

Photo Book Construction and Preservation

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Abstract

Photo books have become the means to preserve photographs for future generations, replacing the scrapbooks of yesteryear. Photo books include photos along with related information creating a unique body of work often dedicated to a specific location, time period, or group of people. They provide a unique perspective on today's events. Unfortunately poorly constructed books with inferior bindings or unstable images will not survive the test of time. These books result when manufacturers use materials and manufacturing processes that they have not properly tested for long-term permanence. In some cases, manufacturers may not have the resources or expertise for testing; in other cases they may not consider it important. While it is impossible to address apathy, experts within the industry can provide general information that makes it easier to produce high-quality photo book.

Introduction

Photo books may be preserved digitally [1], but the hard copy has value as well, since digital copies may be lost or become unreadable over time. Factors that affect the permanence of physical photo books include the paper, adhesives, and other materials, along with the production process [2]. Each factor is important, since the quality of the photo book is dependent on all materials used to make the photo book and how they are put together. Printed images may fade, but they may also be lost if they adhere to adjacent pages or fall out of the book. Failure of any material within the book may cause the book to fail. In general, the first material to fail will determine the expected lifetime for the photo book.

Photo book design has an effect on permanence, as well so on aesthetics. Unlike with traditional books, each photo book may be unique, and the manufacturing process for photo books reflects this difference. Photo book design includes printing technology, binding method, and cover type.

ISO and other international standards provide recommendations for book construction; however, they do not address many of the specific issues related to photo books. Instead, photo book manufacturers must frequently rely on their own experience, as well as general information that is available from trade groups and other manufacturers within the industry. This paper reviews best practices within the photo industry for photo book production.

The information in this paper was compiled from work undertaken at Creative Memories, along with input from Hardcover Binders International/Library Binding Institute and members of ISO TC42 WG5 Physical properties and image permanence of photographic materials.

Construction

General

ISO 18920 [3] requires that photographic prints be stored such that emulsions are not in direct contact with another emulsion layer. Because photo books generally contain double-sided pages,

contact between emulsion layers will take place, unless an interleaving material is placed between pages to prevent direct chemical and physical contact between emulsion layers. Interleaving is highly recommended with imaging materials that have a high tendency to block. An alternative to interleaving is to apply a dry or liquid laminate over the surface of the humidity sensitive emulsion. However, care must be taken to ensure that there are no adverse long term interactions between the laminate materials and the imaging colorants or emulsion components. Another alternative is the use of anti-blocking technology in the top layer of the emulsion to prevent chemical interaction from face-to-face contact. [4]

Note: when selecting a paper substrate for printing, ISO 9706 [5] provides guidance to ensure that the underlying paper does not prematurely age.

Print technology

Like photographic prints, photo books are produced using a wide range of technologies. These technologies include, but are not limited to, inkjet (drop-on-demand or continuous), thermal dye diffusion transfer (“dye-sub”), liquid- and dry-toner electrophotography and traditional chromogenic (“silver-halide”) photographic color materials. The printed pages of a photo book can be either single or double sided, although double sided printing is generally preferred. Double sided pages require either printing on both sides of the page or laminating two single sided prints back-to-back.

Inkjet and electrophotography are most suitable for printing on both sides of standard weight papers, creating a photo book that resembles a traditional bound book. However, newer thermal dye transfer systems also offer double sided printing. Electrophotographic printing is compatible with a wide range of papers, including hinged lay-flat paper, and offers a great deal of flexibility when selecting papers; however, the fusing temperature and pressure must be carefully controlled to ensure proper adhesion of the toner.

Traditional chromogenic prints are high quality and continuous tone, but they require different methods for book binding. Several versions of photo book paper are manufactured that are significantly thinner than traditional silver halide paper base. There are several equipment manufacturers that have specialized pieces of equipment that glue these pages together to form a book block after printing and processing. Professional labs will frequently glue professional silver halide paper to a stiffener board to form a page for a premium wedding album or photo book.

Blocking can occur under conditions of high temperature or high humidity so care should be taken with all materials during transportation and storage. Post-coating the printed page with a suitable varnish or laminating film may reduce the likelihood of blocking.

Adhesive Bindings

Perfect Binding

The perfect binding process is traditionally defined as having a tightly clamped text block passing over both a milling station and

a gluing station before being deposited onto a waiting soft paper, or flexible paperboard cover. However, due to advances in adhesives and the increasing adaptability of machines and materials, perfect bound text blocks can be bound traditionally into soft covers or converted into hard cover case bound books.

