

# Substrates

**I**N GRAPHIC COMMUNICATION, a substrate is the base material on which an image is printed (or coated). Paper substrates are as common in the graphics industry as non-paper substrates, such as vinyl, polystyrene, acetate, and polycarbonate. As a graphic designer or printer, you must evaluate each substrate's properties when selecting the best medium for the job at hand. Which substrate was used on this car?



## Objective:



Evaluate substrates and review paper characteristics.

## Key Terms:



acid-free paper	grain long	paper opacity
basic size	gravure (rotogravure)	ream
basis weight	printing	recycled paper
bleaching	ID paper	security paper
bond paper	kraft paper	substance weight
calendered	laser printing	substrate
cellulose pulp	manila paper	tensile strength (TS)
coated paper	mil	Teslin®
cotton paper (rag paper)	offset printing	UV coatings
equivalent weight	paper	UV printing
finish	paper brightness	vehicle wrap
flexography	paper flatness	vinyl
grain	paper grade	

# Paper and Non-paper Substrates for Printing

In graphic communication, a **substrate** is the base material on which an image is printed (or coated). Substrates are used for the printing of graphic documents and communication vehicles (posters, flags, awnings, window coverings, outdoor furniture, bus advertisements, car wraps, billboards, etc.). As a graphic artist or printer, your central task is to match the best substrate with the desired print job.

## EVALUATE SUBSTRATES

Common graphic communication substrates include:

- ◆ Bond papers
- ◆ Conventional papers and parchments (including acid-free, adhesive-coated, coated, uncoated, cover, ledger, newsprint, offset, paperboard, or cardboard)
- ◆ Handmade papers
- ◆ ID and security papers
- ◆ Metal
- ◆ Plastic films or foils (from flexible to inflexible sheets or rolls)
- ◆ Textiles
- ◆ Vinyl (from flexible to inflexible sheets or rolls)
- ◆ UV inks and coatings (images and coatings are only visible under ultraviolet or black light)
- ◆ Wood

## Paper Categories

**Paper** is a thin substrate created from wood or cellulose pulp, and it is used for writing, printing, packaging, cleaning, and numerous other industrial and construction processes. **Cellulose pulp** is separated and cleaned organic fibers from woody plants, cotton, rags, or flax (to name a few). In selecting the appropriate type of paper, it is necessary to understand the basic qualities and common uses of each type. You will use a wide-range of paper types in graphic communication operations. Three major categories of paper types are coated, uncoated, and recycled.

### Coated

**Coated paper** is a glossy or matte finish paper with layers of fine clay, latex, pigments, or adhesives applied to its smooth and strong surface. The coating fills in the tiny pores and crevices of plain paper, creating a smooth finish. When paper is coated, it absorbs less moisture. As

a result, printed ink will sit on the surface rather than sinking in. Coated paper requires the use of less ink than uncoated paper. Due to the nature of coated paper, few characteristics should be remembered.

- ◆ Inks will take longer to dry.
- ◆ Images are clear, defined, and glossy.
- ◆ Final results for images are excellent (photographs, logos, etc.).
- ◆ The final result for text readability is poor (too glossy and easily smudged).

## Uncoated

Uncoated papers are more absorbent, have less definition, and possess a matte finish. Uncoated paper qualities should be considered in your print jobs.

- ◆ Inks will dry quickly for tight deadlines.
- ◆ Images are less defined (than on coated paper).
- ◆ Final results for image quality are dull and lose details.
- ◆ The final result for text readability is excellent.

## Recycled

**Recycled paper** is a substrate made (at least in part) from recovered, re-used fibers (old or used wastepaper products). According to the U.S. Environmental Protection Agency (EPA), nearly 31 percent of the solid waste in landfills is made up of paper and paper-based packaging. The EPA considers any unrecovered paper an economical and environmental cost.

## Paper Substrates

Several paper substrates are available for print.

## Bond

**Bond paper** is a high quality, durable, heavyweight paper (similar to bank paper) with the characteristics of strength, ink receptivity, and erasability. It is made from cotton, rag fiber, or chemical wood pulp. Rag bond is an expensive paper used for high-quality writing and printing tasks. Bond paper uses include:

- ◆ Stationery and business cards
- ◆ Business forms and letterheads
- ◆ Government bonds
- ◆ Invitations, announcements, and note cards

## Cotton

**Cotton paper (rag paper)** is a paper made from cotton linters (linters are short fibers that stick to cottonseeds after the first grinding) or from recycled cotton fabrics (rags). Rag paper is used for important records and official papers, such as archival documents and bank-notes. It is stronger and more durable than standard wood-pulp paper. Rag paper can last hundreds of years without fading, deteriorating, or discoloring.

