Chapter 21
 substrates

Important Terms
- basic size
- bleaching
- calendering
- cellulose
- chain of custody
- chipper
- coated paper
- de-inking
- elemental chlorine free
- equivalent weight
- fillers
- fourdrinier machine
- furnish
- grades
- grain
- grain long
- grain short
- lignin
- opacity
- paper flatness
- petrochemicals
- postconsumer paper
- preconsumer paper
- print strength
- printability
- pulpers
- ream
- recycled paper
- show-through
- sizing
- substance weight
- substrate
- supercalendering
- tensile strength
- thermoformed
- totally chlorine free (TCF)
- trim
- uncoated paper
- watermark

Substrates include any material with a surface that can be printed or coated. Although the most common printing substrate is paper, substances such as plastic, metal, and wood are also classified as substrates.

Matching the substrate to the job is critical. A high-quality layout, plate, ink, and printing technique will be wasted if a low-quality substrate is used. On the other hand, expensive stock should not be used to print low-quality products such as newspapers or sales flyers. ... strippers, press operators, and finishing and binding personnel must have knowledge of the characteristics of paper and its applications. Its misuse can be very costly.

More than one thousand different grades of paper are listed in paper merchant’s catalogs.

Making Paper

For centuries, the principle raw materials used in papermaking were cotton and linen fibers obtained from rags. Some cotton and linen fibers are still used for high-quality writing papers, business letterhead papers, art papers, and documents that will be kept for years. However, cellulose is the raw material used to make most paper today.

Substrate: Any material with a surface that can be printed or coated.

Fourdrinier machine: A paper machine that forms a continuous web of paper on a moving, endless wire belt.

Cellulose: The raw material used to make paper.

Papermaking History

Most paper is manufactured using machine technology, although some paper is still handmade. The use of handmade papers is usually limited to special applications, such as fine art reproductions, or limited editions of books printed and bound by craft workers using hand methods.

Some historical highlights of papermaking are:
- 105 A.D.—Ts’ai Lun, a Chinese official, mixed the bark of the mulberry tree with linen and hemp to make a crude form of paper.
- 500 A.D.—The Mayans produced paper using fig tree bark.
- 751 A.D.—Papermaking spread to Europe as a result of the Crusades and the Moorish conquest of northern Africa and Spain.
- 1400 A.D.—Papermaking by hand flourished.
- 1690 A.D.—The first paper mill in America was established near Philadelphia by William Rittenhouse and William Bradford.
- 1798 A.D.—Nicholas Louis Robert of France invented a machine with an endless wire screen to produce paper in rolls. The machine was financed by two English merchants, the Fourdrinier brothers, and was named the American fourdrinier machine.

Most of the paper manufactured in the United States today is made on the fourdrinier machine. It can produce continuous sheets of paper up to 33’ (10 m) wide at speeds faster than 3000’ (900 m) per minute. Some fourdrinier machines are more than 350’ (110 m) long. The mechanical principles of the original machine have remained nearly unchanged. Other inventions have occurred, but many are simply refinements.

Significant improvements in papermaking in recent years include thermomechanical pulping, synthetic wires and felts, twin-wire machines, and the use of computers to control pulping and papermaking operations. Paper manufacturers have also worked to improve pollution control and energy conservation in the industry.

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Learning Objectives
After studying this chapter, you will be able to:
- Explain how paper is manufactured.
- Identify the basic characteristics of various types of paper.
- Describe the applications of coated and uncoated papers.
- Explain the basic size and basis weight of paper.
- Determine various paper weights.
- Summarize the characteristics of plastic substrates.
- Explain the changes occurring with substrates based on environmental issues.

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Cellulose: The raw material used to make paper.
Pine, fir, spruce, aspen, beech, birch, maple, and oak are typical species harvested for papermaking. The length of the tree fibers varies and determines, among other characteristics, the strength of the paper.

Papermaking is a complex manufacturing process. It uses both chemical and mechanical means to reduce wood fibers to pulp, which is the material used to ultimately produce paper in sheet form. See Figure 21-1.

**Chipping**

Harvested logs are cut to uniform length, debarked, Figure 21-2, and sent to a chipper or grinder. The *chipper* cuts the logs into 3/8" to 3/4" chips. The chips are sized so the digester is able to separate the cellulose fibers. After the chips are screened for size, they are put in a huge cooking kettle called a digester.