For either output, after being tightly clamped, the text block passes over a milling station. Depending on the desired product, milling may or may not take place. Text blocks made up of single sheets are almost always milled. Text blocks made up of folded signatures can have the folds milled off, or the machine can be set to pass the text block over the milling station with no result, leaving the folded edge intact. If the folds are to be milled off the settings must be deep enough to remove the entire fold to expose each page to the adhesive. Milling is designed to rough up the binding edge and expose paper fibers. Milling stations are also commonly designed to create a series of shallow notches to allow for better penetration of the adhesive.

Adhesive application follows the milling, with the adhesive usually being applied via a roller wheel (rotating parallel to the spine with adhesive applied while the wheel is rotating in the direction of the traveling text block – primarily clockwise) or via an extrusion system. The most common adhesives used are EVA, PVA, and PUR. Both the EVA and PVA systems can make use of a roller wheel application. Because PUR adhesives cure when exposed to air, perfect binding systems using PUR almost exclusively rely on extrusion application. PUR has also proven to have exceptional bonding strength, and as such the amount of PUR applied to the spine is usually less than that of PVA or EVA. Common practices have shown that using an amount of PUR equal to that of EVA or PVA creates a book with far less openability than one using a lesser amount, and, due to its bonding strength, using a lesser amount of PUR to obtain better openability does not compromise page attachment.

EVA formulations are vulnerable to heat over time and are not recommended in ISO 11800 [6] for the manufacture of adhesive-bound books since pages may fall out over time.

Some perfect binding systems will have a second application of adhesive, referred to as side gluing, whereby a small bead of adhesive is applied to the first and last pages of the text block at the edges nearest the spine. This additional adhesive helps to better secure the soft paper cover, or, in the case of a text block intended to be case bound, to better secure a specialized, united endpaper. United endpapers are either two single leaves or two single folded sheets united by a strip of reinforcing cloth.

Following adhesive application, the text block is deposited onto a cover station. With traditional perfect binding a soft paper or flexible paperboard cover is placed flat, with the inside facing up, and the text block is placed to align its spine with that of the waiting cover. Once the text block is in contact with the cover it is unclamped and there is usually some upward pressure applied by the machine as well as additional pressure clamping the front and back of the book just at the edges nearest the spine.

Sewn Bindings

Smythe Sewing or Section Sewing

The text block for a Smythe sewn, also known as section sewn, book is made by gathering a series of folded pages, referred to as signatures, and sewing them together with thread. A typical signature usually has 8 or 16 leaves (16 or 32 pages), however any multiple of 2 leaves is possible.

A section sewn book will have thread passing through each signature at multiple points, or stations. To keep the sewing tight

and secure, the threads are tied off at the end of the last signature. In most cases a single, continuous thread will make up each sewing station within a text block. The overall number of stations is determined the final trim size of the book. Following the sewing process, a layer of adhesive is often added to the spine.

Section sewn books can be soft cover perfect bound or hard cover case bound. If they are case bound, endpapers are included in or added to the text block. Endpapers can be built in as part of the first and last signatures or glued on (tipped on) as part of the binding process.

Sewing through a folded signature allows the finished book to open very nearly flat, but generally not flat enough to qualify as a true lay flat binding. If it is folded accurately the construction of folded sheets made into nested signatures makes it unlikely a photograph will become compromised when it crosses the gutter area of the open book, although care must be taken to maintain registration between the pages.

Side Sewing

The text block for a side sewn book is made when the pages are sewn through the thickness of the book, along the edge nearest the spine, running from head to tail, usually 4.76 to 9.5 mm (0.1875 to 0.375 inches) in from the binding edge.

There are side sewing machines built specifically for bookbinding, but a side sewn text block can be created using any sufficiently powerful machine that can produce a common mechanical lockstitch. Although very specialized machinery exists to produce extremely thick side sewn books, most side sewn text blocks do not exceed a thickness greater than 16 mm (0.625 inches).

Text blocks made up of individual sheets or folded signatures can be side sewn. However, being able to sew individual sheets together allows a production environment to accommodate a high degree of variability in page count with little or no change to the mechanical set-up. Side sewn books are most commonly hard cover case bound, with endpapers sewn on.

