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A performance comparison between a wide-hinged endpaper construction and the Library Binding Institute standard endpaper construction

Claudia Chaback

A PERFORMANCE COMPARISON BETWEEN A WIDE-HINGED ENDPAPER CONSTRUCTION AND THE LIBRARY BINDING INSTITUTE STANDARD ENDPAPER CONSTRUCTION

by

Claudia Elizabeth Chaback

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Certificate of Approval -- Master's Thesis

School of Printing Management and Sciences
Rochester Institute of Technology
Rochester, New York

CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to Certify that the Master's Thesis of

Claudia Elizabeth Chaback

With a major in Printing Technology
has been approved by the Thesis Committee as satisfactory for the thesis requirement for the Master of Science Degree at the convocation of

May 1987
(Date)

Thesis Committee: Werner Rebsamen
Thesis Advisor

Joseph L. Noga
Graduate Program Cooridinator

Miles Southworth
Director or Designate

A Performance Comparison Between a Wide-Hinged Endpaper Construction and the Library Binding Institute Standard Endpaper Construction

I, Claudia Elizabeth Chaback, prefer to be contacted each time a request for reproduction is made. I can be reached at the following address:

8080 Harbor Creek Drive
Suite 1101
Mentor-on-the-Lake, Ohio
44060

Date May 21, 1987

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ABSTRACT

For the last fifty years, library binders have employed a standard endpaper construction for all of its bindings. Now, because of new binding techniques and the deterioration of paper some preservationists have placed a demand on library binders to develop an alternate endpaper construction.

The purpose of this study was to determine the hinge strength and openability performance of the two most common library binding techniques, oversewing and Singer side sewing, which were flat backed and rounded/backed in relation to the currently used the LBI Standard endpaper as compared to the wide-hinged endpaper construction.

It was questioned if there would be a significant strength difference between the two endpaper constructions: wide-hinged vs. the LBI Standard. If there were differences, it was further questioned if they were related to the paper which was used. Three tests were utilized in response to these questions: 1) the Instron Hinge-Pull Test, 2) the UBT Tumble Test, and 3) the Tumble Test. These tests provided the data required to analyze the comparisons via the ANOVA Analysis and the Duncan Multiple Range Test. Through these analyses, it was statistically determined that the tested that endpapers were significantly different

in hinge strength at a 99% confidence level. These statistics also determined, early in the testing procedures, that the relationship of paper and grain direction had no significant value in the determination of hinge strength or openability of a book.

It was also questioned if there would be a significant difference between the two endpaper constructions: wide-hinged vs. the LBI Standard, in reference to openability. If there were differences, it was further questioned if they were related to the paper which was used. A Photocopy Openability Test was developed to investigate these questions. The data was measured to the nearest 1/64" and applied to the ANOVA analysis and Multiple Range test. At a 99% confidence level it was determined that the endpapers were statistically different and that the wide-hinged endpaper provided a greater area of openability in all binding techniques.

CHAPTER 1

INTRODUCTION

Printed material is bound for the purpose of its end use. Yet, Margaret Child, assistant director for research services for the Smithsonian Institution libraries stated, "The vast majority of our written heritage is in jeopardy, and it may already be too late to save much of it."[1] It has been estimated that about eighty-percent of the nation's books are threatened by deterioration.[2] The librarian, therefore, has a monumental task to undertake. Books destined for circulation must last long enough to provide low-cost readership among the number of readers.[3]

LIBRARY BINDING INSTITUTE'S STANDARD

The Library Binding Institute (LBI). serves both librarians and library binders in an effort to prolong the useful life of a book. Eighty-percent of all libraries rely upon Certified Library Binders who observe the internationally accepted, "... Library Binding Institute, (LBI), Standard for Library Binding, (sometimes called Class "A"). providing maximum strength and durability, and provide up to approximately 100-150 circulations or uses."[4] "By adhering to these standards inferior binding has largely disappeared from the library scene."[5]

The specifications are for both materials and methods. The primary method of binding specified (excluding exceptional volumes), is oversewing.

Oversewing is a technique where individual sections of loose leaves are sewn through the side, in thin sections which are sewn next to each other. A lock stitch is formed between each separate section. Openability is better than a side sewn volume as the stitches are not through the entire block at once. (For a more detailed explanation see Chapter 2.)

The Library Binding Institute and its members also encourage the development of new equipment and materials. Their objectives are clear: to make available materials equivalent or superior in quality to specified materials, and equipment which can increase productivity per man hour with no diminution of quality.[6] The LBI Technology Committee researches and tests new materials and methods for their performance in comparison with the standard, thus providing technical data to binders and librarians.

LBI specifications have been the standard for binding ninety-nine percent of all library books in the past.[7] It specifies the preferred method of oversewing for many reasons among which are the following:

1. Oversewing gives great strength to a book.
2. An oversewn volume has reasonably good openability.
3. Loose leaves may be bound, thus no bindfold or expensive repairs of the bindfolds are necessary.

4. With equipment adjustments, a wide range of book types (physical characteristics) can be bound by the oversewing technique. Although, more costly, oversize volumes are sewn by hand. This is also an accepted LBI Standard technique, which broadens the range even further.

These four attributes of oversewing are the primary ones which the LBI, library binders, and librarians investigate when considering alternate binding methods.

LIBRARY BINDINGS

The library binding industry is a unique branch of the binding industry. Its main function is to bind books in such a way as to prolong the useful life. The library binding industry shares many technologies with the binding industry as a whole. However, in the past, the vast majority of the library books were bound by a specific type of binding, "library" or called "Class A", in the past was developed exclusively for rigid requirements of library use. Volumes were thus bound according to high standards and specifications yielding strong and durable books. Jack Bendror in his book, Technology and Testing of Library Bound Books, distinguishes the special requirements of binding library books within the library binding industry as follows:

> 1) The library binder must work on a product someone else has made. Consequently, he has no control over variables, such as wear, weight, quality of paper, grain-print relationship, margin size, diversity of volume, and size, all of which are important in the rebinding process.

> 2) Hence, from a technological point of view, and because of the lack of homogeneity in the product, it is a separate and distinct branch of the graphic arts.[8]

Further, library materials are normally subjected to heavy usage and a great number of circulations. This imparts tremendous strains on the bindings. Thus, the rebinding or prebinding must meet high strength requirements and standards. Rebinding is the process of replacing worn bindings, whereas, prebinding is the process of binding new books for library use. The library industry's task then has been to turn a non-uniform product into a uniform one in terms of strength and durability, and of superior quality to the original edition binding. The aim is to prolong the useful life of the books.

THE FUNCTION OF ENDPAPERS

The purpose of the endpaper is to link a book block to its cover, hide some architectural features of the binding and protect the first few pages of the text. (These first folios are not considered part of the book's content.) An endpaper should be visually appealing and its construction must have good dimensional stability and flexing characteristics. Properly constructed endpapers are essential for the durability of a binding.

For over half a century, the LBI Standard requirements were followed for endpaper construction for both oversewn and side sewn volumes. The construction consisted of:

> A single, folded sheet tipped 1/4 inch from the edge of a single leaf to make three leaves. A 1 1/4 inch strip of specified reinforced cloth is adhered along the binding edge of the folded sheet and on the exposed 1/4 inch extension of the single leaf and the reinforcement, the outer most endpaper is folded and tipped back flush to the binding edge in order to cover the sewing thread, and to allow the end-paper to hinge from the binding edge.[9]

Repeated testing validated the superiority of this construction, yet appropriate measures were not taken into account for paper deterioration. Superior strength and the amount of circulations achieved in an everyday library environment were given priority. Now, the commercial library binders and librarians are forced to consider alternate methods to the traditional LBI Standard endpaper construction in order to prevent deterioration to the book block, thus lengthening the book's life. If the test data can show support of the effectiveness of the wide-hinged endpaper, then this construction may serve as an alternative to the conventional system.

The objective of this study is to determine if there is a statistically significant difference in performance between a yet untested wide-hinged endpaper construction and the conventional LBI Standard endpaper construction.

STATEMENT OF THE PROBLEM

For over fifty years, library binders have utilized oversewn endpapers as their standard.

Oversewn endpapers are manufactured to the specifications of the Library Binding Institute and

> consist of a 100% cotton cambric reinforcing tape, a single, folded sheet and a single leaf. These components are adhered to each other with poly-vinyl adhesive. The outer half of the cambric tape receives a layer of dextrin or animal adhesive, which is remoistenable when processing oversewn or side sewn volumes. The oversewn endpaper is sewn through the reinforcing tape and the single leaf to the book block on both sides. After the book is completely sewn, both of the reinforced single sheet portions of the end-paper are repositioned with a special machine designed to fold back, moisten the gummed cambric tape, and tip down the endpaper to the book block in perfect alignment with the spine of the block.[10]

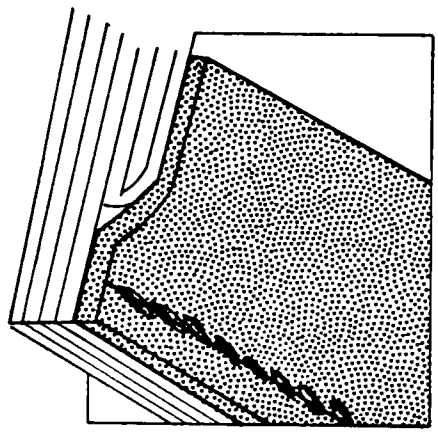


Figure 1. Oversewn Endpaper Attached to Volume.

(Redesigned from: Fritz James, "Alternate Endpaper Construction For Oversewing Library Volumes," Library Binding Service, Winter 1986, p. 1.)

By applying this standard, the hinging area moves to the edge of the spine. "If this were not done, the cover would hinge on the other side of the over-or-side sewing, at least 5/8 inch from the spine, resulting in a very "awkward" looking library bound product."[11]

The problem, which shall be researched, lays within the construction of the endpaper, itself.

By positioning the hinge to the edge of the spine a 1/4 inch tab of rigid material remains in the front and back of the book block. This set of built-in-book ends is made of two layers of 80 lb. endleaf paper, two layers of cotton fabric, and two layers of both polyvinyl and remoistenable animal adhesive. In common use, the front and back sections of the volumes are forced to bend over this stiff 1/4 inch tab.[12]

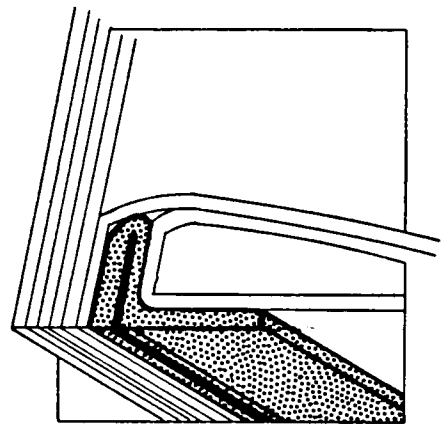


Figure 2. 1/4 " Tab Resulting From Refolding The Cambric Reinforced Hinge.

(Redesigned from: Fritz James, "Alternate Endpaper Construction For Oversewing Library Volumes," Library Binding Service, Winter 1986, p. 1.)

The combination of repeated flexing over these sharp tabs and the weight of the interior leaves when the book is opened may result in the first few leaves breaking off approximately 5/8 inch from the spine. On oversewn volumes the brittle paper caused by aging or paper condition, this situation may become much worse. This fracture of paper can continue into volumes more than 1/4 inch.[13]

HYPOTHESIS

There are no significant differences at a 99% confidence level in hinge strength or openability between wide-hinged endpaper and Standard endpaper of oversewn and Singer side sewn books. Therefore, wide-hinged endpaper may be considered as an alternative construction to the current Library Binding Institute Standard endpaper.

FOOTNOTES FOR CHAPTER ONE

[1]William MacDougall and Sharon Golden, "Battling Father Time to save a Vast Treasure," U.S. News & World Report (April 22, 1985), p.53.

[2] Ibid.

[3]Dudley A. Weiss, "The LBI Standard: The Only Industry Standard for Library Bound Books," The Library Scene (September 1975), p. 19.

[4]Jack Bendror, Technology and Testing of Library Bound Books (Rochester, New York: Graphic Arts Research Center, 1976), p. 2.

[5]John B. Stratton, "Libraries and Commercial Binderies," Library Trends (January 1956), p.14 .

[6]Weiss, p.19.

[7]Werner Rebsamen, "Testing Binding- An Introduction," introduction to Jack Bendror, Technology and Testing of Library Bound Books (Rochester, New York: Graphic Arts Research Center, 1976).

[8]Bendror, p. 2.

[9]Paul A. Parisi and Jan Merrill-Oolham, Library Binding Institute Standard for Library Binding (Rochester, New York: Library Binding Institute, 1986), p.4.

[10]Fritz James, "Alternate Endpaper Construction For Oversewing Library Volumes," Library Binding Service (Winter 1986), p. 2.

[11]Rebsamen, "Alternate Endpaper Construction For Oversewn and side sewn Library Bindings," p. 5.

[12]Ibid.

[13] Ibid., p. 6.

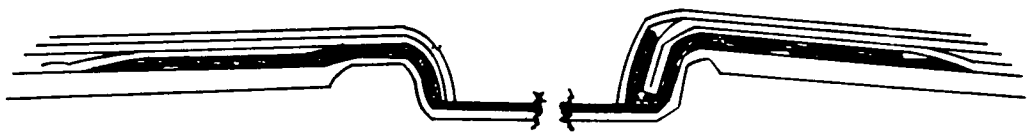
CHAPTER 2

DESCRIPTION OF THE WIDE-HINGED ENDPAPER CONSTRUCTION AND THE SIDESEWN AND OVERSEWN BINDING TECHNIQUES

THE WIDE-HINGED ENDPAPER CONSTRUCTION

The endpapers are sewn approximately 1/4 inch from the edge of the spine. This redesigned hinge would now make the necessity of folding back obsolete. The construction utilizes the LBI Standard for endpapers which require three layers of 80 lb. high-strength paper. A heavier drill reinforcing cotton cloth is substituted for the cambric cloth and joins these separate leaves together so that the heavy cotton drill cloth functions as the hinge. This design creates an oversewn volume without a 1/4 inch tab.

Because of the physical design of the hinge, many attributes quickly become apparent. It offers a wider hinge, however, it should be noted that the volume as a whole does not reflect the appearance of the traditional library oversewn volumes. The most significant value of this construction is that no stress is exerted on the book block because of the wider hinge, thus some binders believe that such a binding has a better and stronger attachment to the book case, eliminating the 1/4 inch tab.[1]



WIDE-HINGED ENDPAPER STANDARD ENDPAPER

Figure 3. Comparison of the Wide-Hinged Endpaper Construction and a Repositioned Oversewn Endpaper

(Redesigned from: Fritz James, "Alternate Endpaper Construction For Oversewing Library Volumes," Library Binding Service, Winter 1986, p.4.)