## Manila

**Manila paper** is a chemical sulfate paper that is relatively strong, can be buff or vanilla in color, and was originally made from Manila hemp (a fibrous plant, also called jute, from the Philippines). Today it's made from wood pulp substitutes and various other fibers. It is an inexpensively produced paper that sometimes has wood fibers visible on the surface. It is not as strong as Kraft or common printing paper, but is able to absorb most inks and dyes better than kraft paper. Manila paper is used for:

- ◆ Children's art projects
- ◆ Envelopes
- ◆ Table coverings
- ◆ Packaging materials
- ◆ File folders

## Kraft

**Kraft paper** (sack paper) is a strong, smooth substrate material made from chemical pulp, and it has a high tensile strength. Kraft papers are typically used as brown wrapping paper, but they may also be bleached and colored. Paper produced by the kraft process is typically stronger and more durable than paper made from the normal pulping process. It is porous, but elastic and tear-resistant. Based on its characteristics, kraft paper is an excellent choice for many items requiring a strong paper source.

- ◆ Paper sacks, shopping and gift bags
- ◆ Food and Industrial containers (sacks made for flour, cement, or dog food)
- ◆ Envelopes
- ◆ Rolls of crafting paper (for bulletin boards and school projects)
- ◆ Base of sandpaper



**FIGURE 1.** Based on its characteristics, kraft paper is an excellent choice for paper sacks, envelopes, and many types of bags.

## Acid-Free

**Acid-free paper** is a paper made from any cellulose fiber that has acidic pulp removed during processing. It is constructed in a neutral pH (about 7.0 or slightly greater) environment to increase paper longevity (other paper can discolor, deteriorate, and become yellow and brittle over time). There are many uses for acid-free paper.

- ◆ Books, art folios
- ◆ Artwork
- ◆ Documents (certificates and diplomas, wedding invitations, stock certificates, etc.)

## Security paper

**Security paper** is a paper manufactured with a printed pattern, watermark, or other features created during the pulp process that will show evidence of document alteration when erasing, writing on, chemically altering, or copying the original paper. Due to technology and criminal ingenuity, security paper has become a high-tech paper type. Security features for printed documents include embedded threads, watermarks, special inks, color-shifting coatings, fluorescent inks or coatings, complex images (fine line borders, microprinting), secure appliques (holographic or prismatic images, and foils), informational add-ons (magnetic stripes and RFID chips), and calculated or changeable content (check digit numbering and images that change after copying). Security papers act to identify or authenticate a document as original via: watermarks, invisible fibers, or features that demonstrate evidence of tampering when fraud is attempted. It is commonly used to print:

- ◆ Banknotes (currency)
- ◆ Checks
- ◆ Passports
- ◆ Tamper-evident labels
- ◆ Product authentication
- ◆ Financial certificates
- ◆ Birth records



**FIGURE 2.** Security paper is a paper manufactured with a printed pattern, watermark, or other features created during the pulp process that will show evidence of document alteration when erasing, writing on, chemically altering, or copying the original paper. Due to technology and criminal ingenuity, security paper has become a high-tech paper type. This picture shows a \$100 bill. What security features can you find? Watermarks? Threads? Magnetic strips?

## ID paper

**ID paper** is a type of strong, durable, coated paper (usually rigid vinyl) used to create identification cards. ID paper comes in a range of widths. It is also waterproof, which makes it suitable for signs and labels. ID paper is available in a range of colors (including translucent and opaque), and it can be die cut or thermoformed into a specific shape. Most ID cards, loyalty



cards, and key tags are ID papers made with PVC or Teslin®. PVC (polyvinyl chloride) is a durable plastic mostly known for construction uses (pipes). It is durable, noncorrosive, and a good option for coating long-term cards. **Teslin®** was created by PPG Industries in the 1980s, and it is a synthetic, waterproof, printable paper that is protected by a thick laminate. It is a good choice for items needing repeated use. ID paper is used for multiple products that almost everyone uses daily.