Because the attachment of the pages occurs well inside the text block, the openability of a side sewn book is less than that of other methods. Having the grain direction of the paper is run parallel to the spine allows for greatest flexibility. In a side sewn photo book, it is important to accommodate for the lesser degree of openability. When setting up the layout, artwork or text should be spaced appropriately to remain visible. It is common to leave between 6.35 to 9.5 mm (0.25 to 0.375 inches) in the gutter margin.

Thread Sealing

Upon initial inspection a thread sealed book might appear to be Smythe sewn or section sewn. However, the difference is the threads passing through the folded signatures are not continuous. Each station in each signature is made of an individual thread. In the interior the thread lays in the gutter running parallel to the spine. The length visible in the interior can vary but is usually no longer than 25.4 mm (1 inch). Each end of the thread exits at a punched hole and what remains of the thread is left hanging loose. Once the folded signatures are gathered into a complete text block the hanging threads are sealed in place with adhesive, or, if plastic-coated threads are used, they are heat-sealed.

Like a section sewn book the number of stations in a book is determined by the length of the spine. The strength of a thread sealed book is about 70 percent of that of a section sewn book and more than twice that of a traditional perfect bound book.

Thread sealed books can be soft cover perfect bound or hard cover case bound. If they are case bound, endpapers are included

in or added to the text block. Endpapers can be built in as part of the first and last signatures or glued on (tipped on) as part of the binding process.

Using a folded signature allows the finished book to open very nearly flat, but generally not flat enough to qualify the book as a true lay flat binding. If it is folded accurately the construction of folded sheets made into nested signatures makes it unlikely a photograph will become compromised when it crosses the gutter area of the open book, although care must be taken to maintain registration between the pages.

Book block lay flat binding

Lay-Flat bindings take two forms. In the first type, the page is manufactured with an integrated hinge. Because the hinge is more flexible than the paper used for the page, the pages appear to lay-flat. With this technique two facing pages appear to be nearly continuous, although care must be taken to maintain registration between the pages, since they are printed separately. Lay-flat pages of this type may be side-stitched or for a larger number of pages held together with metal staples. Flexibility in the binding is not critical since the hinge provides added flexibility for the page. Hinged lay-flat pages minimize the portion of the image that is lost in the binding process.

The second type of lay-flat binding uses single sided printing to create a single sheet that forms both facing pages. The unprinted sides of multiple printed sheets are adhered together to create the complete book block. This process is particularly suitable for heavy weight pages that are not easily bound using traditional methods, such as silver halide photographic paper. Books of this type do not require stitching since the adhesive that holds the pages together also serves to keep the entire binding in place. In some cases, manufacturers may choose to place an additional paper or plastic support between two sheets that are adhered together to provide additional support and enhance structural integrity. With lay-flat binding of this type, care should be taken to ensure that the printed sheets are not damaged when they are creased to form pages or when the pages are turned to view the book.

Mechanical Bindings

Wire-O, Twin Loop, or Double Wire Binding

Wire-O, twin loop, or double wire binding is most commonly used for books that will be viewed or read in an office or home type environment. The binding involves the use of a prefabricated wire spine, open at one side and having a "C" shape. The text block is made up of single sheets and most often independent front and back cover pieces made of soft paper or flexible paperboard pages. Because single sheets of paper are used this method of binding can easily accommodate a variable number of pages.

The entire text block, pages and covers, are punched at the binding edge with either square or round holes, at regular intervals to correspond with the prefabricated wire. The pages are threaded onto the wire which is then squeezed into a round shape using a wire closing device similar to a vice. The patterns of hole spacing and the wire used on thinner books is different than those used for thicker books. On thicker books the holes are slightly bigger to accommodate slightly thicker, stronger wire. It is possible to use turned-edge, hardcover boards as the front and back covers, as long as the density of the cover boards does not hinder hole punching.

It is most common for the wire to be exposed, but there are alternative cover designs available which allow a paper cover to wrap across the spine, covering over the wire. It is also possible, but less common, to bind a wire-o bound text block into a

hardcover case. All methods allow the book to maintain maximum openability. Regardless of the style of cover, it is often preferable to have a wide margin at the binding edge so photos and text are not compromised by the holes punched into the binding edge. While the pages lay flat, wire-o binding is not considered a lay-flat binding because the pages are not contiguous.