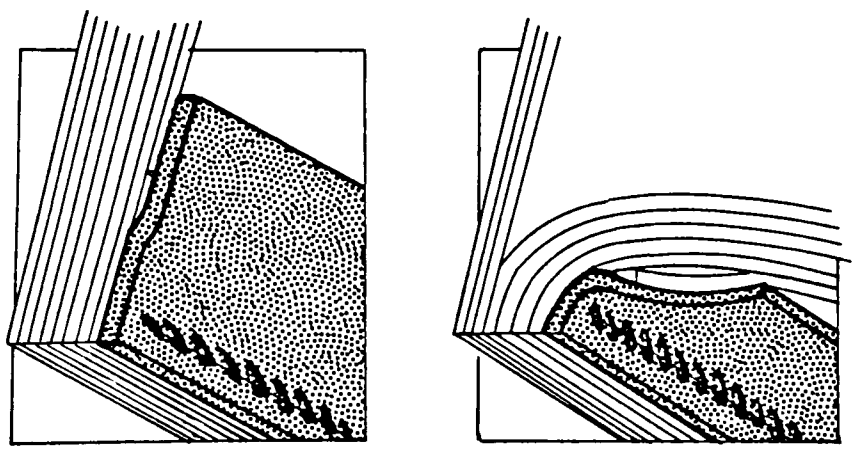


Figure 4. Schematics Demonstrating the Easy Opening End Leaves With the Wide-Hinged Endpaper Construction

(Redesigned from: Fritz James, "Alternate Endpaper Construction For Oversewing Library Volumes," Library Binding Service, Winter 1896, p.3.)

OVERSEWING

Oversewing is a binding technique which can be performed either by hand or by machine; the principle is the same for both. Machine oversewing requires extensive training as the pattern of sewing is quite complex. Pages in sections of folded signatures are prepared, or more often, a block of loose leaves is divided into separate but equal sections, "The oversewing machine has a series of individual needles which move diagonally through several sections at a time,"[2] through the edge of the sections. A lock stitch is formed with each separate section. Great strength is obtained from the number of stitches, and the particular pattern used. Flexibility is acquired since sewing is not through the edge of the entire block of sections at once. Oversewing is a machine technique used exclusively for library bindings. New books are oversewn when they are bound or prebound for library use; old books are oversewn if their binding must be renewed.[3]

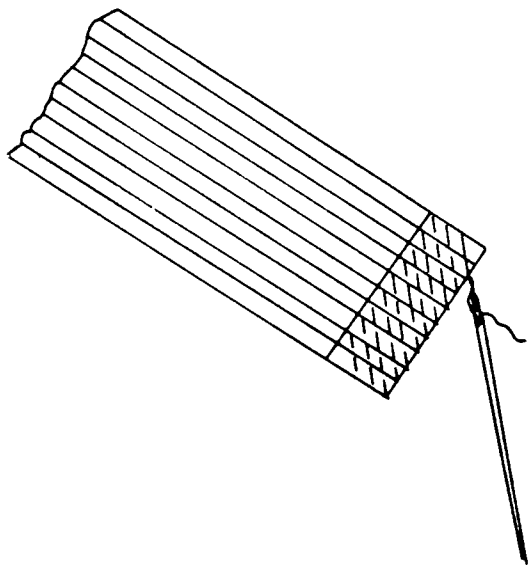


Figure 5. The Oversewing Principle

(Reproduction from: Werner Rebsamen, "Third Part in a Series on: A study of Simple Binding Methods," The Library Scene, December 1979, p. 20.)

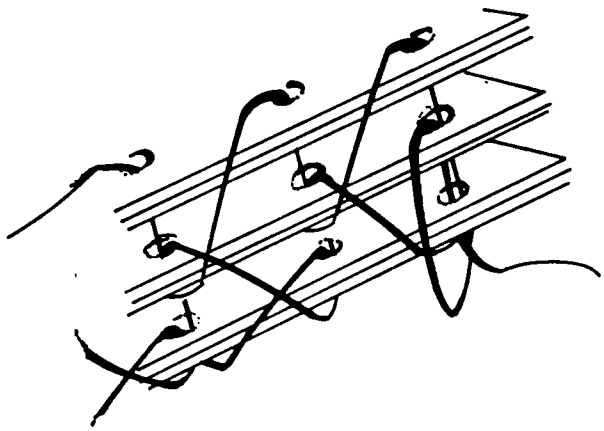


Figure 6. Oversewing Stitching Pattern

(Reproduction from: Victor Strauss, The Printing Industry, (Washington, D.C.: Printing Industries of America, Inc., 1967),p. 659.

SIDE SEWING UTILIZING THE SINGER SIDE SEWING METHOD

In the side sewn binding method, the book does not consist of individual sections that were initially fastened by themselves and then sewn to each other, but that the entire book block is sewn through the side along the binding edge. This eliminates costly repairs of individual leaves.

The Singer side sewn method involves the use of a Singer or Moffett sewing machine, which was designed especially for the automation of this sewing process. "Such machines can sew books up to a one-half inch thickness depending on the type of paper to be sewn. With some expections, no holes are drilled."[4] The stitch is locked on the underside by passing the bobbin thread through a loop made with the needle thread. Stitching with heavy thread, the sewing extends the full length of the volume and through the reinforcing fabric. "Certified Library Binders are permitted to use such a side sewing binding method on books not more than one half inch thick."[5] In order to use this method the binders must construct the endpapers to hinge from the binding edge. A library bound volume requires a reinforced endpaper that follows the same specified guide lines developed by LBI for oversewn volumes.[6] Most small, prebound library books are said to be side sewn and are almost indestructible, an important factor when binding books for small children.

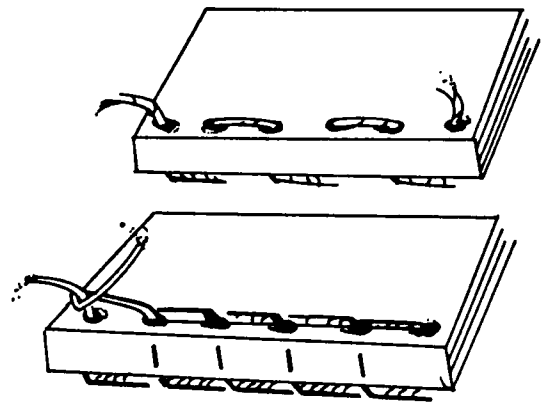


Figure 7. The side Sewing Principle

(Reproduction from: Victor Strauss, The Printing Industry, (Washington, D.C.: Printing Industries of America, Inc., 1967), p. 657.

FOOTNOTES FOR CHAPTER 2

[1]Fritz James, "Alternate Endpaper Construction for Oversewing Library Volumes," Library Binding Service (Winter 1986), p. 4.

[2]Victor Strauss, The Printing Industry (Washington, D.C.: Printing Industries of America, Inc., 1967), p. 659.

[3]Ibid.

[4]Werner Rebsamen, "First Part in a Series on: A Study of Simple Binding Methods," The Library Scene (June 1979), p. 14.

[5]Paul A. Parisi and Jan Merrill-Oldham, Library Binding Institute Standard for Library Binding, Eigth Edition (Rochester, New York: Library Binding Institute, 1986),p. 6.

[6]Ibid., p. 7.

CHAPTER 3

LITERATURE REVIEW

A list, in full, of literature reviewed pertinent to this study is contained in the bibliography (p. 69).

Fritz James article "Alternate Endpaper Construction For Oversewing Library Volumes," published by his company, the Library Binding Service, is a comprehensive source of information directly relating to this study. The paper supports the argument that the style of endpaper used on the oversewn book could potentially damage the text block. Suggested experimental endpaper constructions are discussed pointing out their strengths, as well as weaknesses.

The Library Binding Institute Standard for Library Binding, edited by Paul A. Parisi and Jan Merrill-Oldham, is a substantive revision of technical specifications that meet the current concerns of library binders. The experimental designs, parameters, and objectives in this research are based on these specifications.

Werner Rebsamen, Technical Director to LBI and Professor at Rochester Institute of Technology has published several articles in The Library Scene, a bi-monthly, periodical published by the Library Binding Institute. A series of articles called "A Study of Simple Binding Methods," and an article for The New Library Scene, "Endpaper Construction of Recasing," describes the endpaper constructions and binding methods tested in his study along with their advantages and

disadvantages. Within the contents of these articles are problems which plague the library binding industry. Rebsamen proposes solutions to current dilemmas by evaluating books in the LBI/RIT Book Testing Laboratory. Two articles, "Upgrading Binding Quality: Report on the New RIT/LBI Testing Laboratory," and "Bookbinding Testing Laboratory Evaluates Machinery, Materials, Techniques," describe book testing and its great value to library binders and librarians.

William MacDougall and Sharon Golden wrote "Battling Father Time to Save a Vast Treasure." Supporting the argument that millions of books are decaying on our library shelves, this article offers many solutions which paper companies and national libraries, alike, are undertaking to prevent further decay.

Dudley A. Weiss, Executive Director of the Library Binding Institute has published several articles in the Institute's periodical, The Library Scene, explaining the function of LBI and its great value to librarians and library binders, whom it serves. LBI's main concern is to preserve books, through quality binding. Weiss emphasizes the need for their Standard, what should be done in the future to keep quality binding within the library binding industry, and inferior binding methods out. The Technology Committee of LBI evaluates and investigates binding equipment, procedures, and materials to provide valid technical information to librarians and library binders. LBI's Technology Reports (through 1976) is a chronological record of all evaluations, recommendations, and testing performed by our sponsored by the Library Binding Institute.

CHAPTER 4

DESIGN PARAMETERS AND METHODOLOGY

These experiments were developed to test the specific factors concerning endpaper construction, strength and openability, and the effects upon binding methods. For those untested variables, all efforts were made to minimize error at a given level and fix their variation.

EXPERIMENTAL OBJECTIVES

The purpose of this experiment was to provide binders, librarians, and others with an analysis of strength and openability characteristics an alternate endpaper construction, or wide-hinged endpaper as compared to the Standard endpaper. This was accomplished by performing a series of experiments on various binding methods, materials, and variables affecting the techniques. The experimental program involved the testing and analytical comparison of the two endpaper constructions; wide-hinged vs. Standard, which utilized the binding methods of oversewing and side sewing. As of the date of this report, no experimental evidence of these endpaper's performance characteristics has been published.

Openability comprises characteristics, which are unique to each of the binding methods that were studied. Therefore, the data collected played an integral role in determining the acceptability of the wide-hinge endpaper construction as an alternative to the current Standard endpaper construction.

A series of tests were run and data statistically analyzed to answer the following specific questions:

A. Was there a significant average strength difference as measured by the Instron Hinge-Pull Tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers?
2. between wide-hinged, oversewn books: flat backed vs rounded/backed spine treatments?
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed?
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers?
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments?
6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed?
7. between Singer side sewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed?

B. Was there a significant difference in average openability as measured by the Photocopy Test at a 99% confidence level:

1. between wide-hinged, oversewn, flat backed books with coated paper: cross grain vs long grain?
2. between Standard hinged, oversewn, flat backed books with coated paper: cross grain vs long grain paper?
3. between wide-hinged, oversewn, flat backed books with uncoated paper: cross grain vs long grain paper?

4. between Standard hinged, oversewn, flat backed books with uncoated paper: long grain vs cross grain paper?
5. between oversewn, flat backed books with cross grain, coated paper: wide-hinged vs Standard hinged endpaper?
6. between oversewn, flat backed books with coated paper: wide-hinge with cross grain paper vs Standard hinge with long grain paper?
7. between oversewn, flat backed books with coated paper: wide-hinge with long grain paper vs Standard hinge with cross grain paper?
8. between oversewn, flat backed books with long grain, coated paper: wide-hinged vs Standard hinged endpaper?
9. between oversewn, flat backed books with cross grain, uncoated paper: wide-hinged vs Standard hinged endpaper?
10. between oversewn, flat backed books with uncoated paper: wide-hinged with cross grain paper vs Standard hinged with long grain paper?
11. between oversewn, flat backed books with long grain, uncoated paper: wide-hinged vs Standard hinged endpapers?
12. between oversewn, flat backed books with long grain, uncoated paper: wide- hinged vs Standard hinged endpapers?
13. between wide-hinged, oversewn, rounded/backed books with cross grain, coated paper: long grain vs cross grain paper?
14. between Standard hinged, rounded/backed, oversewn books with coated paper: long grain vs cross grain paper?

15. between wide-hinged, oversewn, rounded/backed books with uncoated paper: long grain vs cross grain paper?
16. between Standard hinged, oversewn, rounded/backed books with uncoated paper: long grain vs cross grain paper? utilizing a grain paper?
17. between oversewn, rounded/backed books with cross grain, coated paper: wide-hinged vs Standard hinged endpapers?
18. between oversewn, rounded/backed books with coated paper: wide-hinged endpaper with cross grain paper and Standard hinged endpaper with long, grain paper?
19. between oversewn, rounded/backed books with coated paper: wide-hinged endpaper with long grain paper and Standard hinged endpaper with cross grain paper?
20. between oversewn, rounded/backed books with coated, long grain paper: wide-hinged vs Standard hinged endpapers?
21. between oversewn, rounded/backed books with uncoated, cross grain paper: wide-hinged vs Standard hinged endpapers?
22. between oversewn, rounded/backed books with uncoated paper: wide-hinged with cross grain paper vs Standard hinged with long grain paper?
23. between oversewn, rounded/backed books with uncoated paper: wide-hinged with long grain paper vs Standard hinged with cross grain paper?
24. between oversewn, rounded/backed books with long grain, uncoated paper: wide-hinged vs Standard hinged endpaper?

25. between Singer side sewn, flat backed books with coated paper: wide-hinged with cross grain paper vs Standard hinged endpaper with long grain paper?
26. between Singer side sewn books with coated paper: wide-hinged, flat backed spine with long grain paper vs a Standard hinged, rounded/backed spine with cross grain paper?
27. between Singer side sewn books with cross grain, coated paper: flat backed, wide-hinged vs rounded/backed, Standard hinged?
28. between a rounded/backed, Singer side sewn book utilizing a Standard hinge with cross grain, coated paper and a rounded/backed, Singer side sewn book utilizing a Standard hinge with cross grain, uncoated paper?
29. between Standard hinged, rounded/backed, Singer side sewn books with coated paper: cross grain paper vs long grain paper?
30. between Singer side sewn books with coated paper: flat backed, wide-hinged endpaper with cross grain paper vs a rounded/backed, Standard hinged endpaper with long grain paper?
31. between Singer side sewn books with coated, long grain paper: a flat backed spine with wide-hinged endpaper vs a rounded/backed spine with Standard hinged endpaper?
32. between flat backed, wide-hinged Singer side sewn books with coated paper: cross grain vs long grain papers?
33. between rounded/backed, Standard hinged, Singer side sewn books with uncoated paper: cross grain vs long grain papers?
34. between Singer side sewn books: flat backed with a wide-hinge using long grain paper vs a rounded/backed with a Standard

hinge using cross grain paper?

35. between Singer side sewn books with uncoated, cross grain paper: flat backed spine with a wide-hinge vs a rounded/backed spine with a Standard hinge?
36. between Singer side sewn books with uncoated paper: flat backed spine with a wide-hinge and cross grain paper vs a rounded/backed spine with a Standard hinge and long grain paper?
37. between Singer side sewn books with uncoated, long grain paper: a flat backed spine with a wide-hinge vs a rounded/backed spine with a Standard hinge?

C. Was there a significant average strength difference as measured by the Tumble Tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers?
2. between wide-hinged, oversewn books:rounded/backed vs flat backed spine treatments?
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed?
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers?
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments?
6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed?
7. between Singer side sewn books: wide-hinged, rounded/backed vs

Standard hinged, flat backed?