**Making Pulp**

In the chemical pulpmaking process, chemicals in the sealed, pressurized digester break down the *lignin* present in the cellulose fibers. The cellulose fibers, which once resembled soda straws, become pulp, a mass of soft, spongy matter. The pulp is blown into a pit where the chemicals are washed away.

**Sizing and Fillers**

*Sizing* is added to the pulp slurry to make the paper more resistant to moisture. Rosin is a common sizing material. Alum is added as a binding agent. Binding is a part of the sizing process.

*Fillers* are needed to improve a paper’s opacity, brightness, smoothness, and ink receptivity. Two common fillers are clay and titanium dioxide.

**Dyes, Pigments, and Bleach**

Dyes and pigments are added to produce colored substrates, while bleach makes the pulp white. Coloring or bleaching additives are mixed in vats called *pulpers*. The pulp goes through a final beating and refining stage before it is pumped to a stock chest.

**Removing Water**

A jordan machine is a beater or refiner of the fibers. A jordan machine refines the fiber slurry until it is about 99% water and 1% fiber and other solids. At this point, the paper is known as *furnish*. The solution is pumped into the headbox of the papermaking machine.

The pulp furnish is evenly dispersed on the fourdrinier wire, Figure 21-3. The wire screen vibrates as it travels along an endless belt, aligning the fibers in the direction of travel. A continuous web of paper is formed in the process. Gravity and suction remove about 35% of the water.

Some papers are given a *watermark*, a translucent identifying design impressed in the paper while it is still wet. The symbols or images are created by rearranging the fibers with a tool known as a dandy roll. See Figure 21-4.

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*chipper*: A machine that cuts logs into chips.

*lignin*: A glue-like substance that bonds wood fibers together.

*sizing*: Material, such as rosin, that is added to pulp slurry to make the paper stronger and more moisture-resistant.

*fillers*: Inorganic materials, such as clay or titanium dioxide, added to the papermaking furnish to improve opacity, brightness, smoothness, and ink receptivity.

*pulpers*: Vats in which coloring or bleaching additives are added to pulp.

*furnish*: The slurry of fillers, sizing, and colorants in a water suspension from which paper is made.

*watermark*: A translucent design impressed in paper.
When the furnish leaves the screen, it enters the press section, which removes more water. Then, the paper enters a dryer section consisting of large temperature-controlled rollers. More moisture is removed. Coatings are applied as the paper moves through the machine, Figure 21-5. At some stage of the drying process, the paper must be calendered. 

**Calendering** is the process of flattening and smoothing the paper surface by passing it between a series of rollers. **Supercalendering** uses heated steel rollers and pressure to form a very smooth, high-gloss finish, Figure 21-6.

**Drying**

When the furnish leaves the screen, it enters the press section, which removes more water. Then, the paper enters a dryer section consisting of large temperature-controlled rollers. More moisture is removed. Coatings are applied as the paper moves through the machine, Figure 21-5.

**Rolling**

The untrimmed paper is wound into rolls. Some rolls are rewound, slit, and cut into lengths to make flat packages of paper. Others remain as rolls for use in web-fed presses, Figure 21-7.

**Paper Types**

**Coated and Uncoated Papers**

Coated paper is a broad classification of paper that has layers of latex, pigments and adhesives applied to its surface. Coated papers typically have a smoother, stronger surface than uncoated papers. Finishes may be high-gloss, dull-coated, or matte-coated. They are more expensive than uncoated papers but yield better reproduction of images.

Coated papers are rated by brightness. A No. 1 rated paper is suitable for high-quality jobs, such as sales literature. Material intended to convey a prestigious image might use a matte finish, while high gloss might be used to convey a bright and exciting image. No. 1 paper produces very bright color through the use of transparent inks. Printed material, such as catalogs or posters, is typically printed on No. 2 or No. 3. Groundwood-processed sheets are of lower-grade stock, often No. 4 or No. 5.

Uncoated paper does not have a layer applied over the surface and tends to have a textured feel. Uncoated paper textures include laid, woven, and linen. These textures are suited to printed pieces that will be written on, such as stationery. Uncoated papers also enhance legibility, making them good choices for text-intensive printed material, such as textbooks or novels.