- ◆ ID badges
- ◆ Drivers license and other licenses
- ◆ Membership cards
- ◆ Permits
- ◆ Credit cards
- ◆ Safety signage, tags, and technical instructions

## Non-Paper Substrates

Many non-paper types of substrates can be printed on.

### Vinyl

**Vinyl** is a non-paper substrate—a type of plastic polymer. Graphics can be printed on vinyl for both interior and exterior use. Vinyl prints can range from several square feet to billboard-size, and they can wrap vehicles and technical devices. A **vehicle wrap** is a decal that covers a vehicle (partially to completely). Vinyl has many practical uses.

- ◆ Banners and flags
- ◆ Billboards
- ◆ Magnetic, safety, or traffic signs
- ◆ Wallpaper
- ◆ Vehicle wraps

### Polyester

Polyester is used to create signs, labels, and decals. It's clear, tough, and stable: A strong and durable substrate for printing. Polyester does require the surface to be treated for offset printing. (Clear, oriented polyester is used for signs and labels that are intended for short-term use, such as temporary displays, signs, and product promotions. It is very cost effective and has good clarity, but it can be easily torn or scratched.)

### Cellulose

Cellulose acetate is used to print book covers, folders, and transparencies. Its clear, printable surface is a soft substrate that can hold a wide range of inks. However, it is an unstable substrate than can tear easily. Its cousin, celluloid, was popularly used for film-making in the early

20th Century. Due to being heat-sensitive and deteriorative, film is now made from cellulose acetate or polyester.

### Polycarbonate Film

Polycarbonate film is used to print product identification labels, decals, and overlays. It is a stable and heat-resistant substrate that easily transmits light and comes in a high gloss finish. Some grades can be printed on offset presses without pretreatment.

### Polystyrene

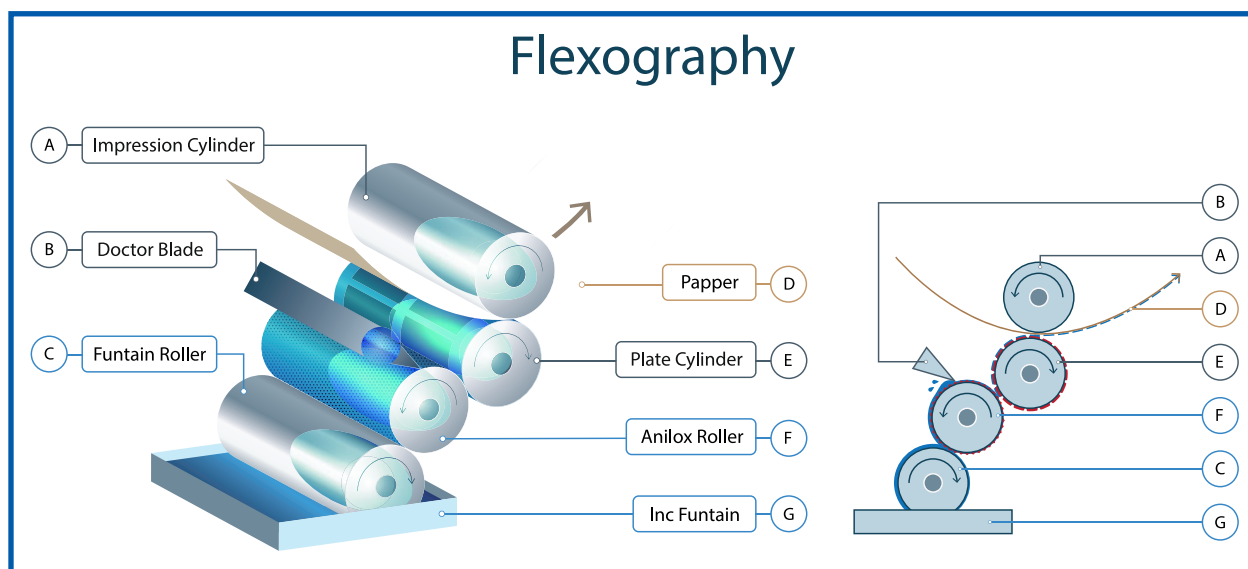
High-impact polystyrene is used for toys, signs, and in-store, point-of-purchase displays. It can be used on offset printers, and comes in a range of translucent and opaque colors.