D. Was there a significant average strength difference as measured by the UBT Tumble tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers?
2. between wide-hinged, oversewn books:rounded/backed vs flat backed spine treatments?
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed?
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers?
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments?
6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed?
7. between Singer side sewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed?

In order to eliminate prejudice, four companies, which were considered to be the best in library binding, were selected to construct the books. When neccessitated in this writing, the companies would be referred to as company A,B,C, and D. All tests were run blind as to eliminate bias.

BOOK PREPARATION

The four factors that were initially tested: binding method, endpaper construction, paper, and paper grain, each had two levels. The two

levels of the endpaper construction were: 1) Wide hinged and the 2) Library Binding Institute Standard. The two levels of binding methods were: 1) Oversewn, flat backed and rounded/backed volumes and 2) Singer side sewn, flat backed and rounded/backed volumes. The internal factor of paper was introduced in two levels; 1) uncoated and 2) coated. Applying the influence of grain direction introduced two further levels: 1) long grain and 2) cross grain. The levels produced a total of twenty-four (24) individual book treatments (see Figures 8 and 9). The mathematical model for the levels; endpaper, binding, paper, and paper grain were represented by A, B, C, and D. This model represented the crosses of the levels that were tested.

MODEL= A B C D
A x B A x C A x D B x C B x D C x D
A x B x C A x C x D B x C x D
A x B x C x D

To support the hypothesis testing, 4 replicates of each book treatment were prepared; 24 crossed factors x 4 replicates = 96 bound books (see Figure 10).

Werner Rebsamen states in his "Binding Testing Laboratory" article published in Book Production Industry and Magazine Production "In comparison performance testing, it is most important that the books be of equal dimension, weight and paper. Otherwise, there are so many variables that fair judgement becomes difficult."[1] Therefore, the testing of oversewn books weighed about three pounds and Singer side sewn books weighed about 1.25 lbs. All books were approximately 6 x 9 inches in size. The uncoated paper consisted of 20 lb. bond and the

Figure 8

Model for Multi-level Oversewn Crosses

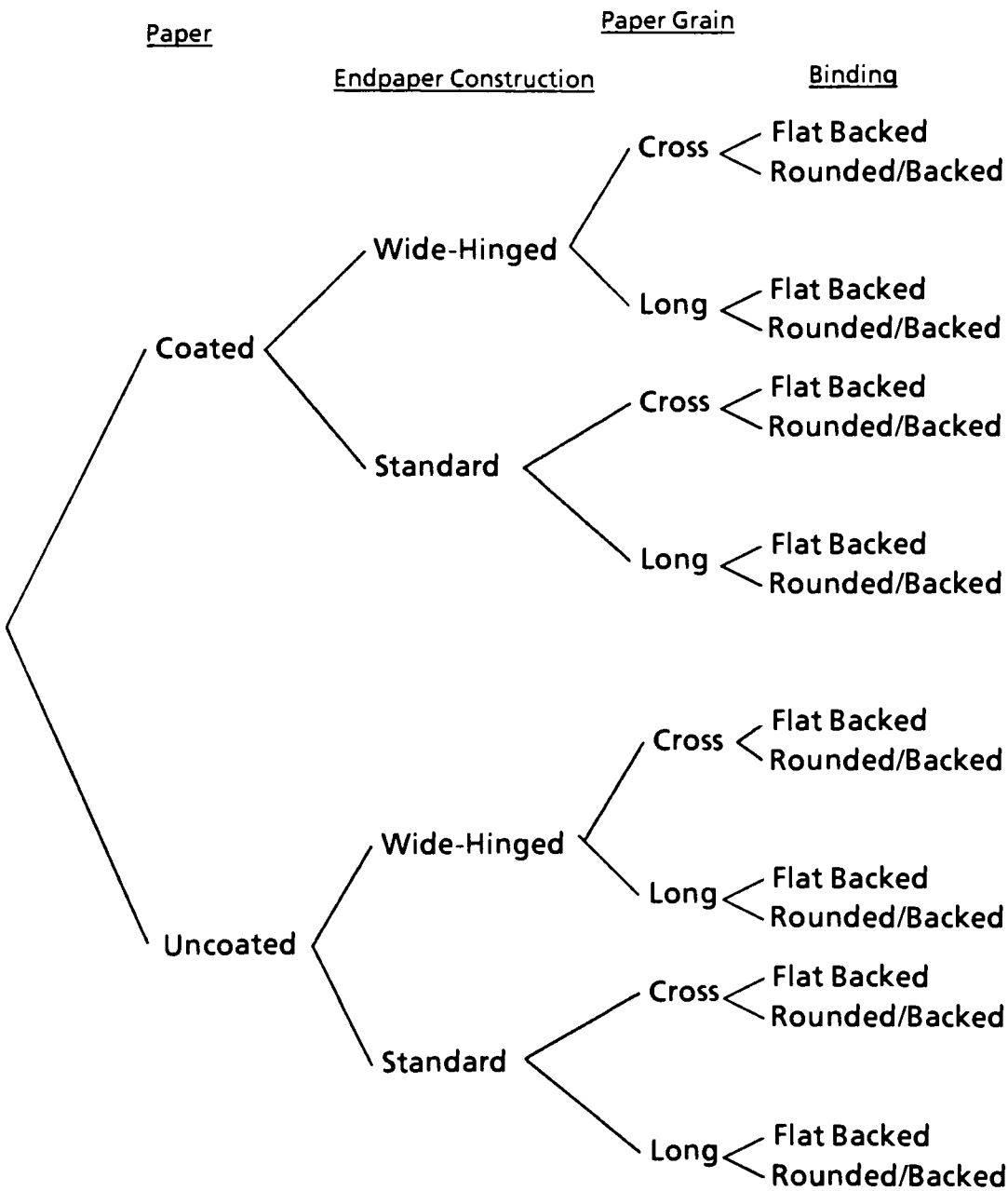


Figure 9

Model for One-way ANOVA Summary of Singer Side Sewn Crosses

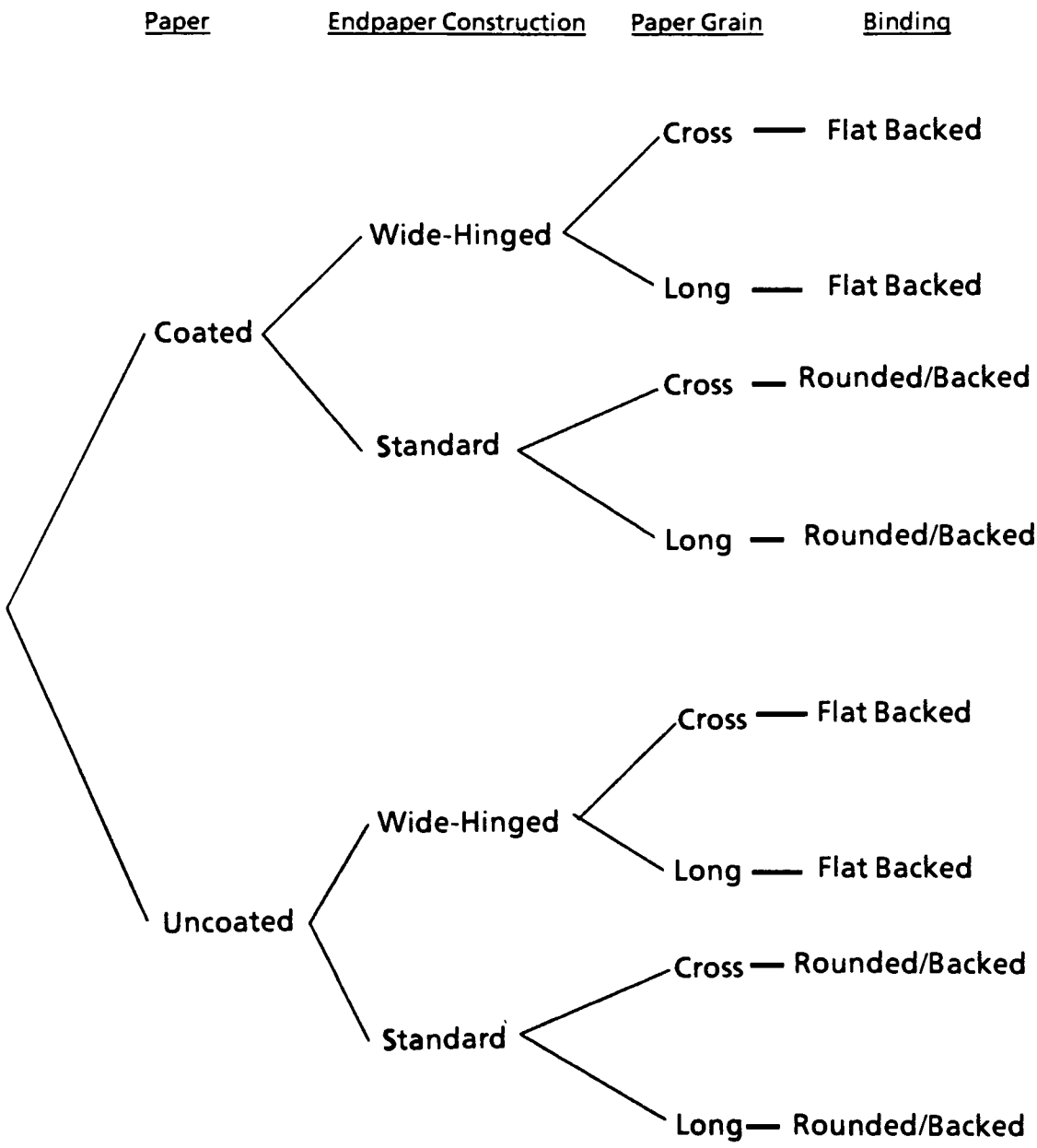


Figure 10

BOOK TYPE PREPARATION CHART

BINDING	PAPER: COATED — WIDE HINGED ENDPAPER — CROSS GRAIN		LONG GRAIN		STANDARD ENDPAPER — CROSS GRAIN		LONG GRAIN		PAPER: UNCOATED — WIDE HINGED ENDPAPER — CROSS GRAIN		LONG GRAIN		STANDARD ENDPAPER — CROSS GRAIN		LONG GRAIN		VOLUMES
	A1		A2		A3		A4		A5		A6		A7		A8		
OVERSEWN FLAT BACKED B1	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	B
	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	B
	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	8
	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	B
OVERSEWN ROUNDED/ BACKED B2	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	B
	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	8
	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	B
	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	B
SINGER SIDE SEWN FLAT BACKED B3	1F	1B	1F	1B					1F	1B	1F	1B					4
	2F	2B	2F	2B					2F	2B	2F	2B					4
	3F	3B	3F	3B					3F	3B	3F	3B					4
	4F	4B	4F	4B					4F	4B	4F	4B					4
SINGER SIDE SEWN ROUNDED/ BACKED B4					1F	1B	1F	1B					1F	1B	1F	1B	4
					2F	2B	2F	2B					2F	2B	2F	2B	4
					3F	3B	3F	3B					3F	3B	3F	3B	4
					4F	4B	4F	4B					4F	4B	4F	4B	4

TOTAL: 96

Total Book Treatments: 24
f = FRONT ENDPAPER, b = BACK ENDPAPER
Uncoated = 20 lb. Bond
Coated = 60lb. Machine Coated Book
Key identification example: A3B4-1f identifies the front of a volume which has a Standard endpaper construction with the paper in a cross-grain direction that is Singer Side Sewn and rounded/backed.

coated of 60 lb. book. The bulk of all oversewn books consisted of 1¼" and 3/8" for Singer side sewn books (See Appendix A).

TESTING

Although no testing devise could exactly replicate the actual usage, or "wear and tear," of books, there were valid testing methods, procedures, and equipment available at the DAW (Dudley A. Weiss) Book Testing Laboratory and the Mechanical Engineering Laboratory, both at RIT, to simulate various usage strains normally placed on library volumes. The specific tests selected quantified hinge strength and openability permitting performance comparisons by statistical analysis. The three types of tests that were performed and replicated consisted of: 1) Openability, 2) Hinge Strength and, 3) Hinge Delamination, (also see Appendix A).

1. Openability Tests

A. Photocopy Openability Test

In 1966, the ALA published The Development of Performance Standards for Binding used in Libraries, Phase II. This book described the ALA's Standard test apparatus and testing method for openability.[2] The ALA method furnished a very simple and reasonable way to gauge the openability of a book, defined as the ability of a bound book to be opened easily and to lie open unaided. Based on this procedure a method was devised to test unprinted volumes and rate the openability of the books to the nearest 1/64 inch. This was

named the "Photocopy Openability Test" both because the test was performed with the use of a photocopy machine and because a photocopy, itself, was used to collect the data.

The Photocopy Openability Test was very simple. Each of the ninety-six books were opened to the first folio and last folio of the outer book block. After confirmation of trim accuracy, a line was drawn on each of the two facing pages at a pre-determined distance of five (5) inches from the fore edge as shown in Figure 9, Book Preparation for Photocopy Openability Test. The various volumes were then placed face down on a photocopy machine, a one pound weight was placed in the center of its spine (for uniform, slight down-pressure), and a photocopy taken. Copies were made of the first and last folios, five (5) inches inward from the fore edge of the book block. The distance between the two lines on the photocopy were then measured at a predetermined area and recorded to the nearest 1/64 inch. Prior to testing, the photocopy machine was previously tested for 100 percent reproduction size.

It was anticipated that binding methods, endpaper constructions, paper, paper grain, and shape of backbone would influence the results. Due to the destructive nature of the remaining tests the openability test was carried out first. This sample size was the largest since minimal damage was incurred to the book, thus the twenty-four book types and their replicates were utilized in the remaining experiment with minimal influence of error.

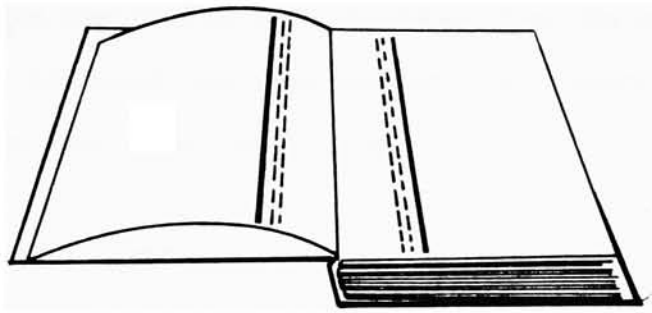


Figure 11. Book Preparation For Photocopy Openability Test

2. Hinge-Strength Test

A. Instron Hinge-Pull Test

The Instron Universal Testing Instrument (Figure 12), incorporated a highly sensitive electronic load weighing system with a load cell that used strain gages for detecting tensile or compressible loads. This system was highly reliable for the evaluation of the mechanical properties the hinge and allowed for the repetitive testing of the books. Because this test was destructive, the sample size was one third of the original 96 books. The remaining two thirds of the books were distributed evenly between the two remaining tests.

To test the possible differences in strength between the Standard endpaper and the wide hinged endpaper, the bound volumes were first split on the spine, paying particular attention

as to avoid cutting into the back lining of the volume. Mounted into the Instron Tester, the cover-boards are thereafter pulled from the book block (see Figure 13). The value, that was the tensile force required to pull the hinge from the book block, was measured in kilograms and then converted into pounds and applied to a comparison chart (see Appendix B).