**Adhesive-Coated Paper**

Adhesive-coated stock is coated with an adhesive material that is permanently tacky or activated by water or heat. Labels are a common product that use this type of substrate. The heat-seal type of paper uses heat to melt the coating so it will stick to another surface. Stock with a coating that is permanently tacky is commonly called pressure-sensitive. These stocks require contact and pressure to make them adhere to another surface.

**Safety Paper**

Safety stock is typically used for printing checks. The specifications are very rigid because the stock must expose any attempted alteration of the document. If someone tries to alter it by erasure or by using chemicals, the paper automatically displays a change in the design or color. Some other documents using safety paper include bonds, deposit slips, coupons, tickets, certificates of title, warranties, and legal forms.

**Bond Paper**

Bond paper is a broad classification of quality paper used for business forms, letterheads, stationery, and many other products. Characteristics

- **Calendering:** Passing paper between rollers to increase the smoothness and gloss of the paper’s surface.
- **Supercalendering:** Using heated steel rollers and pressure to form a very smooth, high-gloss finish on paper.
- **Coated paper:** Paper with a mineral substance applied to it for a smoother, stronger surface.
- **Uncoated paper:** Paper that does not have a mineral layer applied over the surface, so it has a slightly textured feel.
of bond paper include strength, good ink receptivity, and erasability.

Bond paper is used extensively for printers connected to desktop computers. Laser printers can provide acceptable quality using the same paper designed for photocopying machines. Paper for use in inkjet printers has a coating formulated to accept the dye-like inks used by these printers.

Bond paper is made from cotton or rag fiber, or from chemical wood pulps. It has an even, hard finish on both sides. Rag bond is the most expensive type of paper and often has a watermark.

Duplicator Paper
Duplicator paper is an inexpensive bond paper designed for use in photocopying machines and laser printers. Duplicator paper should never be used as a stock for offset lithography or other forms of printing. Its surface strength and other qualities are not suitable for use on press.

Carbonless Paper
Carbonless paper is used to make multipart business forms that will be written on or used in some type of impact printer (a device, such as a typewriter, that makes a physical impression by striking the paper). Carbonless paper starts with a base stock similar to ordinary bond. The paper is coated with encapsulated colorless dyes and a receptor coating that reacts with the dye to produce an image. The capsules are broken when pressure is applied, releasing the dye onto the sheet below. The receptor coating develops the image.

Carbonless business forms have a variety of applications. Checks, vouchers, shipping labels in clear plastic envelopes, and continuous forms for impact-type printers are common uses.

Offset Paper
Offset paper is designed specifically for use on offset printing presses. It has good opacity, rapid ink absorption, and permanence. It can be coated or uncoated. Offset paper is used for a wide variety of products, such as books, form letters, magazines, manuals, and advertisements. See Figure 21-8.

Offset paper is sometimes called book paper because both have similar properties and construction methods. Offset papers are made from various materials, including chemical wood pulp, mechanical wood pulp, recycled papers, and even straw. Frequently, two or more of these raw materials are combined to make offset paper.

Impregnated offset paper receives a mineral film to smooth and strengthen the surface for better image reproduction. It is sometimes called pigmentized offset paper.

Text paper is an expensive grade of offset or book paper. Depending on its surface smoothness, it can be both attractive and functional. Smooth text paper is used for accurate reproduction of halftones. Rougher surfaces are used when halftone reproduction quality is not important.

Cover Paper
Cover paper is a thick or heavy paper, typically used for the covers of books, catalogs, brochures, manuals, and similar publications. Sometimes, two layers of cover paper are bonded together to produce double thickness. When pasted together, it can be sold by caliper or thickness.

Ledger Paper
Ledger paper has a smooth, matte finish that resists erasing. It easily accepts pen and is both strong and durable. Ledger paper is used for accounting notepads, bookkeeping forms, business ledger sheets, and financial statement forms.

Index Paper
Index paper is a thick, stiff, smooth paper, frequently two-ply or greater. Index stock may be coated or uncoated. Its most common uses are index cards and postcards, so it must be sturdy enough to withstand frequent handling. Bristol paper is not as smooth as index paper, but the thickness and use is similar.

