the latest restoration and conservation methods and technologies. The VISK 4 program is aimed at ensuring the long-term protection of physical documents stored in library collections against degradation. The program specifically supports restoration and conservation interventions (including support for retrofitting central and regional workplaces), the prevention of mould and microbiological threats to collections, the production of protective packaging made of archival quality cardboard, support for systematic research of the physical condition of library collections, the de-acidification of documents affected by the degradation of wood pulp paper, the purchase of measuring and recording instruments for measuring and recording microclimate parameters and other equipment for improving the parameters for storing library collections and, last but not least, the further development of coordination tools.

ethanolate as the de-acidifying agent and hexamethyldisiloxane as the carrier medium. This is a chamber process (see Fig. 5), whereby, after pre-drying, the books are placed in a special tank and immersed in de-acidifying solution. The paper is impregnated with alkaline substances and an alkaline reserve is created. The latter protects the paper from the influence of acidic substances from the environment or natural ageing of the paper itself for decades or centuries after the treatment. The books are then placed in air-conditioning chambers and left there for several weeks to allow the natural moisture to return and the resulting ethanol to escape.



Figure 5. PaperSave Swiss[®] mass deacidification technology. Source Nitrochemie.

This process meets the defined requirements for an “ideal” method of mass deacidification⁶ of library collections:

- Neutralised books must not be unbound.
- The process must be applicable to all types of paper or papers contained in the library collection of the National Library of the Czech Republic.
- The process must not adversely affect any kind of material used on the book. The appearance of the book must not change.
- All acids must be completely and permanently neutralised.
- The neutralisation process must create an alkaline reserve in the paper equivalent to 2% calcium carbonate.
- The distribution of the pH and alkaline reserve must be homogeneous throughout the book and book materials.
- The pH value of the paper must be between 7 and 8.5 (tolerance for highly acidic materials min. 6.5 to 9.5 for less acidic materials).
- The lifetime of the neutralised paper should ideally increase fivefold.
- The mechanical properties of the book materials should remain unchanged, if there is an improvement, this is desirable.

⁶ The aim is to get as close to these parameters as possible. However, it is necessary to take into account that each book, each type of paper has a different chemical composition.

- The chemicals used must not be hazardous to the operator, future readers or the environment.
- The chemicals used must be permanently harmless to all parts of the book.

6. Quality control after deacidification

Along with the books, test samples are sent through the deacidification technology. For these de-acidified samples, the alkaline reserve is determined before and after deacidification according to ČSN ISO 9706:5. The test is destructive and is therefore carried out exclusively on samples. The overall colour change of the paper is also monitored before and after de-acidification.

Each book that has undergone deacidification is also checked for the tendency of some dyes to activate and dissolve under the influence of the de-acidifying solution. This phenomenon is rare, but cannot be completely ruled out. In addition to the chemical composition, the degree of damage or degradation of the paint binder also plays a role. Each such case is carefully recorded so that the future selection of specimens for this method excludes books with these risk elements. The team at the National Library of the Czech Republic involved in the process of preparing for mass de-acidification, thoroughly maps a wide range of risk elements to ensure maximum safety for the specimens being treated from undesirable changes.

Samples are permanently stored and remeasured over time, with selected specimens checked for undesirable changes over the long-term. Currently, no negative phenomena associated with mass deacidification processes have been observed, with samples de-acidified using various technologies having been monitored continuously for almost 10 years.

For de-acidified books showing binding damage, protective covers made of alkaline cardboard were made to protect the book from mechanical damage.

7. Implementation of mass deacidification in the Czech Republic and neighbouring countries

The National Library of the Czech Republic has published a methodology, entitled "*Preparation of modern library collections for mass deacidification and quality control of deacidification - selection criteria and processing*", which has been certified and is available through the National Repository of Grey Literature (NUŠL)⁷. Cooperation with Slovak institutions (SNK Martin, Slovak University of Technology, University Library) is developing well and a joint seminar is planned. Within the framework of the IN-PROVE⁸ project (funded through NAKI II), an analytical study on the establishment of a Methodological Centre for the Preservation and Conservation of Modern Library Documents has been set up. The study also includes an evaluation of deacidification and the possibility of operating a deacidification line in the Czech Republic.