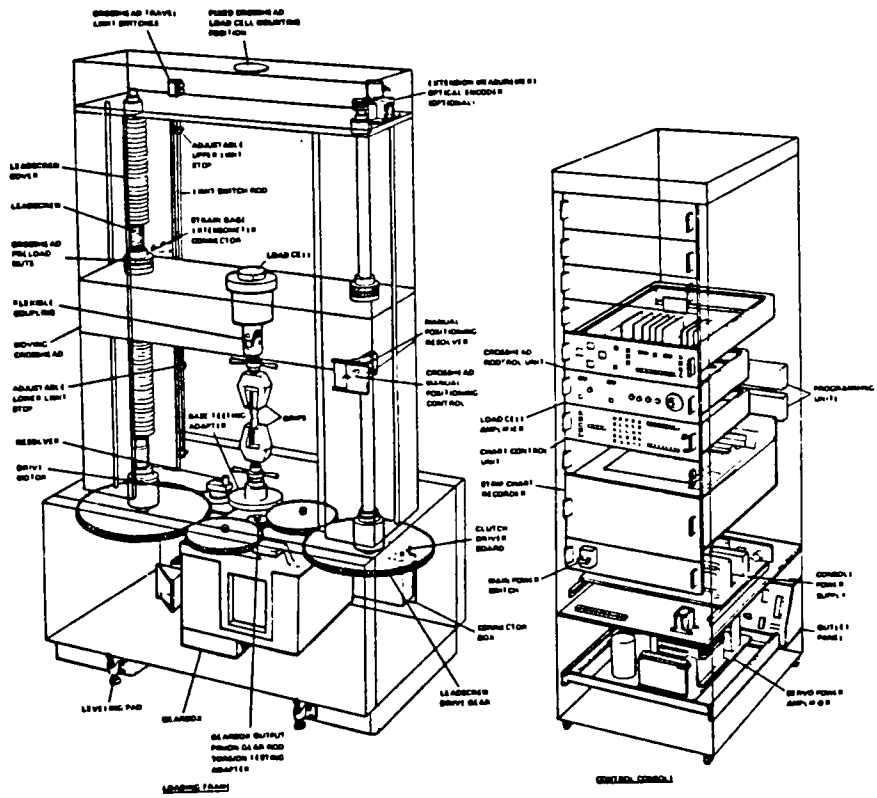


Figure 12. Schematic of the Instron Testing Instrument.

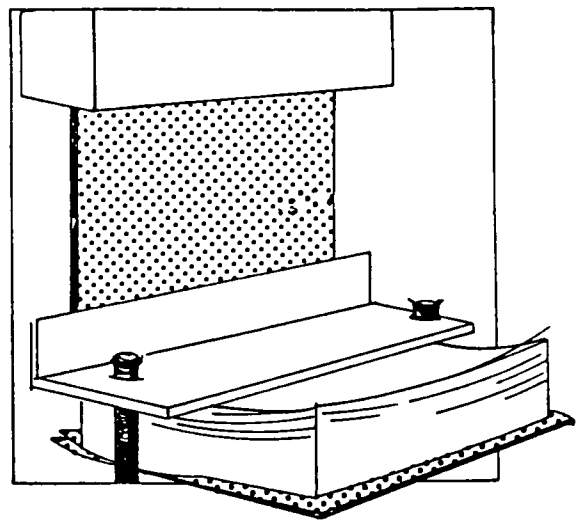


Figure 13. Instron Hinge-Pull Preparation and Mounting

3. Hinge-Delamination Tests

A. UBT and Tumble Testing

To test the effect of circulation or handling on a book's hinges and binding strength, the Universal Book Tester, (UBT) and Tumble Tester were employed. Thirty (30) books were subjected to each test: ten (10) books for each level of oversewn bindings and five (5) books for Singer side sewn books.

The Universal Book Tester, (UBT) developed by the W.J. Barrow Research Laboratory through sponsorship of the Library Technology Project of the ALA, consisted of a rectangular chamber with the sides of the bottom rounded to 1½" radius. The chamber was lined with stainless steel fabric to provide abrasion when the chamber

was rotated in an inclined plane. The volume received repeated impact and abrasion when the apparatus was in operation. The shaft rotated the chamber at a 20^{o} angle for approximately 20 rotations per minute. Each book was placed into identical chambers for three hours of tumbling. The UBT produced the following results:

1. Abrasions of the shoulder of the spine or external hinge.
2. Impact and abrasion on the head and tail caps.
3. Light abrasion of the cover.
4. Limited flexing of the external and internal hinges.
5. Breaking and tearing of the internal hinge.
6. Occasional failure of the sewing, loosening of signatures and splitting of the spine.[4]

In utilizing both, the UBT Test and the Tumble Test, qualitative data was initially produced. The judgement as to the performance of the tested endpapers were analyzed by a panel of experts, then graded in performance according to the following categories:

5) Superior-no damages, no loose joints, good adhesion throughout;
4) Good-loose joints, endpapers remained adhered to boards, no separation from book block;
3) Fair-slight splits or other damages to endpaper construction, endpaper remained adhered to boards, no separation from book block, internal split endpaper;
2) Poor-partially split endpaper, loose joints, endpapers coming loose from boards but not more than ¼ inch;
1) Inferior-split endpapers, loose joints, book block hanging loose between cover boards, endpaper separation from book block.

This non-parametric data was then applied to the ANOVA analysis.

ANALYSIS OF VARIANCE

To properly analyze the effect of endpaper construction, relative relation to openability and hinge strength, a statistical method called "analysis of variance," commonly abbreviated "ANOVA," was employed. ANOVA is a test of averages (means) and a technique by which one can assign to each of the factors tested some portion of the total variability in the data. After carrying out the analysis, tests of significance (F Ratio) were carried out to find whether or not the variance assigned to a specific factor was greater than that which can plausibly be assigned to error.[5] In this case, error was a known value computed from the data or response variables. The significance tests were used with an alpha risk of one percent (= 0.01), which meant that only a one percent probability could exist of the data being incorrect.[6] In so doing, the confidence level was set at 99%.

The specific ANOVA utilized four factors, which had two levels, each was crossed, replicated and nested. The four factors each with two levels were:

1. FACTOR: ENDPAPER
   A. Wide Hinged
   B. Standard
2. FACTOR: BINDING METHOD
   A. Oversewn, flat backed, and rounded/backed
   B. Singer side sewn, flat backed, and rounded/backed
3. FACTOR: PAPER
   A. Coated
   B. Uncoated
4. FACTOR: GRAIN
   A. Cross
   B. Long

In this case, crossed meant that the tests were run at each level in combination with every other level,[7] yielding 16 different combinations or treatments of books (2 x 2 x 2 x 2) for oversewn books and 8 different treatments for Singer side sewn books. Nested was to mean that some of the factors were contained within other factors as subclasses; so they could not be compared at each level of every other factor.[8] The testing was also replicated, which allowed for a more sensitive ANOVA because it provided the estimate of error needed for the F Ratio. In this case, 4 volumes were prepared for each of the sixteen (16) categories for a total of ninety-six (96) test books.

The mathematical model for the four factor, two level, crossed, nested, and replicated experiment was:

$$X_{ijkl4}^{*} = u + A_i + B_j + C_k + D_l + (A \times B)_{ij} + (A \times C)_{ik} + (A \times D)_{il} + (B \times C)_{jk} + (B \times D)_{jl} + (C \times D)_{kl} + (A \times B \times C)_{ijk} + (A \times C \times D)_{ikl} + (B \times C \times D)_{jkl} + (A \times B \times C \times D)_{ijkl} + E_4(ijkl)$$

Conceptually, this meant a single observation or response variable, X_{ijkl}, was hypothesized to be accurate for sixteen (16) possible influences. They were:

1. u, The general average (mean) of the population of all tested books
2. A_i, a possible endpaper effect
3. B_j, a possible binding effect
4. C_k, a possible paper effect

5. D_l, a possible grain effect
6. $(A \times B)_{ij}$, a possible endpaper/binding interaction effect
7. $(A \times C)_{ik}$, a possible endpaper/paper interaction effect
8. $(A \times D)_{il}$, a possible endpaper/grain interaction effect
9. $(B \times C)_{jk}$, a possible binding/paper interaction effect
10. $(B \times D)_{jl}$, a possible binding/grain interaction effect
11. $(C \times D)_{kl}$, a possible paper/grain interaction effect
12. $(A \times B \times C)_{ijk}$, a possible endpaper/binding/paper interaction effect
13. $(A \times C \times D)_{ikl,}$ a possible endpaper//paper/grain interaction effect
14. $(B \times C \times D)_{jkl}$, a possible binding/paper/grain interaction effect
15. $(A \times B \times C \times D)_{ijkl}$, a possible endpaper/binding/paper/grain interaction effect
16. E4(ijkl), Error.

* The letter i,j,k,and l stand for different treatment levels of the factors, 4 stands for replicates.

A null hypothesis (H_0) was stated for each of the effects (2 through 15) above, each stating that the effect of the factor or interaction was zero or attributed to error at any level.[9] These were:

H_0: $A_i = 0$, H_0: $B_j = 0$, H_0: $C_k = 0$, H_0: $D_l = 0$, H_0: $(A \times B)_{ij} = 0$,

H_0: $(A \times D)_{il} = 0$, H_0: $(B \times C)_{jk} = 0$, H_0: $(B \times D)_{jl} = 0$,

H_0: $(C \times D)_{kl} = 0$, H_0: $(A \times B \times C)_{ijk} = 0$, H_0: $(A \times C \times D)_{ikl} = 0$,

H_0: $(B \times C \times D)_{jkl} = 0$ H_0: $(A \times B \times C \times D)_{ijkl} = 0$.

These null hypotheses were what the ANOVAs tested, by means of the Openability, Instron Hinge Pull, UBT and Tumble tests.

DUNCAN MULTIPLE RANGE TEST

If the ANOVA had led to the reject of the null hypothesis for a tested factor, the Multiple Range test was applied to discover which levels of the factor contributed to the effect. This test utilized the significant studentized range which allowed the writer to evaluate the difference between the two means that involved different populations.[10]

Data tables and charts of the ANOVA and Duncan Multiple Range Test are included in the Appendix section.

FOOTNOTES FOR CHAPTER FOUR

[1]Werner Rebsamen, "Bookbinding Testing Laboratory Evaluates Machinery, Materials, and Techniques," Book Production & Magazine Production (May 1977), p.66.

[2]American Library Association, Library Technology Project, Development of Performance Standards for Library Binding, Phase II. LPT Publications No. 10 (Chicago: American Library Association, 1966), p. 37.

[3]Instron Universal Testing Instrument Manual for Model 1125, p. 1-1.

[4]Jack Bendror, Technology and Testing of Library Bound Books (Rochester, New York: Graphic Arts Research Center, 1976), p.8.

[5]Albert D. Rickmers and Hollis N. Todd, Statistics: An Introduction (New York: McGraw Hill Book Company, 1967), p. 179.

6Ibid., p.64.

[7]Ibid., p. 199.

[8]Ibid., p. 200.

[9]Ibid., p. 182.

[10]Ibid., p. 222-224.

CHAPTER 5

ANALYSIS OF DATA AND RESULTS

It was the writer's original intent to compare the effects of paper, grain, endpaper, binding and their appropriate crosses. In the initial ANOVA analysis, the writer quantified the statistics at an alpha risk of .05 with a confidence level of 95%. The findings validated that greatly significant differences were exclusive to the levels of endpaper, binding and their crosses. At this particular confidence level, no significant differences in the remaining levels and crosses were detected, therefore these levels were excluded from all testing, (Figure 14). The question which then arose was, "To what extreme are endpaper, binding and their crosses significant?" All testing of these particular levels were run at an alpha risk of .01 and a confidence level of 99%.

It is imperative that the reader keep in mind that these performance comparisons were done using papers of the similar basis weights. It would be unwise to conclude that the relationships between paper quality (weight and stiffness) and grain direction in openability would not be significantly different for all papers and basis weights. All raw scores, ANOVA Summaries, and Duncan analyses may be found in Appendices.

Figure 14.

MULTI-LEVEL ANOVA SUMMARY FOR FLAT BACKED AND ROUNDED/BACKED BOOKS AT AN ALPHA RISK OF .05 AND CONFIDENCE LEVEL OF 95%

SOURCE	DF	ANOVA SS	F VALUE	PR>F
Paper	1	0.03219453	2.89	0.0921
***Endpaper**	**1**	**0.17038203**	**15.28**	**0.0002**
Endpaper X Binding	1	0.04314453	3.87	0.0517
Grain	1	0.09975788	0.89	0.3463
Paper X Grain	1	0.00564453	0.51	0.4783
Endpaper X Grain	1	0.00564453	0.51	0.4783
Paper X Grain X Endpap.	1	0.00085078	0.08	0.7829
***Binding**	**1**	**0.56312578**	**50.50**	**0.0001**
Paper X Binding	1	0.03955078	3.55	0.0622
***Endpaper X Binding**	**1**	**0.47166328**	**42.30**	**0.0001**
Endpap. X Paper X Bind	1	0.00618828	0.55	0.4579
Grain X Binding	1	0.00013203	0.01	0.9135
Paper X Grain X Bind	1	0.00310078	0.28	0.5990
Endpaper X Grain X Bind	1	0.00416328	0.37	0.5424
Pap X End. X Grain X Bind	1	.01688203	1.51	0.2211