Newsprint Paper
Newsprint is one of the lowest grades of printing paper. It is made by the groundwood or mechanical method of papermaking. Newsprint has very short fibers which enable the paper to be folded easily in any direction. When new, it has a grayish-white color, but it turns yellow and becomes brittle with age. Since newsprint absorbs ink readily, a drying system on the press is not needed.

Zink Paper
Zink™ stands for Zero Ink. This product is a very unusual substrate. It is made of composite materials composed of different layers. Embedded between the top layer and the polymer base are dye crystals of cyan, yellow, and magenta. The paper is colorless and appears as a regular sheet of paper stock. The printer uses heat to activate the embedded crystals which in turncolorizes the stock.

Recycled Paper
Several environmental issues, such as depleting resources and landfill space, have contributed to the trend toward buying and using recycled paper.

Recycled paper is made from old or used paper products, Figure 21-9. There are different grades of recycled paper. High grades can be made into quality printing paper. Low grades can be made into newsprint, cartons, and other products.

The recycled paper arena is dynamic. Guidelines relating to the manufacture of recycled paper are continually being reviewed by the United States Environmental Protection Agency (EPA). The federal government has established minimum-content standards for the paper it purchases.

Recycled papers may contain preconsumer waste, postconsumer waste, or both. Waste material created by manufacturing processes that would otherwise be disposed of is called preconsumer paper waste. Used materials that have served a purpose and may be recycled into new paper is called postconsumer paper waste.

Guidelines were issued by the Federal Trade Commission for the use of labeling products as recycled in a way that is clear and truthful for consumers. The label must consist of the percentage and type of recycled content.

Figure 21-8. Books and many other printed products are produced using offset paper, often on web-fed presses like this one. (Heidelberg Harris)
papers can be printed by the lithographic process, the direction or structure of paper fibers. Figure 21-11.

Before paper can be reused, it is subjected to chemical and mechanical processes to return it to a pure condition. De-inking is the process of removing inks, fillers, and coatings from waste paper. The mixture is reduced to cellulose fibers suspended in a water slurry.

After the waste paper is de-inked, the fibers are bleached. Bleaching is the use of chlorine bleach to give paper a bright white appearance. Elemental chlorine was used to bleach paper. However, the waste given off from chlorine was linked to the creation of dioxin, which can cause health problems including cancer. Once this discovery was made, the EPA began to develop emission standards for the pulp and paper industry. Since then, alternatives to bleaching by chlorine have been used throughout the world.

Elementally chlorine-free (ECF) bleaching uses safer chemicals, such as chlorine dioxide or sodium hypochlorite, instead of chlorine gas. Using oxygen or other nonchlorine bleaching processes is another alternative to eliminate the formation of dioxin. Another alternative is to use unbleached (slightly brown) paper products known as totally chlorine-free (TCF).

Paper Applications

Some papers are adaptable to different applications, while others are very limited in their use. The applications of paper to various printing processes will be discussed next.

Paper for Gravure

Newspaper produced for gravure printing typically contains mineral fillers and a calendered surface. Mail-order catalogs are a good example of this type of stock. When high-quality gravure printing is desired, the paper used contains mineral filler, but also a larger percentage of short-fiber chemical pulp.

The directions of fibers in a sheet or web of paper must have dimensional stability, thickness must be controlled, and moisture content must be considered. The reaction of the stock to the process is critical in the high-production speeds required of gravure.

Paper for Offset Lithography

In offset lithography, fuzz, lint, and dust must be strictly limited. See Figure 21-11. A wide variety of papers can be printed by the lithographic process, whether printed on a small duplicator or a large web-fed press, must have a surface resistant to having fibers pulled loose by tacky ink. Loose fibers can cause specks and other defects in the printed product.

De-inking: The process of removing inks, fillers, and coatings from waste paper. Bleaching: A chemical treatment to whiten wood pulp. Elemental chlorine: Chlorine gas used to bleach paper pulp and to separate the pulp from lignin. Totally chlorine free (TCF): Refers to unbleached paper with a slightly brown appearance. Grain: The direction or structure of paper fibers.
The weight of one ream of paper of a size that is larger or smaller than the basic size. 