In addition to partial projects focused on the deacidification of library collections financed from resources under VISK 7, other similar activities financed from other sources have been initiated. Worthy of mention are the systematically prepared activities of the Moravian-Silesian Research Library in Ostrava and the regional budget-funded deacidification of endangered documents from the collections of the Research

⁷ <http://invenio.nusl.cz/record/390315/files>

⁸IN-PROVE: Building an Integrated Environment for Research, Preservation, Research and Recordkeeping of Modern Library Documents

Library in Olomouc, which was the first institution to implement a massive rescue project focused on the deacidification of library collections in 2018 with the support - running into millions of Czech crowns - of the regional administration. The libraries of the Museum of Decorative Arts, the National Gallery, the National Museum and the Museum of Southeast Moravia in Zlín were involved with smaller volumes of library collections (pilot projects). Independent of the above, a one-off special-purpose grant of CZK 6 million from the Ministry of Culture of the Czech Republic was awarded to the National Library of the Czech Republic for the deacidification of critically endangered signatures 54 E and the so-called 19th century conservation fund. A total of 8,650 volumes with a total weight of 4,593 kg were treated. This larger one-off project demonstrated the ability of individual departments of the National Library of the Czech Republic to fully organise all activities related to the mass deacidification of library collections. The issue of documents at risk of paper acidity is a long-standing concern. Many documents are at risk of decay caused by, among other things, low pH values. This issue needs to be systematically addressed in the medium- and long-terms, given that any systemic, conceptual solution will be very costly both financially and in terms of personnel. The topic of mass deacidification of library collections has therefore become an important subject of the meeting of the Guarantee Council of the National Library of the Czech Republic, including requests for a comprehensive analysis dealing with the organisational and financial aspects thereof. At the end of 2020, as part of a joint project across the V4 countries, professional cooperation was established between two libraries (National Library of the Czech Republic and Slovak National Library Martin, Slovakia), one archive (Budapest City Archives, Hungary) and one university (Faculty of Biology, University of Warsaw, Poland)⁹. Countries are losing a large part of their cultural heritage, which is crucial for the preservation of national identity and national cultural heritage. Archival and library documents are frequently used by the general public. The management of memory institutions is therefore directly responsible for, among other things, the prevention and spread of communicable diseases through borrowed documents. Their task is also to educate future generations on the need to care for and protect cultural heritage. The project plans professional workshops for archivists and librarians in the region. The aim is to provide access to the knowledge of restorers, share professional know-how, and present knowledge in the field of the permanent preservation of collections and documents, including deacidification.

8. Conclusions

The implementation of mass deacidification carried out over the last 12 years by the National Library of the Czech Republic has shown that this issue cannot be solved through separate partial projects of individual libraries, but must be tackled on a national scale. In the Czech Republic, these activities are coordinated with the Ministry of Culture because it financially supports de-acidification. The degradation of the physical condition of book volumes is not a problem limited to a few select institutions. It also shows that over the long-term, it is not possible to rely on deacidification of the funds by contractors, as this is a complex activity that is financially and organisationally demanding for both parties. Acquiring your own deacidification technology is also a very costly affair, including payments for the purchase of the necessary chemicals without which the process cannot be carried out. However, there are great opportunities for active and comprehensive cooperation between different memory institutions, which could lead to the establishment of a central deacidification facility that could also reflect

⁹ The Written Visegrad Heritage - Protection for the Future

the requirements from neighbouring countries. In building such a facility, it would be practical to expand the deacidification facility to include a methodological center for the protection and conservation of modern documents, which would conduct research into various areas within this field, transfer know-how, and monitor the correctness of procedures. This goal should therefore be one of the priorities of the cultural policy of the Czech Republic.

A long-term limiting factor is the question of financial resources, with the only stable mechanism supporting the mass deacidification of library collections being the former VISK 7 program and the current VISK 4 program (as of 2022). Due to these funds, and the support of their founders, deacidification has also been started by other libraries. For example, by the Municipal Library in Prague and the Scientific Library in Olomouc. Institutions such as the libraries of the Museum of Decorative Arts, the National Gallery, the National Museum and the Museum of Southeast Moravia in Zlín have also started the deacidification of small volumes of library collections, with other libraries gradually being added to the list.

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