***Levels which have shown significant differences**

THE OPENABILITY PHOTOCOPY TEST RESULTS AND ANALYSIS

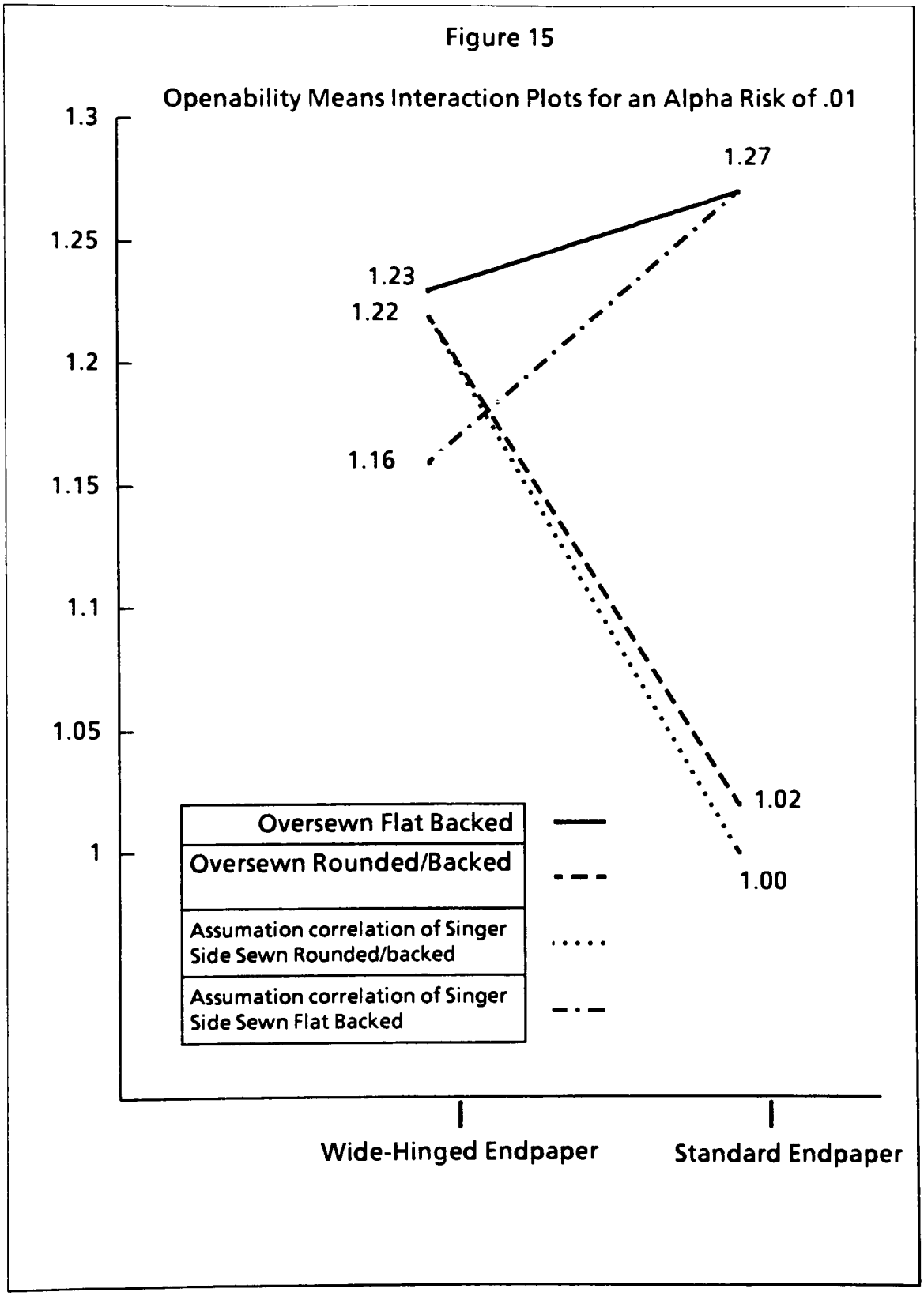
The Openability Photocopy Test revealed that there were significant differences in the ability of a book to lie open flat when comparing endpaper types; Wide-hinged vs. Standard, as well as binding differences; rounded/backed vs. flat backed in oversewn and Singer side sewn books.

In the ANOVA Summary for Openability of Oversewn Books (Table 9), the endpapers: wide hinged vs. Standard endpapers showed a significant difference at a 99% confidence level. The critical value for endpaper was 6.90. The calculated F Value was 15.13, indicating that the null hypothesis must be denied. This meant that there was a significant difference between the endpaper. The application of this data to the Duncan Multiple Range test showed that the wide hinged endpaper had a greater mean openability of 1.22 as to the Standard endpaper which had an openability average of 1.15.

The ANOVA for Openability of oversewn binding comparisons: flat backed vs. rounded/backed showed a significant difference at a 99% confidence level. The calculated F Value was 50.00 which exceeded the critical value of 6.90. Therefore, the null hypothesis was rejected. The Multiple Range test showed the bindings to be significantly different. The flat backed spine treatment allowed for greater openability with a mean of 1.25 as compared to the rounded/backed spine treatment with a mean openability average of 1.18.

For further analysis, one may refer to the Openability Mean Interaction Graph (Figure 15). These interpretations are based on the above ANOVAs, Multiple Range tests, and the mean averages for oversewn

Figure 15


Openability Means Interaction Plots for an Alpha Risk of .01
1.3
1.25
1.2
1.15
1.1
1.05
1
1.27
1.23
1.22
1.16
1.02
1.00
Oversewn Flat Backed
Oversewn Rounded/Backed
Assumation correlation of Singer Side Sewn Rounded/backed
Assumation correlation of Singer Side Sewn Flat Backed
Wide-Hinged Endpaper
Standard Endpaper

books in response to the questions proposed in the Objectives (p. 20).

1) For oversewn books, wide-hinged endpaper may be considered to be an alternative endpaper construction to Standard endpapers.
2) For flat backed, oversewn books, the wide-hinged endpaper may be considered to be equal in openability to the Standard endpaper since the mean difference was .04 of an inch which in this test may be considered an insignificant difference.
3) For rounded/backed, oversewn books: a wide-hinged endpaper construction may be considered to have a greater openability by .20 of an inch than the Standard endpaper with the same binding.
4) As indicated via the Multiple Range test, oversewn, flat backed books exceed the average openability of rounded/backed, oversewn books.
5) In the comparison of oversewn books: flat backed vs. rounded/backed, flat backed books yield an overall greater openability utilizing either endpaper construction.

It was the authors intent through out to offer similar analysis of comparison for Singer side sewn rounded/backed vs. flat backed books. However, the experimental design prohibited accurate cross correlations for comparison, therefore averaged means data of oversewn, rounded/backed books with wide-hinged endpaper and oversewn, flat backed books with Standard endpaper served as reference points for non-tested data based on the intellectual assumption that Singer side sewn books would perform in a similar manner.

The ANOVA Summaries for Singer side sewn books with coated and uncoated papers showed significant differences at a 99% confidence level. For

books constructed of coated substrates, the endpaper F Value was 59.04 vs. uncoated papers which had a F Value of 81.34. Both F Values exceed the critical value of 7.56, thus allowing for the acceptance of the alternative hypothesis. The Multiple Range test showed the endpapers: wide-hinged and Standard, to be significantly different. The mean openability average for wide hinged endpaper was greater than the Standard endpaper by an overall average of 0.16 inches. Finding that the wide-hinged endpaper was superior then the Standard endpaper in openability was in accordance with the previous findings for oversewn books.

By applying the means data for Singer side sewn books to the Interaction Means Graph, it was found that:

1) Singer side sewn, flat backed books with a wide-hinged endpaper offered a greater area of openability then a Singer side sewn, rounded/backed book with a Standard endpaper by .16 of an inch.
2) All Singer side sewn books responded in a similar manner to those of oversewn books, thus proving the validity of the previously stated assumption for the proposed response of Singer side sewn books.

THE INSTRON HINGE PULL TEST ANALYSIS

This hinge strength test, too, supported the findings that only the variables of endpaper and binding affected the strength of the endpaper construction. With this in mind, the factors of paper and grain direction were not tested further.

The ANOVA Summary for the Instron Hinge Pull test, (Table 15)

concluded that the endpaper variance between the levels: wide-hinged vs. Standard endpaper in oversewn books was so minimal that no significant difference was detected at a 99% confidence level. The critical value for this comparison was 7.26 and the F Value for endpaper was 3.21. Thus, the critical value for significance was not exceeded and the null hypothesis was accepted. By accepting this hypothesis, there was an 8% chance of a Type One error. Although, no significant difference was detected in the ANOVA, the Multiple Range test was applied to determine the least significant difference between the endpapers. The mean load for wide-hinged endpaper was 378.69 lbs. as compared to the mean load of 409.46 lbs. for Standard endpaper. The analysis of this data indicated that the Standard endpaper is superior in strength by only a minimal difference, that the null hypothesis was further supported. Therefore, in this test, both wide-hinged and Standard endpaper in oversewn books may be considered equal in strength.

The levels of binding: Flatbacked vs. Rounded/Backed for oversewn books indicated a significant difference in the ANOVA. The critical value was 7.26 which was exceeded by the F Value of 45.56. In lieu of this, the null hypothesis was rejected. The Multiple Range test determined that flat backed books had a greater mean load of 452.03 lbs. as compared to rounded/backed books with a mean load of 336.11 lbs. Therefore, books which utilized a flat backed binding required a greater force to pull the hinge from the binding. This may be explained by the spine characteristic known as the clamping effect, which is a unique phenomenon associated with flat backed books. Due to the flat spine construction, great strength is built into the binding edge but

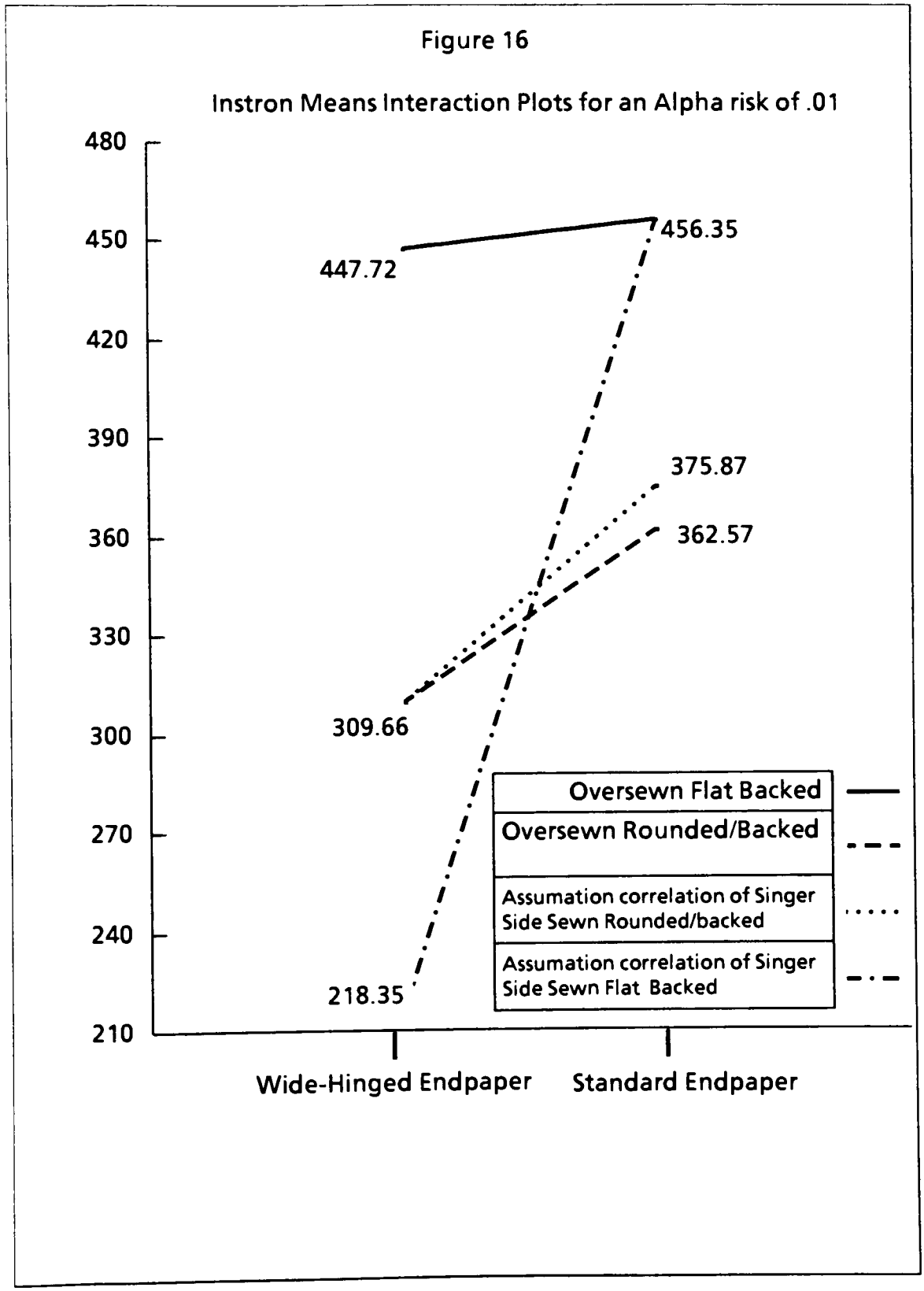
limitations in the flexing angles and hinge movement are incurred.[1] Consequently, the greater mean load for flat backed books may be attributed to this factor.

The analyses of the Instron Means Interaction Graph, (Figure 16), are based on the proceeding ANOVA data, Multiple Range test and the mean averages for oversewn books in response to the questions posed in the Objectives section (p. 20).

1) For oversewn, flat backed books, wide-hinged endpaper may be considered to be an alternative endpaper construction to Standard endpapers.
2) As indicated by the Multiple Range test and verified by the Means Interaction Graph, oversewn, flat backed books showed a greater strength difference than oversewn, rounded/backed books.
3) For oversewn, rounded/backed books: the Standard endpaper construction required a greater force to be delamination from the hinge from the binding, (362.57>309.66). This evidence suggests that the Standard endpaper had a greater influence on the response strength of rounded/backed, oversewn bindings then the wide-hinged construction.

The One-Way ANOVA Summary Analysis for Instron-Pulled Singer side sewn Books (Table 17), showed that the endpapers; wide-hinged vs. Standard endpapers in Singer side sewn books, were significant factors in the effectiveness of hinge strength on a book's durability. At a 99% confidence level, the factor of endpaper showed an F Value of 52.06 which exceeded the Critical Value of 7.95. The Multiple Range test discriminated between the two tested endpapers via their mean. The

Figure 16


Instron Means Interaction Plots for an Alpha risk of .01
480
450
420
390
360
330
300
270
240
210
447.72
456.35
375.87
362.57
309.66
218.35
Oversewn Flat Backed
Oversewn Rounded/Backed
Assumation correlation of Singer Side Sewn Rounded/backed
Assumation correlation of Singer Side Sewn Flat Backed
Wide-Hinged Endpaper
Standard Endpaper

Standard endpaper had a greater mean load at 375.87 lbs. as compared to the mean load of 218.35 for wide-hinged endpaper. This indicated that books bound utilizing the Standard endpaper required a greater force to be delaminated from the hinge of the book block, thus demonstrating it's superiority in this test.

However, there is a question as to the validity of the test results for some of the samples. The averages for the Instron Pull Test for Singer side sewn books with wide hinged endpapers were questioned. In this test, the force required to pull the board from the hinge was designed to be perpendicular to the grain direction of the board. In order to meet Library Standards, the manufacturing of all books must follow the LBI requirements. They specify that the book case must be constructed of binders board in which the grain is parallel to the binding edge.[2] (This creates a stronger, more readable book.) Upon close examination, the boards which created the book case for all Singer side sewn, wide-hinged books were constructed in the cross grain direction. According to Werner Rebsamen, in his article "Paper Grain", "Most papers and boards generally will offer greater resistance to being torn in a direction perpendicular to the grain."[3] However, the construction of these particular book cases in question: Singer side sewn, flat backed books with wide-hinged endpapers, were bound with the board grain perpendicular to the spine which allowed for the load force to delaminate the cover in the direction of the grain; the response was considered an abnormally low (Figure 17).