Equivalent weight: 

Basic sizes. 

Some common types of paper and their grades: 

Figure 21-14. 

The actual weight of a ream of paper. 

ream: 

Five hundred sheets of paper. 

Substrate weight: 

The actual weight of the ream. Papers have many basic sizes and basis weights. Therefore, the thickness of a ream of stock can vary based on its substrate weight. 

Equivalent weight: 

The weight of one ream of paper that is of a size larger or smaller than the basic size. Use the following formula to find the equivalent weight of paper, referring to Figure 21-15 for the basic size. 

<table>
<thead>
<tr>
<th>Type</th>
<th>Basic Size</th>
<th>Weights</th>
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<tbody>
<tr>
<td>Writing</td>
<td>17&quot; × 22&quot;</td>
<td>26</td>
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<td>32</td>
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<td>64</td>
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<td>etc.</td>
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<tr>
<td>Cover</td>
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<td>180</td>
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<td>etc.</td>
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<tr>
<td>Bock</td>
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<td>160</td>
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<td>etc.</td>
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<tr>
<td>Index Bristol</td>
<td>25 1/2&quot; × 30 1/2&quot;</td>
<td>117</td>
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<td></td>
<td>144</td>
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<td>etc.</td>
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Paper Flatness 

Paper flatness refers to how well the paper remains straight or unwarped. Flatness is a basic requirement if the stock is to feed through a sheet-fed press without problems. 

Paper is naturally hygroscopic, meaning the cellulose fibers seek the moisture in the surrounding area. Most paper is shipped with 4% to 6% moisture content. In a facility with an air temperature of 70°F to 75°F (21°C to 24°C), that equates to 42% to 48% relative humidity. 

Wavy paper edges indicate a greater amount of moisture in the edges than inside the sheet. Figure 21-13. Sometimes the opposite occurs, resulting in tight edges and a sheet that curls up or down. 

Paper Size and Weight 

All paper has a grade, a basic size, and a basis weight. The types of paper are also known as grades. Each grade has certain characteristics and uses. The choice of paper grade depends on the intended use. 

Basic size, specified by length and width, varies with grade, Figure 21-14. The basic size of bond paper is 17" × 22". One ream weighs 16 or 20 lbs.; 16-lb. stock is thinner than 20-lb. stock. The basic size of book paper is 25" × 38". The substance weight of book paper is 2 1/2 times the weight of bond with 2 1/2 times the surface area. 

Cover paper has a basic size of 20" × 26". It is a durable stock with many textures. It comes in 60-lb. to 80-lb. weights. The basic size of index stock is 25 1/2" × 30 1/2". It is a heavy stock and often identified by the number of plies. One-ply equals 90-lb. stock; two-ply equals 110-lb. stock; three-ply equals 140-lb. stock. 

Basis weight is the weight in pounds of one ream of basic-sized stock. A ream has 500 sheets. Usually paper is referred to by its ream weight, as in 20-lb. bond or 70-lb. book. A 20-lb. bond means that 500 sheets of 17" × 22" writing paper weigh 20 pounds. 

If the letter M appears after the weight, it means per 1000 sheets. For example, 25 × 38 – 140M means 1000 sheets of 25" × 38" book paper weigh 140 pounds, Figure 21-15. 

Substrate weight: 

The actual weight of the ream. Papers have many basic sizes and basis weights. Therefore, the thickness of a ream of stock can vary based on its substrate weight. 

Equivalent weight: 

The weight of one ream of paper that is of a size larger or smaller than the basic size. Use the following formula to find the equivalent weight of paper, referring to Figure 21-15 for the basic size. 

- **Grain long:** Important factor of paper that can affect folding and direction of feed for printing. 
- **Grain short:** Indicates that the grain runs across the paper. 
- **Paper flatness:** How well a sheet of paper remains straight or unwarped for feeding through a sheet-fed press. 
- **Grades:** Categories or classes of paper. 
- **Basic size:** The standard length and width, in inches, of a grade of paper. 
- **Ream:** Five hundred sheets of paper. 
- **Substrate weight:** The actual weight of a ream of paper. 
- **Equivalent weight:** The weight of one ream of paper of a size that is larger or smaller than the basic size.
Example: What is the equivalent weight of a ream of 28″ × 34″ ledger paper, 32-lb. stock?