## Printing Processes

Due to the plethora of substrate options, there is an equally plentiful number of printing processes needed for different paper and non-paper products.

### Flexography

**Flexography** (also flexo or aniline printing) is a printing process that uses soft, flexible relief plates that easily transfer ink onto a substrate. It is the process most used to print packaging materials, including corrugated containers, gift wraps, folding cartons, multi-wall paper sacks, plastic bags, milk and beverage cartons, disposable cups and containers, labels, envelopes, newspapers, paperback books, and food and candy wrappers.



**FIGURE 3.** Substrates best suited for flexography include paperboard, plastic, metal films, cellophane, kraft paper, and corrugated paper.

## Laser Printing

**Laser printing** is an electrostatic, digital print process that produces high-quality text and graphics. The process repeatedly moves a laser beam back and forth over a negatively charged cylinder (drum) to define a differentially charged image. The drum selectively collects electrically charged powdered ink (toner), transfers it to an image on paper that is heated, and permanently fuses the text or imagery. Print errors can occur as misregistrations or ink rub off. Many laser printers use special papers.

- ◆ Smooth-Finish: Smooth-finish laser papers have excellent toner grip (bonding) and excellent performance at high speeds.
- ◆ High-Speed/High-Temperature: High-speed, higher-temperature digital printers use paper with heat-resistant qualities.

## Toners

There are two types of toners used in the printing processes. The toner type often corresponds to the paper type that the printer will use.

- ◆ Dry Toner: A dry toner is used with both coated and uncoated paper, including card (cover) stock and 24-pound to 80-pound bond paper (as well as 110-pound index paper).
- ◆ Wet Toner: Wet toner requires special coatings for the best ink adhesion (grip). It works well for transparencies, labels, and heavier texts.

## Intaglio

Intaglio is a printing process that involves the engraving, carving, or etching of a text or an image. These engravings can be fine-detail acid-etchings, like those used in gravure printing. **Gravure (rotogravure) printing** is a printing process in which images and texts are transferred to metal, intaglio cylinders or rotary plates. These inked cylinders can then be rolled to imprint images or text onto a substrate. Gravure printing usually takes place on a rotary printing press that imprints by use of pressure. Substrates with soft surfaces, mineral fibers, or short fibers are commonly used in these processes. Paper and other substrates used for gravure printing tasks are usually soft, and the ink is not sticky. Multi-run catalogs, magazines, and wallpapers are just a few of the products that use gravure printing. Paper types best suited to gravure printing include:

- ◆ Newsprint with mineral fillers and a **calendered** (paper passed through polished metal rolls to increase gloss and smoothness) surface
- ◆ Packaging that does not require compression

## Offset

**Offset printing** (offset lithography) is a technique in which the inked image is transferred (offset) from a plate to a rubber blanket, then to the printed surface. Offset typically requires paper with a strong fiber bond. This is important, as the ink used is sticky and can pull off the



paper surface. With offset printing, it is important to limit the amount of dust, fuzz, and lint on the paper. The best substrate choices for offset printing include:

- ◆ Coated papers (due to ink and low porosity)
- ◆ Stable bond papers with some thickness (best with high production speeds)

## UV

**UV printing** is a digital printing technique that utilizes ultraviolet light to cure and dry ink. As ink is placed on a substrate material, UV lights instantly dry it. This allows printing on a much larger range of substrate types. The quality of the printed image on a substrate is typically much higher, because the ink dries quickly and does not have time to bleed or spread on the material.

- ◆ **UV Coatings:** **UV coatings** are applied as a liquid, using a roller, screen, or blanket, and then exposed to (UV) ultraviolet light. This polymerizes and hardens the coating. The coatings can be applied onto the entire page or on a spot-by-spot basis.
- ◆ **UV Finishes:** UV coatings on paper are usually finished in high gloss, matte, or satin. Some creative, custom finishes include tints, glitter, or various scents.

## PAPER CHARACTERISTICS, GRADES, WEIGHTS, AND SIZES

Matching the correct substrate to the job is a critical step in a graphic communication project. The use of high quality ink, layouts, and advanced printing techniques can be wasted on lower quality paper or substrates. There are many paper substrate characteristics, grades, weights, and sizes to consider when working on a print job.