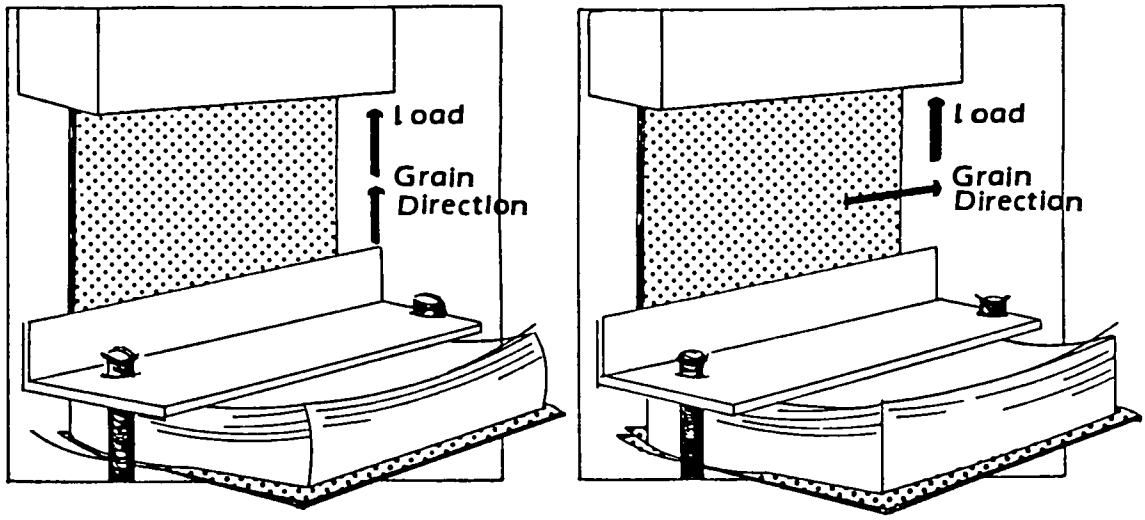


Figure 17. A Comparison of Upward Load Forces and Board Grain Directions.

Therefore, based on this information, it is assumed that the averages for wide-hinged endpaper in Singer side sewn, flat backed books would have been much higher then the mean load average indicated. Consequently, in the analysis of the Interaction Means Graph for Singer side sewn endpaper comparisons it may be considered that:

1)The unsual difference between the endpapers: wide-hinged vs. Standard in flat backed and rounded/backed, (218.35 vs. 456.35) was due to the improper manufacturing of Singer side sewn, flat backed, wide-hinged books and not the result of extreme endpaper differences.

2)It is suggested by the interpretation of the ANOVA and Multiple Range test that the Standard endpaper would yield a greater degree of significance.

THE TUMBLE TEST ANALYSIS

The Tumble Test, run at a 99% confidence level, revealed that all of the books tested (30) showed a significant difference in endpaper construction, binding treatment and in the crosses of binding and endpaper.

Based on the ANOVA Summary for Tumble Tested, oversewn books, (Table 19) wide-hinged endpaper vs. Standard endpaper showed a significant difference in hinge durability. The critical value required at this confidence level was 7.43, and was exceeded by the calculated F Value of 17.85. This data allowed for the rejection of the null hypothesis. The Duncan Multiple Range test for oversewn books allowed for the comparison of least significant differences (LSD) within this level. The Standard endpaper had a greater durability at a mean of 3.65 as compared to the wide-hinged endpaper, which had a mean of 3.10. Thus, in the Tumble Test for oversewn books, the Standard endpaper indicated a greater hinge durability response then the wide-hinged endpaper.

The statistics of the ANOVA analysis for this test indicated that the binding, as anticipated, had a significant influence on the hinge durability. The binding level of flat backed vs. rounded/backed for oversewn books yielded an F Value of 107.56, which far surpassed the critical factor of 7.43, thus supporting the rejection of the null hypothesis. The Multiple Range test showed that flat backed books had a greater durability mean of 4.05 as compared to that of 2.7 for rounded/backed books. Thus, the ANOVA for the oversewn books proved that durability was also based on binding and that the flat backed bindings were superior in hinge durability than oversewn books with rounded/backed bindings.

The proceeding analysis may be exemplified in the Tumble Tested Interaction Means Graph (Figure 18). From this graph it may be concluded that for oversewn bindings:

1)Flatbacked books bound with wide-hinged endpapers are superior in hinge durability as compared to flat backed books which utilized the Standard endpaper.

2)Wide-hinged endpaper may be considered as an alternative to the Standard endpaper in the construction of flat backed, oversewn books.

3)Flatbacked books indicate an over-all superiority in hinge strength as compared to rounded/backed books.

4)Rounded/Backed books bound using Standard endpapers are superior in hinge strength as compared to rounded/backed books with wide-hinged endpapers.

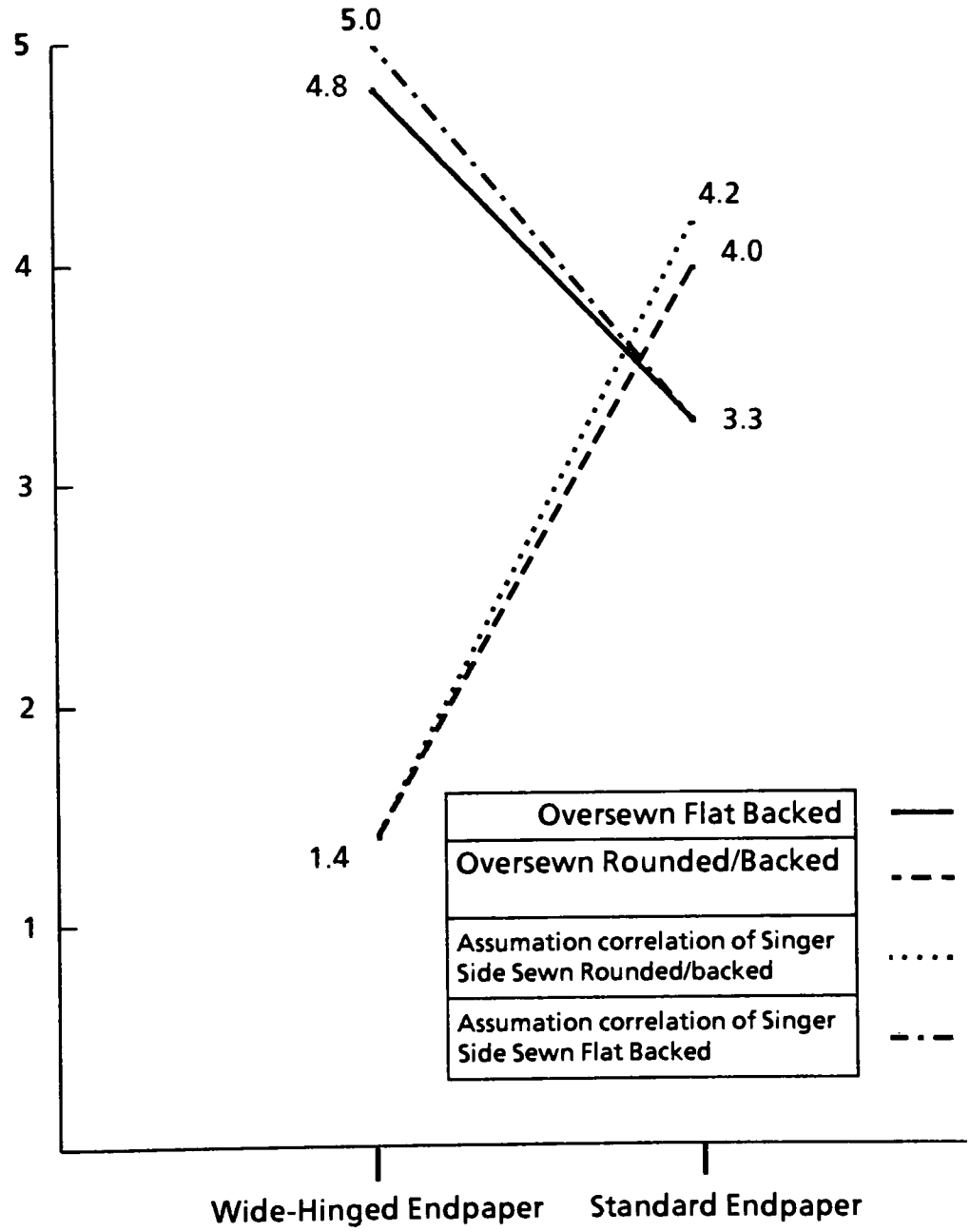
5)Wide-hinged endpaper may not be considered as an alternative endpaper construction in oversewn, rounded/backed books.

The One-Way ANOVA for Singer side sewn books revealed that the two, tested endpapers were significantly different at a 99% confidence level. With a sample size of (10) ten, the F Value was 36.00 compared to the critical value of 8.29. These statistics for flat backed, wide-hinged endpapers vs. rounded/backed, Standard endpapers for Singer side sewn books supported the alternative hypothesis. The LSD was determined by the Multiple Range test. It showed that the wide-hinged endpaper was significantly different (5.0), as compared to the Standard endpaper with a durability mean of (4.2).

Based on the Tumble Test Interaction Graph and the Multiple Range test, it was validated that:

Figure 18

Tumble Test Means Interaction Plots for an Alpha Risk of .01



1) The two, tested endpapers: wide-hinged and Standard, for Singer side sewn books were significantly different.
2) Flatbacked books with wide-hinged endpaper yielded a greater degree of hinge durability as compared to the rounded/backed books, which used Standard endpapers.

THE UBT TUMBLE TEST ANALYSIS

The ANOVA Summary Table for the UBT Tumble Tested Responses of oversewn Books (Table 25) indicated no significant difference at a 99% confidence level for the endpaper levels. This analysis, which tested the hinge durability of endpaper and binding, indicated the critical value of 7.43 for both factors. The calculated F Values for the bindings and the endpapers were 2.28 and 1.01, respectively. By crossing these two levels an F Value of 0.25 was yielded. These values did not surpass the critical value, thus the null hypothesis was accepted. It may be stated that by the acceptance of this hypothesis, the wide-hinged endpaper may serve as an alternative endpaper construction in either binding technique. In accordance with this hypothesis, the probability of a Type One error is .32 for endpaper, .14 for binding and .62 for their crosses.

In this analysis, it is imperative to remember that the origins of the data were based on a nonparametric test who's ranking ranged from 1-5. Therefore, the Multiple Range test concurred with the findings in the ANOVA, such that the difference between the two endpapers indicated very little significance. Further analysis revealed the binding

treatments for oversewn books, too, responded in a comparable manner. The most extreme difference in response was attributed to the interaction between the wide-hinged endpaper vs. the Standard endpaper in oversewn books (5.0>4.3).

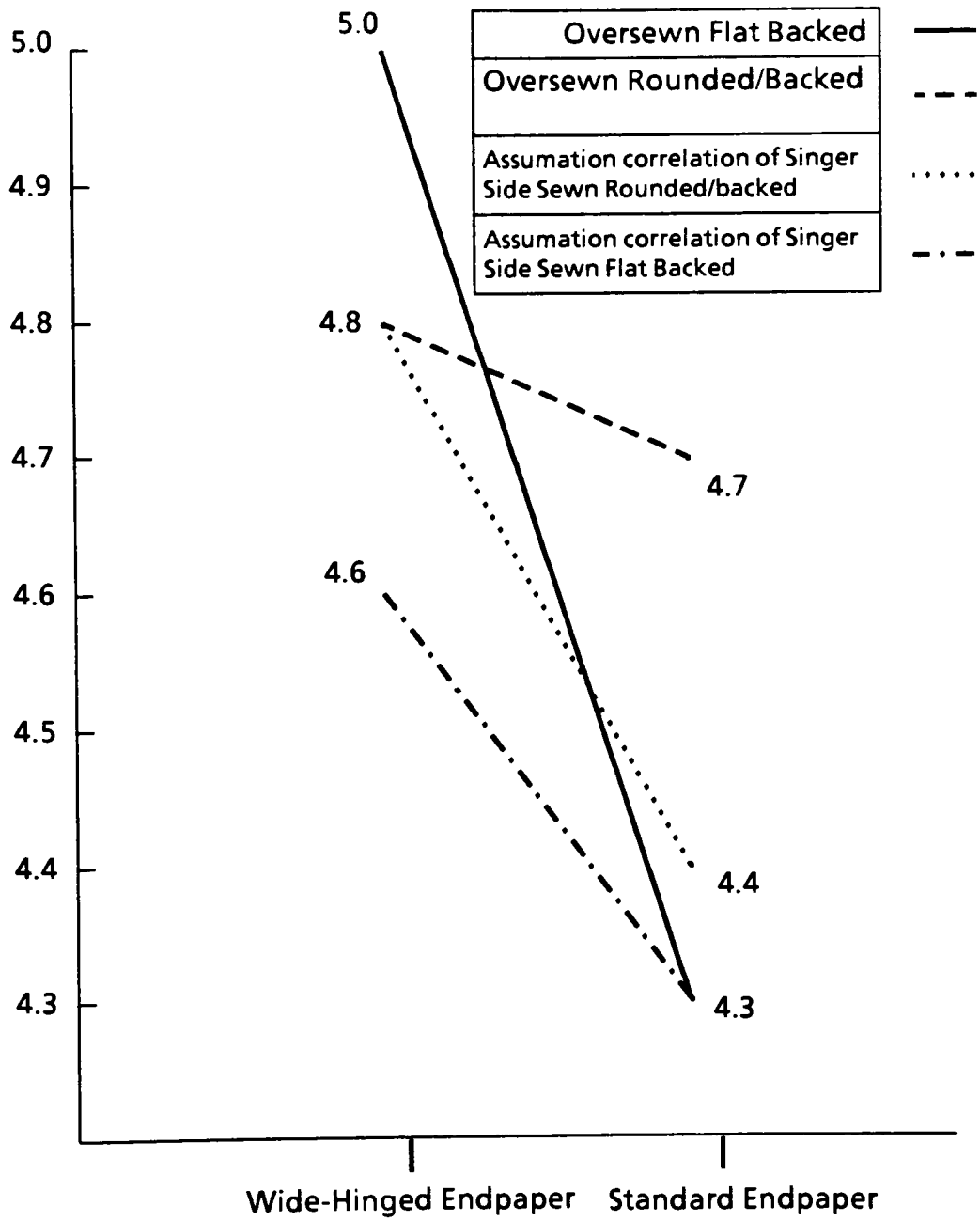
The ANOVA Summary Table for Endpaper Response in Singer side sewn Books (Table 25) showed no significant difference in endpaper construction with a critical F Value of 8.29 at a 99% confidence level. The calculated endpaper factor F Ratio was 5.06. The Multiple Range test indicated the mean difference between wide-hinged endpaper vs. Standard endpaper was 0.6 (5.0 vs. 4.4).

The UBT Means Interaction Means Graph (Figure 19) indicated that:

1) For all books which utilized the wide-hinged endpaper construction a superior durability response was indicated regardless of binding technique.
2) The wide-hinged endpaper may be considered an alternative endpaper construction to the Standard endpaper for all tested oversewn and Singer side sewn binding techniques if the hinge strength is of main concern.

Figure 19

UBT Means Interaction Plots for an Alpha Risk of .01



FOOTNOTES FOR CHAPTER FIVE

[1]Peter Cooper, "Adhesives," Product Information, p. 4.

[2]Paul A. Parisi and Jan Merrill-Oldham, Library Binding Institute Standard for Library Binding (Rochester, New York: Library Binding Institute, 1986), p. 8.

[3]Werner Rebsamen, "Paper Grain" The New Library Scene (February 1985), p.13.