28 × 34 × 32
17 × 22 = 81.4 lbs.

To find the total weight of a number of sheets, use the following formula:

\[ \text{Weight of} \times \text{Number of sheets} \times \text{weight} \]

Example: What is the total weight of 1475 sheets of 17″ × 22″ – 56M, 28-lb. stock?

56 × 1475
1000

To find the basis weight (when the sheet size and ream weight are known) use the following formula:

\[ \text{Basic size} × \text{Ream weight} \]

\[ \text{Length × Width of sheet} \]

Example: What is the basis weight of a ream of book paper 23″ × 29″, with a ream weight of 56 pounds?

25 × 38 × 56
23 × 29

53,200
667

The length and weight of paper in rolls can be calculated by applying the factors shown in Figure 21-16 to the appropriate formula.

To find the roll weight of paper in a roll of known width and net weight (not including wrapper and core), use the following formula:

\[ \text{Roll weight} \times \text{Roll width} \times \text{Factor} = \text{Total weight} \]

Example: How many feet of paper are in a 1000-lb. roll of 35″-wide offset book, 75-lb. stock?

41.67 × 1000 × 950
35 × 75

15,080′

Sometimes it is necessary to figure out how many pieces of paper can be cut out of a large sheet. A typical stock cutting sheet is shown in Figure 21-17. To determine the number of pieces per sheet, the dimensions of the desired cut piece are written below the dimensions of the uncut sheet. First, each dimension of the cut size is divided into its corresponding full-sheet dimension. The resulting whole numbers (fractions are dropped) are multiplied to find the number of pieces that can be cut from the sheet. The computation is done two ways. In the vertical method, the dimensions are divided vertically; in the cross method, division is done diagonally.

Figure 21-17. A stock cutting sheet form. (Central Missouri State University)
Sometimes, it is possible that the trim can be used for another job. To find out, utilize the same type of formula.

**Metric Paper Sizes**

In many countries, the SI Metric system is used for specifying paper size. The letters A and B each designate a different series. The sizes in each series are numbered 0 to 8 and represent the number of times a sheet can be folded to obtain a particular size. The sizes in a series are proportionate; any smaller size is always half the next larger size.

In the A series, A0 has an area of 1 m². The sheet is not a true square but has a proportion of 5:7. Figure 21-19. Using 1 m² as a starting point, the subsequently smaller sizes are determined by halving the larger size. Figure 21-20.

In the B series, the sizes fall between the A series measurements and are used for unusual situations. Standard metric sizes of paper are listed in Figure 21-21. The nearest metric equivalent to the 8 1/2” × 11” standard sheet used in the United States is the A4 size. It is 210 mm × 297 mm (8.27” × 11.69”).

**QUALITIES OF PAPER**

There are several physical qualities that can be used to make judgments about which paper is most well-suited for a particular printing job. These are color, smoothness, strength, brightness, and opacity.

**Color**

Paper color and ink color must be compatible. White paper is essential for full- or four-color printing. It reflects all the colors of the spectrum, while colored paper does not. Colored paper can create a process color value that is undesirable, producing a finished piece that may not be what the customer expected.

**Smoothness**

Smoothness and texture both greatly affect printability, or how well images show fine detail. Smoothness varies with paper type. A smooth sheet requires a very thin film of ink to produce sharp images. The opposite is true for rough papers.

**Opacity**

Opacity refers to the ability of light to pass through a sheet of paper. It is also the ability to see through the sheet. Poor opacity produces an undesirable result called show-through. The image on the back side of the sheet can be seen through the paper, and it is a distraction to the reader. Examine stock carefully to make sure show-through will not occur. A heavyweight paper has high opacity, whereas a thin paper tends to have low opacity.

**Envelopes**

Envelopes come in many styles and sizes for a variety of applications. Envelopes used for postal purposes have a minimum size requirement of 3 1/2” × 5”. Any size over 6 1/8” × 11 1/2”, or thicker than 1/4”, is subject to additional postage fees. Figure 21-22 illustrates common envelope styles.