Comb Binding

A comb binding is similar to both a wire-o binding and a spiral binding. Comb binding uses a rectangular hole pattern punched near the binding edge. The text block of a comb binding is made up of individual sheets of paper, most often with a soft paper or flexible paperboard front and back cover pieces. Similar to wire-o and spiral binding, comb binding can easily accommodate a variable number of pages. Because of the plastic comb there is no final trimming done to square up the pages.

A curled plastic "comb" is passed through the slits and holds the text block together. One advantage comb binding has over wire-o or spiral binding is allowing a book to be disassembled and reassembled by hand without damage to the binding mechanism. However, because the plastic comb allows for easy removal of pages from the text block comb binding is considered less permanent, if not less durable, than other forms of binding.

As with wire-o bindings and spiral bindings, when laying out the text and graphics in a comb binding it is often preferable to have a wide margin at the binding edge so the contents are not compromised by the holes punched into the binding edge. Similarly, comb binding is not considered a lay-flat binding because the pages are not contiguous.

Spiral Binding

Spiral binding is often considered the most economical form of mechanical binding. It is commonly used when it is necessary or desirable to be able to open the book back on itself without breaking the spine. Like wire-o or comb binding, the text block is made up of loose sheets of paper, most often combined with a soft paper or flexible paperboard front and back cover pieces. This process allows for production to easily accommodate a variable number of pages.

Like wire-o and comb binding, spiral binding is made by punching holes along the entire length of the spine. However, spiral binding uses a machine to wind a wire or plastic helix through the holes which provides a fully flexible hinge at the spine. Because of the metal or plastic spiral, there is no final trimming process to square up the completed text block.

As with wire-o bindings and comb bindings, when laying out the text and graphics in a comb binding it is often preferable to have a wide margin at the binding edge so the contents are not compromised by the holes punched into the binding edge. Similarly, spiral binding is not considered a lay-flat binding because the pages are not contiguous.

Channel Binding

Channel binding uses special steel channel with resin which is thermally activated rather than glue inside of it to give it a sturdier bind to hold the pages in place. Aside from the pages being adhered in place the steel channel can be crimped tightly to further hold the pages in place. Channel binding is designed for use with single sheets and can appear similar to perfect binding and be used to bind soft covered documents. Text blocks that are channel bound can also be used for in hardcover books.

Like side sewing, channel binding has more limited openability than other methods of page attachment. As such, flexibility is greatest if the grain direction of the paper runs parallel

to the spine. Also, when setting up the layout, artwork or text should be spaced appropriately to remain visible. Because of the metal channel, it is unlikely a channel bound book will undergo a final trimming process after page attachment. Thus, during the binding process it is important to jog or align the pages squarely.

Covers

Soft Covers

Softcover binding most often refers to perfect binding, a specific process which uses a soft paper or flexible paperboard for the cover. Perfect bindings have rectangular spines and a cover which wraps around the pages of the text block, spanning the back cover, spine and front cover. Scoring or creasing of the cover occurs where it is folded around the spine of the text block.

Some books have slightly more rigid covers made by using an oversized flexible paperboard which is scored and folded inwards prior to the inclusion of a text block, which effects turned edge, complete with mitered corners. The text block is then cased-in as normal. This creates books which have flexible covers and, in comparison to a true hardcover book, are considered soft covers. The main difference between this product and a classic turned edge cover is the softcover variety used a thinner board product that can be scored and turned back on itself and a classic turned edge cover makes use of a thicker, more rigid board that has a separate paper or cloth wrap.

Unless the product is a softcover turned edge binding, most softcover text blocks do not include a set of endpapers. Because softcover books make use of a soft paper or flexible paperboard the cover most always has text or graphics printed directly onto the cover prior to being wrapped around the text block. Embossing or foil stamping are other ways to embellish the cover stock prior to binding.

Softcover books offer an economical option for the final customer. Because fewer machine and materials are required, soft cover binding can be an easy, less costly entry level of book production for companies first getting into photo book production, when compared with hardcover book production.

Hard Covers

The text blocks for hardcover, case bound books differ from most soft cover bindings by the inclusion of set of endpapers, one each at the front and back of the text block, which are used to adhere the text block to a hardcover case. Text blocks which are to be case bound can be sewn or adhesive bound, and have square spines or rounded spines. If the text block formation allows, spines of case bound books may also be backed, forming shoulders parallel to the spine. Case bound books almost always include a paper lining or woven lining applied to the spine of the text block which extends onto the front and back endpapers. This lining not only provides additional reinforcement to the spine and the endpapers and but is also the means for a stronger connection between the text block and the cover.