### Grain

Machine-made paper has a grain. **Grain** is the direction in which the pulp fibers run throughout the paper. This characteristic is important when feeding the paper into the press. Typically, the grain is fed into the offset press parallel to the printing cylinder. Binding by the grain long direction is important. Papers generally get cut with the grains going with the longest paper edge. **Grain long** means that paper has been cut with the grain running the length of the longest edge. In an  $8\frac{1}{2} \times 11$  inch sheet of paper, the grain should be running the direction of the 11-inch edge to ensure fibers do not break easily. A grain-short cut would be made with the grain direction following the  $8\frac{1}{2}$  inch edge.

### Flatness

**Paper flatness** is the degree to which the paper remains level and warp-free during printing processes. Flatness is an important characteristic when feeding paper stock through a sheet press to avoid any curling, tearing, or warping of the paper.

## Bleaching

**Bleaching** is a chemical process to brighten, whiten, purify, refine, and balance pulp fiber. Bleaching produces high-quality paper that resists discoloring during storage, yellowing over time, or damage due to sunlight exposure. Bleaching also removes any wood particles left from the pulp process, so it creates higher levels of absorption and purity.

## Color

Paper color affects the final printed result. To achieve a full display of colors, the selection of pure white, off-white, white, or color tones will affect the final graphic product. Some colored papers can produce an unintended color value or an undesired result. (If printing with blue ink on yellow-died, porous paper, green bleeds could become visible.)

## Smoothness and Texture

The texture of paper significantly effects graphic printing. Detailed images require smooth papers, because rough papers will not create a sharp image.

## Strength

**Tensile strength (TS)** is the maximum force required to break a paper strip (of a given width) under prescribed laboratory conditions. TS is the capacity of a paper type to withstand loads (stress and strain) and resist tension (without being pulled apart). TS is determined by the degree to which the inner paper fibers are bonded together. This is important when ensuring that a roll of paper can be fed through a web-fed press without breaking. Additionally, paper print strength is a property that determines how well the surface of the paper is bonded.



## FURTHER EXPLORATION...

### ONLINE CONNECTION: Specialty Paper

Specialty papers include text paper, Japanese paper, card stock, cotton rag, metallic, felt, translucent vellum, wood grain, and more. The way a paper feels is partially a result of the paper's weight and thickness. To learn more about uses for specialty papers—wedding invitations, fine paper craft, and papers unique to trifold tasks—access the LCI Paper Company website at <https://www.lcipaper.com/specialty-paper.html>.



This handmade Japanese paper is appropriate for stationery, invitations, and fine paper crafts (screens, lamp shades, or kites).

## Brightness

**Paper brightness** is a measure of the amount of light reflected back from a paper—specifically, a wavelength of blue light. It is measured on a scale of "0 to 100." The higher the number, the brighter the paper. Since brighter paper reflects more light, a level 100 paper would result in printed colors appearing more vibrant than a level 60.

## Opacity

**Paper opacity** is the visual density scale of a sheet from one side to the other (how “see-through” or “show-through” it may be). The less see-through a paper is, the higher the opacity. To counteract show-through, the designer and printer can select a heavyweight stock paper with a high opacity. Higher-weight paper has a higher opacity rating.

## Paper Grades

**Paper grade** is a classification given to paper based on its unique characteristics, such as brightness, opacity, and cotton content. A range of commercial paper grades are available. In general, newspaper grades are thin and off-white, while high-quality printing paper is thick and pure white. There are seven grades mostly associated with paper. (Source: Print & Copy Factory.)

- ◆ Bond or writing (letterheads, business forms, or copier use)
- ◆ Book (coated and uncoated types)
- ◆ Text (high-quality sheets in a variety of surfaces and colors)
- ◆ Cover (book covers, postcards, or inserts—many color and surface choices)
- ◆ Tag (Stiff cardstock with a smooth, coated surface, used for store tags)
- ◆ Bristol (uncoated, machine-finished paperboard)
- ◆ Index (stiff, coated, smooth, thin cardstock, mostly used for index and business cards)

## Finishes

A paper's **finish** is the physical look and feel of the paper's surface treatment, including smooth, felt, laid, or linen. Coated, uncoated, and text are all paper types with unique finishes.

### Coated Paper

Coated paper finishes come in three main styles.