CHAPTER SIX

CONCLUSIONS AND SUMMARY

The purpose of this investigation was to determine the hinge strength and openability performance of two endpapers: wide-hinged and Standard endpapers in correlation to the binding factors of oversewing and Singer side sewing in rounded/backed and flat backed books. This study achieved its' main objective: to statistically test the strength and durability characteristics of wide-hinged endpaper as compared to the Standard endpaper at a 99% confidence level and (an alpha risk of 0.01.) The analysis of variance (ANOVA) showed which factors were significant and to which factors the differences were due. The Duncan Multiple Range Test indicated the least significant difference (LSD) between the factors which had initially indicated significance in the original ANOVA. Finally, the mean averages of all tested factors were presented in the form of interaction graphs which allowed for visual analysis of all factors observed within this investigation.

A series of tests were run and data statistically analyzed to answer the following specific questions:

A. Was there a significant average strength difference as measured by the Instron Hinge-Pull Tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. The wide-hinged endpaper may be considered an alternative to the Standard endpaper in response

to hinge strength.

2. between wide-hinged, oversewn books: flat backed vs rounded/backed spine treatments? Yes. The wide-hinged, flat backed books indicated a superior hinge strength.
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? Yes. Wide-hinged, flat backed books indicated a superior hinge-strength.
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. In rounded/backed books, the Standard endpaper showed a greater hinge strength response.
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments? Yes. Oversewn, flat backed books had a greater hinge strength response.
6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? Yes. Oversewn, flat backed books which utilized the Standard endpaper indicate a superior hinge strength.
7. between Singer side sewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? Yes. Singer side sewn books that were flat backed with wide-hinged endpapers indicate a superior hinge strength.

B. Was there a significant difference in average openability as measured by the Photocopy Test at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. The wide-hinged endpaper may be considered an alternative endpaper construction to the Standard

endpaper for oversewn, flat backed books in response to openability.

2. between wide-hinged, oversewn books: flat backed vs rounded/backed spine treatments? No. The acceptance of the null hypothesis allowed the wide-hinged endpaper to serve as an alternate endpaper construction in response to the concerns for openability for either spine treatment.
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? Yes. Wide-hinged, oversewn, flat backed books indicated a superior openability.
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. Wide-hinged endpaper indicated a greater openability response, therefore, may be considered as an alternative endpaper in response to the concerns for openability.
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments? Yes. Flatbacked, oversewn books indicated a greater openability.
6. between Oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? Yes. Oversewn, flat backed books which utilized the Standard endpaper construction indicated superior openability by .04 of an inch.
7. between Singer side sewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? Yes. Singer side sewn, flat backed books with wide-hinged endpaper indicated a superior openability.

C. Was there a significant average strength difference as measured by the Tumble Tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. Oversewn, flat backed books bound with wide-hinged endpapers showed a greater degree of strength, therefore wide-hinged endpaper may be considered an alternative to the Standard endpaper in response to hinge durability.
2. between wide-hinged, oversewn books: rounded/backed vs flat backed spine treatments? Yes. Flatbacked books with the wide-hinged endpaper construction indicated a superior hinge strength.
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? Yes. Oversewn, flat backed books with wide-hinged endpapers displayed a superior hinge strength response.
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers? Yes. For oversewn, rounded/backed books, the Standard hinged endpaper responded with a greater hinge strength.
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments? Yes. Books with a rounded/backed spine were shown to respond with a greater degree of hinge strength.
6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? Yes. In response to hinge strength for

oversewn books, the Standard endpaper construction with flat backed spines were shown to be greater in significance.

7. between Singer side sewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? Yes. Singer side sewn, flat backed books with the Standard endpaper displayed a greater hinge strength in response to this question.

D. Was there a significant average strength difference as measured by the UBT Tumble tester at a 99% confidence level:

1. between flat backed, oversewn books: wide-hinged vs Standard hinged endpapers? No significant difference was found; therefore the wide-hinged endpaper may be considered as an alternative construction in response to this question.
2. between wide-hinged, oversewn books: rounded/backed vs flat backed spine treatments? No significant difference was found in hinge strength.
3. between oversewn books: wide-hinged, flat backed vs Standard hinged, rounded/backed? No significant difference was detected in response to hinge strength.
4. between rounded/backed, oversewn books: wide-hinged vs Standard hinged endpapers? No significant difference was found; therefore the wide-hinged endpaper may be considered as an alternative construction in response to this question.
5. between Standard hinged, oversewn books: flat backed vs rounded/backed spine treatments? No significant difference was indicated.

6. between oversewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? No significant difference in hinge strength was indicated.
7. between Singer side sewn books: wide-hinged, rounded/backed vs Standard hinged, flat backed? No significant difference was detected.

The Photocopy Openability Test provided the support required to evaluate the readability of a book. Both tested factors: endpaper and binding, showed significance. The ANOVA Summary and the Multiple Range Test indicated that the wide-hinged endpaper had a greater mean average than the Standard endpaper. The analyses also indicated that all flat backed books had a superior mean of openability. This determination was further validated by the Openability Mean Interaction Chart. However, from this data it was indicated that the wide-hinged endpaper was only superior in the openability of rounded/backed books and not flat backed books. It may be assumed that the binding factors and their unique characteristics were the most influential factors in determining the openability of a book and that the endpaper construction were only secondary factors.

The general findings of the ANOVA and Multiple Range test for the hinge strength of endpapers indicated in the oversewn books no significant difference between the wide-hinged and Standard endpapers existed. However, in Singer side sewn books, this difference was extremely significant, such that the Standard endpaper was more significant in strength as compared to the wide-hinged. These findings

were further supported by the Interaction Means Graph for the Instron Hinge-Pull test. All books bound with Standard endpapers indicated a greater strength in the hinge.

In the comparison of binding factors, the Singer side sewn and oversewn, flat backed books offered a greater strength in binding hinge as compared to rounded/backed books with the same binding techniques. It was proposed that the clamping effect, characteristic of flat backed books, induced this strength difference.

The Tumble Test, which non-parametrically measured the durability of the hinge strength of the endpapers, indicated that the endpaper construction and binding were significant factors in the determination of a books' longevity. The Multiple Range test showed that the Standard endpaper was the most significant factor within the level of endpaper. As in the previous tests, the flat backed, oversewn books were shown to be of greater significance than rounded/backed, oversewn books. In the Singer side sewn books, wide-hinged endpaper were shown to be the most significance. When applied to an interaction means graph, the data supported these conclusions. Flatbacked, oversewn and Singer side sewn books with wide-hinged endpapers were shown to exhibit the greatest hinge durability. Again, supported by the previous findings in the Openability and Instron Test, the Standard endpaper proved to be superior exclusively to rounded/backed oversewn and rounded/backed Singer side sewn books. Unique to this graph were the interactions between the flat backed books; oversewn and Singer side sewn, and between rounded/backed books; oversewn and Singer side sewn books. For two exceptionally individual binding techniques: oversewing and Singer

side sewing, all books with flat backed spines responded similar as well as all rounded/backed spines.

The results of the UBT Test for Oversewn books suggested that no significant differences had existed between endpapers or binding factors. Indeed, in review of the ANOVA and Multiple Range test, little difference in the data was apparent. Therefore, in this particular test, it may be stated that both endpapers performed equally and that the wide-hinged endpaper may be utilized as an alternative to the Standard endpaper. The response for the factor of endpapers in Singer side sewn books indicated that a wide-hinged construction had a superior durability as compared to the Standard. This was further supported by the interaction graph.

Coupled with the analysis from the Tumble Test, each measuring the durability of hinge strength, it may be stated that all flat backed books: oversewn and Singer side sewn with wide-hinged endpaper exhibited the greatest degree of durability. In this particular analysis, all books with Standard endpaper proved to be subordinate to the alternate or wide-hinged endpaper.

It can be concluded from the results of these experiments that wide-hinged endpaper in flat backed, oversewn books may be considered to serve as an alternative to the current Standard endpaper. This endpaper has either proven to be equal or superior to the Standard when applied to this particular binding technique.

Oversewn and Singer side sewn, rounded/backed books which had employed the use of Standard endpapers proved to exceed the wide-hinged endpapers in strength and durability as indicated by the Tumble Test and the

Instron Hinge-Pull Test. However, these books showed a dramatic decline in openability as compared to books with the same binding treatment but utilizing wide-hinged endpaper.

Singer side sewn, flat backed books, with Standard endpapers proved to be greater in openability and strength than the wide-hinged endpaper. According to the statistical testing, the wide-hinged endpaper proved to be significantly different than the Standard endpaper. This may indicate that indeed, the wide-hinged endpapers are superior but the binding characteristics, themselves, predetermine the final response and that the endpaper construction is secondary.

CHAPTER SEVEN

RECOMMENDATIONS FOR FURTHER RESEARCH

Based on these findings, librarians and library binders may now make a more informed decision in the selection of a suitable endpaper construction in relation to binding technique. These experiments led to optimum choices under the specific set of parameters designed in this study. Further research is required for books with different dimensions and paper qualities. It is also recommended that a more precise testing procedure be developed for an accurate comparison of flat backed and rounded/backed Singer side sewn books. Further, retesting for hinge strength of the Singer side sewn books which use a wide-hinged endpaper is recommended. It was the intention of this study, in its detail, for researchers to follow suit by building on this work. All data gathered in a similar manner may be directly compared to this study.

BIBLIOGRAPHY

American Library Association. Library Technology Project. Development of Performance Standards for Library Binding, Phase II. LPT Publications No. 10. Chicago: American Library Association, 1966.

Bendror, Jack. Technology and Testing of Library Bound Book. Rochester, New York: Graphic Arts Research Center, Rochester Institute of Technology, 1976.

Cooper, Peter. "Hints for Better Adhesive Binding with Hot Melts." Adhesives Product Information, Peter Cooper Corporations, Gowanda, New York.

Instron Co., Instron Universal Testing Instrument, Model 1125.

James, Fritz. "Alternate Endpaper Construction for Oversewing Library Volumes." Library Binding Service, Winter 1986.

Library Binding Institute. Technology Reports, through 1976.

Parisi, Paul A. and Merrill-Oldham, Jan. Library Binding Institute Standard For Library Binding. Rochester, New York: Library Binding Institute, ed. 8, 1986.

MacDougall, William and Golden, Sharon. "Battling Father Time to Save a Vast Treasure." U.S. News & World Report. April 1985.

Rebsamen, Werner. "Alternate Endpaper Construction for Oversewn and side sewn Library Bindings." Proposed article for The New Library Scene.

Rebsamen, Werner. "Binding." Library Trends. Fall 1981.

Rebsamen, Werner. "Bookbinding Testing Laboratory Evaluates Machinery Techniques." Book Production Industry & Magazine Production, May 1977.

Rebsamen, Werner. "Paper Grain." The New Library Scene, February 1985.

Rebsamen, Werner. "A Study of Simple Binding Methods." A five part series. The Library Scene, June 1979-June 1980.

Rebsamen, Werner. "Testing Bindings - An introduction to Bendror, Jack. Technology and Testing of Library Bound Books, 1976.

Rickmers, Albert D., and Hollis N. Todd. Statistics: An Introduction. New York: McGraw Hill Book Company, 1967.

Stratton, John B."Libraries and Commercial Binderies." Library Trends, January 1956.

Strauss, Victor. The Printing Industry. Washington, D.C.: Printing Industries of America, Inc., 1967.

Weiss, Dudley A. "The LBI Standard: The Only Industry Standard for Library Bound Books." The Library Scene, September 1975.

Table 1

BOOK TREATMENT FOR THE OPENABILITY TEST

BINDING		PAPER: COATED — WIDE-HINGED ENDPAPER — CROSS GRAIN		PAPER: COATED — WIDE-HINGED ENDPAPER — LONG GRAIN		PAPER: COATED — STANDARD ENDPAPER — CROSS GRAIN		PAPER: COATED — STANDARD ENDPAPER — LONG GRAIN		PAPER: UNCOATED — WIDE-HINGED ENDPAPER — CROSS GRAIN		PAPER: UNCOATED — WIDE-HINGED ENDPAPER — LONG GRAIN		PAPER: UNCOATED — STANDARD ENDPAPER — CROSS GRAIN		PAPER: UNCOATED — STANDARD ENDPAPER — LONG GRAIN		VOLUMES
		A1		A2		A3		A4		A5		A6		A7		A8		
OVERSEWN FLAT BACKED	B1	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	B
		2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	B
		3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	B
		4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	B
OVERSEWN ROUNDED/ BACKED	B2	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	1F	1B	B
		2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	2F	2B	B
		3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	3F	3B	B
		4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	4F	4B	B
SINGER SIDE SEWN FLAT BACKED	B3	1F	1B	1F	1B					1F	1B	1F	1B					4
		2F	2B	2F	2B					2F	2B	2F	2B					4
		3F	3B	3F	3B					3F	3B	3F	3B					4
		4F	4B	4F	4B					4F	4B	4F	4B					4
SINGER SIDE SEWN ROUNDED/ BACKED	B4					1F	1B	1F	1B					1F	1B	1F	1B	4
						2F	2B	2F	2B					2F	2B	2F	2B	4
						3F	3B	3F	3B					3F	3B	3F	3B	4
						4F	4B	4F	4B					4F	4B	4F	4B	4

TOTAL: 96

Total Book Treatments: 24
f = FRONT ENDPAPER, b = BACK ENDPAPER
Uncoated = 20 lb. Bond
Coated = 60lb. Machine Coated Book
Key identification example: A3B4-1f identifies the front of a volume which has a Standard endpaper construction with the paper in a cross-grain direction that is Singer Side Sewn and rounded/backed.