The thickness of the boards used in hardcover binding varies, based on cost, the desired level of durability, and aesthetic preference. In nearly all cases the cover boards and spine strip are laid down on an oversized piece of paper or cloth. A distinct characteristic of a hard cover book is a joint, or gap between the spine and the front and back cover boards. This gap lets the cover hinge and open properly. However, some processes make use of a deep score, or a series of parallel scores, to create a working hinge point. In either case, the excess cover material is then turned over the four edges (top, bottom, front fore edge, back fore edge) to complete the cover.

Paper cover material can be printed with text or graphics, embossing or foil stamping can be added, and the paper may be laminated for additional strength and durability. Except for foil stamping, all of these features are added to the paper cover material prior to wrapping around the cover boards. Foil stamping may occur before or after the case is wrapped. Foil stamping after the boards are wrapped creates a deboss, or depression into the cover, which is often a desired effect.

Cloth cover material can similarly be printed with text or graphics, although in some cases the surface or the cloth limits the effectiveness of printing. Foil stamping is the most common way to include title information on a cloth wrapped hardcover book.

Padded covers

Because of the nature of the cover board, padded covers are considered to be exclusively a turned edge product. A padded board is a book board that has a layer with padding added to it, usually a foam product – which is then often topped with a thin board or heavy paper liner. The result is a product that has the rigidity of a traditional hardcover book, but also having a soft, pillow-like quality.

A padded cover construction usually makes use of cloth cover material, due to the pliability and yielding nature of the padding. Padded covers can have window cutouts, but because of the exposed board the cloth is often laid over the opening and cut in an “X” pattern with the resulting points wrapped over the exposed board and turned to lay flat on the inside of the cover.

It can be difficult to foil stamp a padded cover because the soft cushion does not provide a firm surface on which the foil can be easily applied. However, with the proper combination of board product, mechanical set-up, and foils, a padded cover can be stamped.

Windows

Window cutouts, most commonly placed on the front cover, are a common feature of hardcover photo books. They offer the option of a closed cover presenting a photo without printing the cover material. This is especially true when covers are wrapped in cloth, which can have a texture that makes printing difficult or impossible.

Window cutouts are most often made with a punch die and can be simple rectangular cuts, or more elaborate patterns such as heart shapes or ovals. A window cut can pass through all layers of a completed cover, including the pastedown endpaper. However punching through all layers of construction exposes the cover board. It is common to use a solid black board so that minimum attention is drawn to the construction of the cover and focus is maintained on the image or area revealed by the cutout.

Some cutouts are made in the cover board before the cover material is wrapped around the boards. In this case the cover material laying over the cutout is most often cut in an “X” pattern with each of the four points turned in so as to wrap around the edge of the cutout and lay flat against the inside of the cover. This method covers the exposed board and omits the need for black cover board being used for cosmetic purposes. But, when adhering the text block to the cover, not cutting directly through all layers of construction creates the added step of aligning the opening in the cover with a corresponding opening in the pastedown endpaper.

Wrapping the cover material around the cover board eliminates the possibility of abrasion that may result at the edge of the window when the window is cut directly into the completed cover. With either method, care must be taken to properly set-up the layout so the image or graphics presented by the window are properly aligned. However, once this alignment is determined it is

relatively easy to duplicate in subsequent books, even in high volume production environments.

Printed Covers

Printed covers are most commonly a feature of a paper covers, either softcover or hardcover. It is less common for a cloth cover to be printed, but it is possible with the right combination of cover material and printing technology.

A printed cover allows for maximum flexibility when presenting graphics on the outside of a book. As such the variety of options is only limited by printing technology, substrate properties, and graphic design capabilities. Printed covers can also be used in conjunction with window cutouts to create multi-layered effect.

Laminates are frequently applied over printed covers to provide durability, as well as to add strength to the paper substrate. They are typically made from polyvinyl acetate, polyvinyl chloride, polyurethane, polyester, polypropylene or other polymeric material. Laminates may be applied as a film with an adhesive at room temperature or at elevated temperatures. They may also be applied as a liquid coating which is subsequently dried or exposed to UV light for curing.

When using a printed cover in conjunction with a turned edge cover, testing is recommended if the printed area is large enough that it crosses over the turned edge. In some cases, when the cover material is wrapped around the edge of the boards the printing can crack or otherwise become blemished. This can be due to the substrate being too rigid to easily turn over the cover board or it can be due to use of a printing technology that is not designed for making a turned edge product.