- ◆ Matte (wash or dull)
- ◆ Premium (silk, suede, or velvet)
- ◆ Ultra gloss (gloss, high gloss)

## Uncoated Paper

Uncoated paper may come in one of four categories.

- ◆ #1 Offset
- ◆ #3 Offset
- ◆ Opaque
- ◆ Lightweights

## Uncoated Text Paper

Uncoated text paper finishes generally relate to their surface feel.

- ◆ Smooth (smoothed by passing through rollers, such as vellum, a smooth finish with an eggshell texture)
- ◆ Felt (embossed finishes with a raised surface)
- ◆ Laid (a ribbed texture)
- ◆ Linen (embossed to resemble a linen fabric texture)

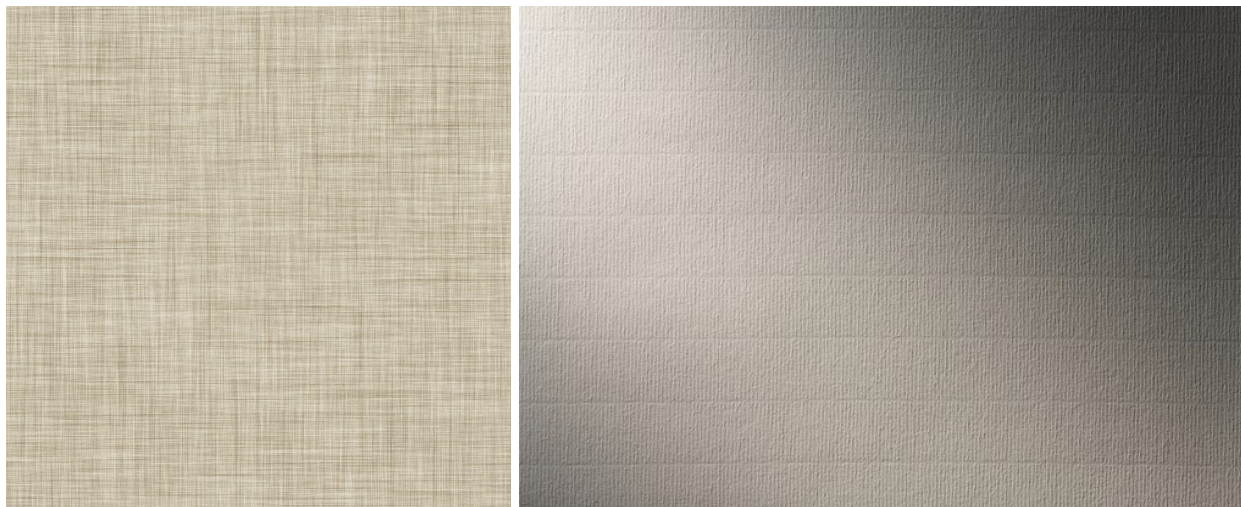


FIGURE 4. One of these images has a laid paper texture and the other has a linen paper texture. Which is which?

## Paper Weight Terminology

The **basis weight** is the mass, in pounds, of one ream of paper (at its base size in inches). A **ream** is 500 sheets of paper. A paper's weight is actually the weight of that paper in a ream. For example, a basic bond paper has a base size of  $17 \times 22$  inches, and a ream can weigh between 16 and 20 pounds—depending on the paper's characteristics. Therefore, if a sheet of  $17 \times 22$  inch stock paper is labeled 16, then that means a ream (500 sheets) of that paper weighs approximately 16 pounds.

## Equivalent Weight

The **equivalent weight** is the comparison of different types of paper and weights from the basis weight and size of a particular paper. For example, bond paper is based off of a 17 × 22 inch base size, with a normal 16 rating. An equivalent weight of that size for cover paper is 22 pounds. Cover paper is usually at a 50 for its base size of 20 × 26 inches.

## Substance Weight

**Substance weight** is the actual mass of one ream of a specific type of paper.

## Mils

Some substrates may list thickness in mils rather than by weight. A **mil** is a thousandth of an inch (0.001 inch), and its measurement is commonly used with large scale plastics and vinyl substrates.

## Weights by Grade

Paper grades have common weights associated with them.