Table 2

BOOK TREATMENT FOR THE INSTRON HINGE PULL TEST

BINDING		WIDE-HINGED ENDPAPER	STANDARD ENDPAPER	VOLUMES
		A1	A2	
OVERSEWN FLAT BACKED	B1	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B	12
OVERSEWN ROUNDED/ BACKED	B2	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B	12
SINGER SIDE SEWN FLAT BACKED	B3	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B		6
SINGER SIDE SEWN ROUNDED/ BACKED	B4		1F 1B 2F 2B 3F 3B 4F 4B 5F 5B 6F 6B	6

Total: 36

Total Book Treatment = 6
f = Front Endpaper, b = Back Endpaper

Table 3

BOOK TREATMENT FOR THE TUMBLE TEST

BINDING	WIDE-HINGED ENDPAPER		STANDARD ENDPAPER		VOLUMES
	A1		A2		
OVERSEWN FLAT BACKED B1	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		10
OVERSEWN ROUNDED/ BACKED B2	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		10
SINGER SIDE SEWN FLAT BACKED B3	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B				5
SINGER SIDE SEWN ROUNDED/ BACKED B4			1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		5

Total: 30

Table 4

BOOK TREATMENT FOR THE UBT TEST

BINDING	WIDE-HINGED ENDPAPER		STANDARD ENDPAPER		VOLUMES
	A1		A2		
OVERSEWN FLAT BACKED B1	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		10
OVERSEWN ROUNDED/ BACKED B2	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		10
SINGER SIDE SEWN FLAT BACKED B3	1F 1B 2F 2B 3F 3B 4F 4B 5F 5B				5
SINGER SIDE SEWN ROUNDED/ BACKED B4			1F 1B 2F 2B 3F 3B 4F 4B 5F 5B		5

Total: 30

Total Book Treatment for each test = 6
f = Front Endpaper, b = Back Endpaper

APPENDIX B

TABLES 5A - 8

TEST DATA CHARTS

Table 5a

OPENABILITY PHOTOCOPY TEST DATA FOR UNCOATED PAPER MEASURED 5" INWARD FROM THE FORE EDGE OF THE BOOK

BINDING		WIDE-HINGED ENDPAPER				STANDARD ENDPAPER			
		CROSS GRAIN A1		LONG GRAIN A2		CROSS GRAIN A3		LONG GRAIN A4	
OVERSEWN FLAT BACKED	B1	1.18	1.23	1.03	1.30	1.29	1.32	1.22	1.30
		1.18	1.36	1.11	1.32	1.24	1.30	1.29	1.38
		1.21	1.36	1.18	1.37	1.24	1.32	1.14	1.16
		1.16	1.30	1.13	1.42	1.10	1.43	1.21	1.30
		X 1.25	SD 0.06	X 1.23	SD 0.13	X 1.28	SD 0.08	X 1.26	SD 0.06
OVERSEWN ROUNDED/ BACKED	B2	1.13	1.24	1.16	1.26	0.98	1.12	0.93	1.08
		1.12	1.18	1.12	1.35	0.93	1.11	0.85	1.01
		1.22	1.16	1.28	1.14	0.77	1.08	0.78	1.11
		1.21	1.43	1.01	1.30	0.96	1.02	0.70	0.96
		X 1.21	SD 0.09	X 1.20	SD 0.15	X 1.00	SD 0.10	X 0.93	SD 0.13
SINGER SIDE SEWN FLAT BACKED	B3	1.11	1.03	1.16	1.21				
		1.18	1.18	1.10	1.14				
		1.14	1.19	1.13	1.14				
		1.11	1.18	1.22	1.21				
		X 1.14	SD 0.11	X 1.16	SD 0.04				
SINGER SIDE SEWN ROUNDED/ BACKED	B4					1.08	0.99	0.94	1.08
						1.08	0.96	1.03	0.98
						1.03	1.03	0.90	1.00
						0.99	0.98	1.01	1.02
						X 1.02	SD 0.12	X 1.12	SD 0.31

The Openability Photocopy test data are averaged in pounds. From the averages, standard devations were derived. These results supplied the necessary data for the ANOVA and Duncan analysis. Measured in 1/64 = .016"

Table 5b

OPENABILITY PHOTOCOPY TEST DATA FOR COATED PAPER MEASURED 5" INWARD FROM THE FORE EDGE OF THE BOOK

BINDING		WIDE-HINGED ENDPAPER				STANDARD ENDPAPER			
		CROSS GRAIN A1		LONG GRAIN A2		CROSS GRAIN A3		LONG GRAIN A4	
OVERSEWN FLAT BACKED	B1	1.08	1.22	1.03	1.24	1.16	1.41	1.14	1.26
		1.14	1.22	1.13	1.30	1.25	1.37	1.30	1.21
		1.16	1.27	1.26	1.29	1.21	1.37	1.19	1.32
		1.18	1.33	1.24	1.32	1.32	1.42	1.24	1.38
		X 1.20	SD 0.06	X 1.23	SD 0.09	X 1.31	SD 0.08	X 1.26	SD 0.05
OVERSEWN ROUNDED/ BACKED	B2	1.19	1.28	1.11	1.27	0.96	1.14	0.96	0.91
		1.19	1.33	1.13	1.40	0.99	1.12	1.14	1.21
		1.07	1.30	1.11	1.26	0.91	1.10	1.16	1.35
		1.16	1.34	1.16	1.27	1.10	1.18	1.02	1.01
		X 1.24	SD 0.08	X 1.21	SD 0.09	X 1.06	SD 0.08	X 1.10	SD 0.13
SINGER SIDE SEWN FLAT BACKED	B3	1.13	1.10	1.19	1.23				
		1.18	1.26	1.18	1.11				
		1.16	1.19	1.18	1.16				
		1.18	1.18	1.14	1.10				
		X 1.17	SD 0.03	X 1.16	SD 0.04				
SINGER SIDE SEWN ROUNDED/ BACKED	B4					1.03	1.08	0.93	0.98
						1.00	1.00	1.08	1.02
						0.94	1.00	1.08	1.02
						1.03	0.90	1.04	1.03
						X 1.00	SD 0.05	X 1.02	SD 0.03

The Openability Photocopy test data are averaged in pounds. From the averages, standard devations were derived. These results supplied the necessary data for the ANOVA and Duncan analysis. Measured in 1/64 = .016"

Table 6

INSTRON HINGE PULL TEST DATA CHART

BINDING	WIDE-HINGED ENDPAPER A1	STANDARD ENDPAPER A2	VOLUMES
OVERSEWN FLAT BACKED B1	363.76 350.53 396.83 356.04 424.39 432.10 531.31 532.41 501.55 543.43 504.85 435.41 X 447.72 SD 69.47	407.85 518.08 469.58 520.28 418.87 359.35 440.92 443.12 507.06 403.44 546.74 440.92 X 456.35 SD 54.34	12
OVERSEWN ROUNDED/ BACKED B2	186.29 298.72 383.60 311.95 369.27 309.75 374.78 348.33 288.80 348.33 220.46 275.58 X 309.65 SD 71.08	417.77 324.08 341.71 330.69 350.53 363.76 295.42 328.49 407.85 352.74 440.92 396.83 X 362.57 SD 42.09	12
SINGER SIDE SEWN FLAT BACKED B3	275.57 248.02 286.60 231.48 264.55 231.48 203.93 103.62 213.85 200.62 159.83 200.62 X 218.35 SD 47.43		6
SINGER SIDE SEWN ROUNDED/ BACKED B4		410.94 287.04 427.69 382.28 410.50 368.17 242.51 369.49 396.02 409.17 417.11 392.42 X 396.02 SD 57.15	6

MEASURED IN POUNDS

Table 7

TUMBLE TEST DATA CHART

BINDING		WIDE-HINGED ENDPAPER A1				STANDARD ENDPAPER A2				VOLUMES
OVERSEWN FLAT BACKED	B1	5 5 4	5 5 4	5 5	5 5	3 4 3	4 3 3	3 3	4 3	10
OVERSEWN ROUNDED/ BACKED	B2	1 1 1	2 1 2	1 2	1 2	4 4 4	4 4 4	4 4	4 4	10
SINGER SIDE SEWN FLAT BACKED	B3	5 5 5	5 5 5	5 5	5 5					S
SINGER SIDE SEWN ROUNDED/ BACKED	B4					5 4 4	4 4 4	4 4	4 5	S

TESTED AT 1127 REVOLUTIONS OR ONE HOUR

S = Superior: No damages, no loose joints, good adhesion throughout

4 = Good: Loose joints, endpaper adhered to boards, no separation from book block

3 = Fair: Slight splits or other damages to endpaper construction, adhered well to boards, no separation from book block, internal split endpaper

2 = Poor: Parially split endpapers, loose joints, endpapers coming loose from boards but not more than one quater of an inch

1 = Inferior: Split endpapers, loose joints, book block hanging loose between cover boards, endaper separation from book bnlock

Table 8

UBT TUMBLE TEST DATA CHART

BINDING		WIDE HINGED ENDPAPER A1				STANDARD ENDPAPER A2				VOLUMES
OVERSEWN FLATBACKED	B1	5 5 3	5 5 3	5 5	5 5	4 4 5	4 4 5	4 3	5 5	10
OVERSEWN ROUNDED/ BACKED	B2	5 5 5	5 5 5	5 4	5 4	5 4 5	5 4 5	5 5	5 5	10
SINGER SIDESEWN FLATBACKED	B3	5 5 5	5 5 5	5 5	5 5					5
SINGER SIDESEWN ROUNDED/ BACKED	B4					5 4 4	3 4 5	5 4	3 5	5

TESTED AT 1127 REVOLUTIONS OR ONE HOUR

5 = Superior: No damages, no loose joints, good adhesion throughout

4 = Good: Loose joints, endpaper adhered to boards, no separation from book block

3 = Fair: Slight splits or other damages to endpaper construction, adhered well to boards, no separation from book block, internal split endpaper

2 = Poor: Partially split endpapers, loose joints, endpapers coming loose from boards but not more than one quater of an inch

1 = Inferior: Split endpapers, loose joints, book block hanging loose between cover boards, endaper separation from book block

APPENDIX C

TABLES 9-26

ANOVA SUMMARIES AND DUNCAN'S MULTIPLE RANGE ANALYSIS

TABLE 9

MULTI-LEVEL ANOVA SUMMARY OF OPENABILITY FOR OVERSEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	0.17038203	15.13	0.0002
*Binding	1	0.56312578	50.00	0.0001
*Endpaper X Binding	1	0.47166328	41.87	0.0001
Paper	1	0.03219453	2.86	0.0935
Grain	1	0.00997578	0.89	0.3485

Critical Value = 6.90

TABLE 10

DUNCAN'S MULTIPLE RANGE TEST FOR OPENABILITY OF OVERSEWN BOOKS

ALPHA = .01 DF = 122 MSE = 0.0112636
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.0492624

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide -Hinged Endpaper	**1.22063	64
*Standard Endpaper	1.14706	64
FACTOR : BINDING		
*Flat Backed	**1.25047	64
*Rounded/Backed	1.11781	64
FACTOR : PAPER		
Coated Paper	1.20000	64
Uncoated Paper	1.16828	64
FACTOR: GRAIN DIRECTION		
Cross Grain	1.19297	64
Long Grain	1.17531	64

***Levels which have shown significant differences**
****Most significant factor in level**

TABLE 11

ONE-WAY ANOVA SUMMARY OF OPENABILITY FOR SINGER SIDE SEWN BOOKS WITH COATED STOCK AT AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	0.15540313	59.04	0.0001

Critical Value : 7.56

TABLE 12

DUNCAN'S MULTIPLE RANGE TEST FOR OPENABILITY OF SINGER SIDE SEWN BOOKS WITH COATED STOCK

ALPHA = .01 DF = 122 MSE = 0.112636
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.047618

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide-Hinged Endpaper	**1.14563	16
*Standard Endpaper,	1.00625	16

*Crosses which have significant differences
**Most significant factor in level

TABLE 13

ONE-WAY ANOVA SUMMARY OF OPENABILITY FOR SINGER SIDE SEWN BOOKS WITH UNCOATED STOCK AT AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	0.19531250	81.34	0.0001

Critical Value : 7.56

TABLE 14

DUNCAN'S MULTIPLE RANGE TEST FOR OPENABILITY OF SINGER SIDE SEWN BOOKS WITH UNCOATED STOCK

ALPHA = .01 DF = 122 MSE = 0.112636
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.0476718

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide-Hinged, Flatbacked	**1.16688	16
*Standard Endpaper	1.01063	16

*Levels which have shown significant differences
** Most significant factor in level

TABLE 15

MULTI-LEVEL ANOVA SUMMARY OF THE INSTRON TEST FOR OVERSEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
Endpaper	1	11363.05335208	3.21	0.0801
*Binding	1	161259.78976875	45.56	0.0001
Endpaper X Binding	1	5881.49101875	1.66	0.2041

Critical Value = 7.26

TABLE 16

DUNCAN'S MULTIPLE RANGE TEST OF THE INSTRRON PULL RESULTS FOR OVERSEWN BOOKS

ALPHA = .01 DF = 44 MSE = 3539.76
NUMBER OF MEANS = 2 CRITICAL RANGE = 46.258

DUNCAN GROUPING	MEAN	N
FACTOR: ENDPAPER		
Wide-Hinged Endpaper	378.69	24
Standard Endpaper	409.46	24
***FACTOR: BINDING**		
*Flat Backed	**452.03	24
*Rounded/Backed	336.11	24

*Levels which have shown significant differences
**Most significant factor in level

TABLE 17

ONE-WAY ANOVA SUMMARY OF THE INSTRON PULLTEST FOR SINGER SIDE SEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	148872.152016	52.06	0.0001

Critical Value = 7.95

TABLE 18

DUNCAN'S MULTIPLE RANGE TEST FOR SINGER SIDE SEWN, INSTRON PULLED TESTED BOOKS

ALPHA = .01 DF = 22 MSE = 2859.53
NUMBER OF MEANS = 2 CRITICAL RANGE = 61.5765

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide-Hinged Endpaper	218.35	12
*tandard Endpaper	**375.87	12

*Crosses which have significant differences
**Most significant factor in level

TABLE 19

MULTI-LEVEL ANOVA SUMMARY OF THE TUMBLE TEST FOR OVERSEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	3.02500000	17.85	0.0002
*Binding	1	18.22500000	107.56	0.0001
*Endpaper X Binding	1	42.02500000	248.02	0.0001

Critical Value : 7.43

TABLE 20

DUNCAN'S MULTIPLE RANGE TEST FOR OVERSEWN, TUMBLE TESTED BOOKS

ALPHA = .01 DF = 36 MSE = 0.169444
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.354176

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide-Hinged Endpaper	3.1000	20
*Standard Endpaper	**3.6500	20
FACTOR : BINDING		
*Flat Backed	**4.0500	20
*Rounded/Backed	2.7000	20

*Levels which have shown significant differences
** Most significant factor in level

TABLE 21

ONE-WAY ANOVA SUMMARY OF THE TUMBLE TESTED SINGER SIDE SEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
*Endpaper	1	3.200000000	36.00	0.0001

Critical Value : 8.29

TABLE 22

DUNCAN'S MULTIPLE RANGE TEST FOR SINGER SIDE SEWN TUMBLE TESTED BOOKS

ALPHA = .01 DF = 18 MSE = 0.888889
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.38403

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
*Wide-Hinged Endpaper	**5.0000	10
*Standard Endpaper	4.2000	10

*Crosses which have significant differences
**Most significant factor in level

TABLE 23

MULTI-LEVEL ANOVA SUMMARY OF THE UBT TUMBLE TEST FOR OVERSEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
Endpaper	1	0.400000000	1.01	0.3206
Binding	1	0.900000000	2.28	0.1396
Endpaper X Binding	1	0.100000000	0.25	0.6177

Critical Value : 7.43

TABLE 24

DUNCAN'S MULTIPLE RANGE TEST FOR OVERSEWN, UBT TUMBLE TESTED BOOKS

ALPHA = .01 DF = 36 MSE = 0.394444
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.540379

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
Wide-Hinged Endpaper	4.7000	20
Standard Endpaper	4.5000	20
FACTOR : BINDING		
Flat Backed	4.4500	20
Rounded/Backed	4.7500	20

*Crosses which have significant differences
** Most significant factor in level

TABLE 25

ONE-WAY ANOVA SUMMARY OF THE UBT TUMBLE TEST FOR SINGER SIDE SEWN FLAT BACKED AND ROUNDED/BACKED BOOKS FOR AN ALPHA RISK OF .01

SOURCE	DF	ANOVA SS	F VALUE	PR>F
Endpaper	1	1.800000000	5.06	0.0372

Critical Value : 8.29

TABLE 26

DUNCAN'S MULTIPLE RANGE TEST FOR SINGER SIDE SEWN, UBT TUMBLE TESTED BOOKS

ALPHA = .01 DF = 18 MSE = 0.355556
NUMBER OF MEANS = 2 CRITICAL RANGE = 0.76806

DUNCAN GROUPING	MEAN	N
FACTOR : ENDPAPER		
Wide-Hinged Endpaper	5.0000	10
Standard Endpaper	4.4000	10

***Crosses which have significant differences**
****Most significant factor in level**