- The window envelope allows the address to appear through the clear opening.
- The commercial envelope is typically used to send correspondence. The No. 10 size (4 1/8” × 9 1/2”) is the most widely used.
- The booklet envelope, with its opening on the left side, is used to mail bulky materials. The manner of fastening will vary, but it is strong and can take abuse.
- The clasp envelope is used to mail bulky items. The image on the back side of the sheet can be seen through the paper, and it is a distraction to the reader.
- The booklet envelope is used mostly for invitations, announcements, and greeting cards.

**Acid-Free Paper**

The acid found in manufactured paper occurs naturally in wood pulp and may also be absorbed from the environment, printing processes, and human hands. This acid causes the paper to turn yellow in color and physically deteriorate. To ensure longevity, acid-free (or alkaline) paper has become the standard substrate used for archival and historical documents and projects.

During production, acid-free paper is treated with an alkaline compound, usually calcium carbonate, to neutralize the acid and bring the pH of the paper to 7 or slightly more. Acid-free paper also contains a reserve of the alkaline compound to neutralize any acids the paper may encounter once in use or that develop as the paper ages. The integrity of acid-free paper is expected to last hundreds of years. The life span of paper that has not been treated with an alkaline compound may only be a couple of decades.

What are some other common uses of calcium carbonate?

- The booklet envelope, with its opening on the side, is used to hold house publications and direct mail pieces.
- The clasp envelope is used to mail bulky materials. The manner of fastening will vary, but it is strong and can take abuse.
Plastic Substrates

Plastic has many variations. Sometimes it is a thin film. Other times it is a sturdy yet flexible material. Another plastic might be stiff or even rigid. Plastic substrates are blended from various petrochemicals and other compounds. Most plastic substrates are available in both roll and sheet form.

### Polyester

Polyester is one of the strongest plastic films used as a printing substrate. It has high clarity, toughness, durability, and good dimensional stability. It must be treated to prepare its surface for offset printing. Polyester substrates are used for decals, labels, and signs.

### Copolyester

Copolyester is an extruded and dull-finished plastic substrate. It has a high degree of dimensional stability, clarity, and formability. It is available in matte finish or transparent colors. Copolyester is a comparatively inexpensive plastic substrate. Book report covers, overhead projector overlays, and flip charts are a few of its applications.

### Polycarbonate Film

Polycarbonate film is a high-gloss substrate with good dimensional stability, good heat resistance, and excellent light transmittance. Low-haze polycarbonate film can be printed on offset presses without pretreatment. It is easily die cut and embossed. Polycarbonate film is used for decals, nameplates, membrane switch panels, overlays, and product identification.

### Rigid Vinyl

A rigid vinyl substrate has good stability and is available in calendared gloss or matte finish. It comes in white translucent, white opaque, and standard opaque colors. Rigid vinyl is commonly used for identification cards or credit cards, but it is also used for shelf signs or labels, danglers, wall signs, and pocket calendars. Rigid vinyl is easily die-cut and thermoformed into shapes.

### High-Impact Polystyrene

High-impact polystyrene is a versatile and economical plastic substrate. It is offset-printable and available in translucent and opaque colors. It is used for point-of-purchase display signs and toys.

### Cellulose Acetate

Cellulose acetate is a plastic film. It provides outstanding clarity but poor dimensional stability and tear-resistance. Its soft surface is receptive to a wide variety of inks. Cellulose acetate is used for folders, book jackets, and overhead projector transparencies.

### Clear-Oriented Polyester

Clear-oriented polyester is the cheapest plastic substrate available. It tears and scratches easily but provides good clarity. It is used for short-term display signs, labels, visual aids, and similar products.

### Kimdura®

Kimdura® is a white opaque or translucent polypropylene film substrate. It serves as a “synthetic paper” that has been treated for offset printing. It is tough and durable, and can withstand repeated folding. Kimdura has good dimensional stability and a waterproof printing surface. It is used for posters, brochures, catalogs, children’s books, outdoor maps, globes, menus, and instructional manuals.

### Reemay®

Reemay® is a spunbonded polyester that is acrylic-coated on both sides. It is bright white. Reemay feels like fabric and can be sewn and grommeted. It is used for banners and similar applications and has excellent UV-resistance.