## Bond

Bond or writing paper weights are usually listed in pounds as:

- ◆ 16 (for forms)
- ◆ 20 (for copying)
- ◆ 24 (for stationery)

## Book

Book (coated) paper usually comes (in pounds) at:

- ◆ 30 to 70 (for Web)
- ◆ 60 to 110 (for sheet-fed)

## Text

Text paper is usually at 60 to 100 pounds (70 to 80 pounds are the most common ratings).

## Cover

Cover paper pounds available are 60, 65, 80, 100, 110, and 130.

## Offset

Offset paper is usually figured at 50 to 70 pounds.

## Paper Size

A **basic size** is the standard sheet size (width and length, in inches) of a given grade of paper. It varies depending on the paper grade or use. Paper sizes in North America are different from most of the world. In 1996, the American National Standards Institute (ANSI) adopted ANSI/ASME Y14.1, a regular series of paper sizes based on the standard  $8\frac{1}{2} \times 11$  inch letter size. It was assigned the name “ANSI A” for technical and engineering drawings.

### North American

The most common North American paper sizes, in inches, are:

- ◆ Letter size is  $8\frac{1}{2} \times 11$
- ◆ Legal size is  $8\frac{1}{2} \times 14$
- ◆ Ledger size is  $17 \times 11$
- ◆ Tabloid size is  $11 \times 17$

### International

The ISO 216 A Series (metric) is the international standard used by nearly all countries except those in North America. The A4 size is the most common. The following international paper sizes are included in Cascading Style Sheets (CSS): A3, A4, A5, B4, B5. (The international sizes are in millimeters, which is why they don’t translate perfectly into American paper measurements. A4 is closest to our letter size—in inches, it is  $8\frac{3}{10} \times 11\frac{7}{10}$ .)

## Summary:



A substrate is the base material on which something can be printed or coated. Paper substrates are categorized as coated, uncoated, and recycled. The paper substrates used in commercial printing processes include bond, cotton, manila, and kraft paper. A non-paper substrate example is vinyl—a type of plastic polymer used to create signs and identification cards and tags.

Matching the correct paper substrate to the job is critical. As a graphic designer or printer, you should consider paper characteristics (such as paper grain, paper flatness, and bleaching) when selecting the best substrate. Paper qualities that can affect the printed result include color, smoothness, texture, strength, brightness, and opacity.

Other considerations in matching substrates to the task are grade, basis weight, and size. Paper grade is a classification given to paper based on its unique characteristics, including brightness, opacity, or cotton content. Basis weight is the mass, in pounds, of one ream of paper (at its base size, in inches). A ream is five hundred (500) sheets of paper. A basic size is the standard sheet size (width and length, in inches) of a given grade of paper.



## Checking Your Knowledge:

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1. List commercial printing and coating substrates.
2. How do paper characteristics affect substrate selection?
3. How does paper flatness affect substrate selection?
4. What types of paper finishes are there?
5. For what purposes are non-paper substrates used?

## Expanding Your Knowledge:

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Print houses use substrates in common and creative ways. During the selection process, designers usually assess a range of sample substrates. Plan a trip to a graphic designer's office or print house to observe the paper and non-paper substrates they have as samples. Ask the designer to describe how they chose a substrate for different jobs. If possible, bring some job samples back to the classroom. Describe the process the designer used to select each substrate.

## Web Links:

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### Grammage

<https://en.wikipedia.org/wiki/Grammage>

### How Can Teslin Paper Be Used?

<http://brainstormidsupply.com/teslin-paper-uses.html>

### Paper Size

[https://en.wikipedia.org/wiki/Paper\\_size](https://en.wikipedia.org/wiki/Paper_size)

### Printing Processes

<http://www.prepressure.com/printing/processes>

### Rotogravure Diagram

[https://commons.wikimedia.org/wiki/File:Rotogravure\\_PrintUnit.svg](https://commons.wikimedia.org/wiki/File:Rotogravure_PrintUnit.svg)

### Vehicle Advertising & Branding Wraps

<http://graphicd-signs.com/services/vehicle-advertising/>

### Wrap Advertising

[https://commons.wikimedia.org/wiki/File:ALRV\\_4204\\_in\\_CBC\\_Radio\\_2\\_Wrap\\_Advertising.jpg](https://commons.wikimedia.org/wiki/File:ALRV_4204_in_CBC_Radio_2_Wrap_Advertising.jpg)