Testing

Commonly seen photo book failure mechanisms include blocking, delamination, loss of pages, and warp. These problems do not appear immediately but instead develop over time. The majority of photo book returns that are not a result of an initial defect are due to these causes. Many other failure modes are possible, but in practice these are less common than blocking, delamination, loss of pages, and warp.

Blocking

Blocking results when pages of the photo book adhere to each other, more or less permanently. In extreme cases, the entire book block becomes a “brick.” Blocking requires pressure in addition to heat or humidity.

Photo books produced with pages that have humidity sensitive emulsions are particularly vulnerable to blocking [7]. These photo books are primarily books made with traditional silver-halide photographic paper but may also include books made with coated inkjet papers. Blocking may be reduced in these instances by coating or laminating the pages to prevent humidity from adversely affecting the emulsion layer.

Blocking may also result in books printed with solid electrophotographic toners, if the book is exposed to conditions that exceed the glass transition temperature of the toner. High temperature conditions frequently result from shipping or transporting the photo book during the hot summer months. Temperature during transport may reach 60°C or higher in hot cars [8].

Tests for blocking involve placing the photo book under pressure in high humidity or high temperature conditions for 8-48 hours. Simulating a tropical climate requires 40°C with 90% RH, while simulating a hot, dry desert environment requires 60°C with 15% RH [9]. For blocking tests, a pressure of 1.0 kPa corresponds

to the approximate pressure at the bottom of a stack of ten books, each containing 100 pages of standard paper (148 g/m²). It also corresponds to the approximate pressure experienced in a tightly packed book shelf.

Table 1. Susceptibility to Blocking

Rating	Susceptibility to Blocking	Product Performance
4	Highly Susceptible to Blocking	Pages adhered together and separation result in tearing of one or more pages the pages.
3	Moderately Susceptible to Blocking	Pages adhered together and separation results in ink transfer from one or more pages to the facing page.
2	Susceptible to Blocking	Pages adhered together; separation results in change in appearance without color transfer.
1	Not Susceptible to Blocking	All pages are separated without damage.

Delamination

Separation of the laminate from the cover is particularly apparent near the spine. The laminate is under greatest stress here, both from the binding process, as well as from continued use of the book. Stress is placed on the cover every time it is opened, and this damage is most apparent near the spine. High temperature and humidity aggravate the problem.

Inks and toners may also include components that reduce laminate adhesion. Liquid toners are particularly vulnerable since these materials may contain small amounts of solvents that may adversely affect laminate adhesion.

Problems with laminate adhesion are best prevented by ensuring that the laminate is held with sufficient force to prevent separation from the cover material. Pages that are laminated may also undergo delamination; however page delamination is far less of a problem than cover delamination, since the pages are under less stress during usage than the cover.

Lamination strength is measured with a peel tester that pulls the laminate apart at a 90° angle [10]. In this test, photo books should show no or low susceptibility to delamination.

Table 2. Photo book susceptibility to cover delamination.

Rating	Susceptibility to Delamination	Product Performance
4	High Susceptibility to Delamination	Lamination strength < 1.0 N/cm
3	Moderate Susceptibility to Delamination	1.0 N ≤ Lamination Strength < 1.3 N/cm
2	Low Susceptibility to Delamination	1.3 N ≤ Lamination Strength < 2.0 N/cm
1	Not Susceptible to Delamination	Lamination Strength ≥ 2.0 N.

Usage tests, which typically involve repeatedly opening and closing a book, can also help identify potential problems with delamination. These tests are usually carried out with a mechanical test system but can also be done manually. Delamination ranges from cracking of the laminates to near total separation of the laminate from the underlying material.

Table 3. Photo book susceptibility to binding delamination.

Rating	Susceptibility to Delamination	Product Performance
4	High Susceptibility to Binding Delamination	Lamination shows complete separation along the length of the spine.
3	Moderate Susceptibility to Binding Delamination	Lamination shows some separation along the spine
2	Low Susceptibility to Binding Delamination	Lamination shows cracking at the spine without complete separation
1	Not Susceptible to Binding Delamination	Lamination shows no cracking or separation at the spine.

Loss of Pages

Unfortunately, low quality binding adhesives do not permanently hold pages in place, with hot-melt adhesives not recommended for permanent binding. The best option is generally stitching the pages together, which relies on the mechanical strength of the thread used for binding. An alternative approach is to rely on a permanent adhesive such as polyurethane (PUR) to hold the pages together.