### Tyvek®

Tyvek® is a strong spunbonded polyolefin plastic substrate. It has a smooth surface, good dimensional stability, resistance to ultraviolet light and moisture, and excellent opacity. Tyvek is treated with an antistatic agent to facilitate sheet handling. For printing purposes, it is commonly used for envelopes, tags, labels, maps, and book coverings.

# Environmental Issues

The paper industry is trying diligently to be good stewards of the earth’s natural resources. Reforestation is taking place. Programs are ensuring that perpetual planting, growing, and harvesting of trees is taking place while protecting the environment. The driving force behind recycling advocacy is to keep...
Chain of Custody

The chain of custody is the process of tracking and recording the possession and transfer of wood and fiber from forests of origin, through the different stages of production, to the end user. This means that the responsibility now includes paper merchants, printers, agencies, and independent designers. The Sustainable Forestry Initiative (SFI) and the Forest Stewardship Council (FSC) are two programs that authenticate that the fiber source comes from responsibly managed forests.

Standards

Professionals and biologists are managing the forests to be in compliance with the standards of the SFI program. The FSC was established to create an honest and credible system for identifying well-managed forests. The Chlorine Free Products Association (CFPA) is a not-for-profit accreditation and standard-setting organization. The standards relate to the reduction of energy and water consumption, eliminating harmful toxins, providing a chain of custody for all fibers, and reviewing social, environmental, and financial responsibility of their products and services.

Summary

The surface of many materials has the capability of being printed on to give a visible image. Although paper is the most commonly used substrate, plastics and metal have favorable surfaces. The papermaking process requires consistency so that the surface of the stock allows true repeatability of an image. Many types of paper are needed to produce a variety of products. It is essential to know the characteristics of paper when printing as all designed products may not be suitable for a selected stock. Knowledge of the quality of paper is also essential. Federal and state regulations have forced major changes within the manufacturing process as well as sustainable forestry and certification.

Review Questions

Please do not write in this book. Write your answers on a separate sheet of paper.

1. List three common materials used as printing substrates.
2. Most paper manufactured in the U.S. is made on what machine?
3. What is the raw material used to make paper?
4. ______ is added to the pulp to make paper moisture-resistant. ______ are added to improve opacity, brightness, smoothness, and ink receptivity.
5. The process that impresses a translucent design in paper is ______.
   A. watermarking
   B. calendering
   C. furnishing
   D. embossing
6. ______ paper is smoother, stronger, and yields a better image than ______ paper.
7. What are two alternatives to using chlorine gas to bleach paper?
8. What characteristic is contained by machine-made papers?
9. How many sheets are in a ream of paper?
10. What is the formula for determining basis weight?
11. How many sheets of 8” x 10” can be cut out of a 17” x 22” sheet?
12. What color of paper is essential for true process color reproduction?
13. Print ______ is an important factor affecting hickeys or specks on the printed image.
14. The ______ of paper affects whether the paper will exhibit an undesirable problem called ______.
15. Which plastic substrate is typically used to make identification cards and credit cards?
16. Explain the role of the chain of custody.

Suggested Activities

1. Explore the possibility of making handmade paper.
2. Using a rubber stamp, place the stamp image on seven different substrate surfaces. Analyze the effect of the stamp on each surface of the various substrates.

3. Visit a paper storage facility and list the paper classifications as well as the paper sizes associated with that classification.
4. As a group project, request the specifications for an actual job from a printing plant. Do all of the calculations necessary to determine how much paper is necessary for the job. Then visit the plant and find out if your calculations were correct.

Related Web Links

International Paper
www.ipaper.com
Site for the paper and packaging company with information on different types of forests and paper.

Forest Stewardship Council
www.fsc.org
Information and standards for responsible forest management.

ForestEthics
www.forestethics.org
An organization dedicated to the future health of endangered forests worldwide.

Green Seal
www.greenseal.org
Organization that offers studies, information, and standards about different environmental issues.

Green-e
www.green-e.org
Organization with standards for products made with renewable energy.

Chlorine Free Products Association
www.chlorinefreeproducts.org
Organization dedicated to creating products without the use of chlorine compounds.

Sustainable Forestry Initiative
www.sfi-program.org
Organization with information and standards to help protect from deforestation.

chain of custody: The process of tracking and recording the possession and transfer of wood and fiber from forests of origin to the end user.