To measure page attachment strength, the book is laid flat with the page pulled upwards at a 90° angle. Pages are tested from front, middle, and back of the photo book to ensure that binding strength remains consistent throughout the book.

Table 4. Page Attachment Tensile Strength for Durability and Physical Binding Integrity

Rating	Susceptibility to page separation	Tensile Strength (N/cm)
5	Very susceptible to page separation	Below 4.50
4	Susceptible to page separation	4.50-6.25
3	Moderately susceptible to page separation	6.25-7.25
2	Resistant to page separation	7.25-8.00
1	Very resistant to page separation	Above 8.00

Warp

Warp results when multiple materials with different responses to humidity are used to create a cover. These materials may include the laminate that protects the front cover, the substrate the cover is printed on, the board material that makes up the cover, the lining sheet, and adhesives that are used. In general it is difficult to predict when warp will occur, although water-based adhesives contribute to the problem since they add moisture to the system which must be removed during the manufacturing process. Warp is generally not a problem with soft-cover books, since the covers do not include as many materials as hard-cover books.

Warp can be measured under controlled conditions, and this information can be used to select materials that minimize warp. Low, standard, and high humidity conditions of 20%, 50%, and 80% RH, respectively, are necessary to characterize warp under different environmental conditions. Minimizing warp also requires carefully controlled manufacturing processes, since any changes to the manufacturing process may adversely affect warp in the final photo book.

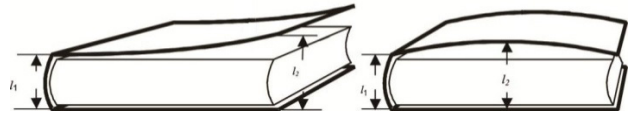


Figure 1. Example of photo books with concave warp (left) and convex warp (right).

All warp is not the same. Concave warp, which curves toward the reader and away from the text block is far more objectionable than convex warp, which curves away from the reader and toward the text block. Consequently, any evaluation of warp must assign greater weight to concave warp than to convex warp.

Table 5. Susceptibility to warp for the maximum deviation, d, relative to the user

Rating	Description	Warp concave (mm)	Warp convex (mm)
5	Very High Warp	$d \geq 3.0$	$d \geq 5.0$
4	High Warp	$3.0 > d \geq 2.5$	$5.0 > d \geq 3.0$
3	Moderate Warp	$2.5 > d \geq 1.0$	$3.0 > d \geq 2.5$
2	Low Warp	$1.0 > d \geq 0.8$	$2.5 > d \geq 1.0$
1	Minimal Warp	$d < 0.8$	$d < 1.0$

Inspection

The photo book must be free from defects when manufactured. Quality standards are available for final inspection of bound books [11] and similar standards apply to photo books.

- a) The book block shall have form stability and low or minimal warp.
- b) No excess of adhesive shall be visible on any part of the final product.
- c) All visible surfaces shall have no scratches or marks.
- d) The adhesion between the cover and the book block shall be strong enough to ensure that the attempt to remove the cover from the book block results in a rupture of the cover material.
- e) The adhesion of the spine glue shall be strong enough to ensure that no sheets separate from the book block under conditions of intended use.
- f) The content of the book block shall be as intended with all pages and additions in the correct order and orientation.
- g) The transition of photos and text from page to page should meet accurately; any deviation should not exceed 1.5 mm.
- h) The trimmed edges shall be smooth and without knife marks or turned-over edges.
- i) The cover or book case shall be flat and without wrinkles, bubbles or damages.
- j) Case-bound books should have firm joints from the head to the tail and uniform squares on all edges. Covering material shall adhere squarely to the case boards and to the inlay.
- k) The endpapers should adhere to the case boards and the block without wrinkles and bubbles.
- l) Saddle-stitched photo books shall have staples positioned in the folding edge, and there shall be no cracked or misshaped staples.

Conclusion

Photo books must meet specific requirements for long-term preservation. First, the manufacturer must carefully design the production process and select quality materials. Second, the manufacturer must test the resulting photo book for specific failure modes, including blocking, delamination, loss of pages, and warp. Third, the manufacturer must ensure that the photo book has no initial defects.

These three steps are necessary for the production of high-quality photo books. They play an essential role in preserving the photos and stories in photo books for the future. Without these steps, photo books will fail over time and today's memories will be lost to the future generations.

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