CHAPTER 3

DEMOGRAPHICS, PSYCHOGRAPHICS AND ETHNOGRAPHY

Designing correct package communication requires, first of all, an understanding of the intended receiver of the communication.

Consumption habits and motivations of targeted audience segments are different, sometimes dramatically so. It is important to understand the target audience and the best manner in which to motivate purchase decisions. Information about the consuming public usually falls into the scope of demographics and psychographics. Observing a consumer's buying preferences, as well as how that person interacts with the package and product when at home, requires the study of ethnography.

Demography is a numerical count of how many consumers there are in specific, easily quantifiable classifications. Much demographic information is derived from a country's national census and might include such information as::

gender	age	occupation
residence	cultural background	ethnic background
education level	marital status	family size
socioeconomic status	geographic factors	religious beliefs

Packaging always should anticipate tomorrow's market, and demographic trends are the first place to look when trying to anticipate future packaging needs. People are living longer, family size is decreasing and consumers exist in a virtual world now more than ever.

Some demographic trends can be difficult to project. For example, North American birth rates are low, and immigration accounts for a significant part of population growth. Simply saying that there is a large ethnic market is not useful. The specific influence these newcomers have on living, working and consumption habits must be determined.

Broad demographic categorizations, while useful, are rarely enough to identify a group with similar motivational triggers. Not all 26-year-olds are interested in, or motivated by, the same thing.

Psychographics is the study of how groups of people are motivated and how they behave. Unlike demographics, it is not a precise study. Although often not recognized as such, psychographic terms are common in everyday usage. When we say "Millennial," or "Gen Z," we are identifying a real or imagined group of people who supposedly have a characteristic behavior.

True ethnography—the study of buying habits—observes as a person goes about the day or performs a specific task. Companies such as Microsoft and Apple do this to identify the opportunities for more functional solutions with their products. Ethnography has been changed a bit by researchers, such as KW Strategems. The research teams give the consumer a task in the store (shop the shelf to determine what you will put in your cart today, for example). The consumer also is asked to narrate their experience and explain the rationale for their buying decision.

For example, if the researchers are studying cereal, the consumer might walk through the aisle and say, "The first thing I look for is the big blue box of Frosted Flakes, which is always on the bottom shelf. Then I know the Corn Flakes are nearby,

but I can't always find it as quickly. Usually, the Corn Pops cereal catches my eye as I walk past, along with Honey Nut Cheerios, but my kids don't like those anymore and besides, they have too much sugar." From that, the researchers discover that the Frosted Flakes pack is a place marker, the Corn Flakes pack is not cutting through the clutter and variety (for kids) and health (for moms) is important.

There is a continuous effort to identify tomorrow's hot trend or an unfulfilled need. The objective is to discover the purchasing preference or need of a significant consumer block. Many studies seek to identify behavioral patterns that may help in the design of packaging that will appeal to specific groups.

The public's mood can be difficult to define, and apparent psychographic trends should be carefully analyzed. It would appear, for example, that there is a great desire among the majority of the population to have environmentally-friendly packaging. Various surveys have suggested that upward of 90% of the population would give purchasing preference to packages made from recycled material, or that they would be willing to pay a premium for more environmentally-responsible packaging. In practice, this has proved not to be the case. "Bright greens," those consumers willing to change habits and spend extra time and money in support of environmental beliefs, may represent a smaller percentage.

In addition to basic demographic/psychographic information, there is other essential information about the consumer. At first sight, these other pieces of the motivational puzzle do not seem to be related to demographics/psychographics. However, they are affected by the relationship between the product and the way the consumer views it. Packagers need to ask:

What is the preferred purchase unit? Is this an impulse item? Is it a seasonal purchase? Is it a durable good? A staple item? A gift item?

Facts about how the product is used also can be helpful in determining the extra structural and graphic features that will attract a potential customer's attention. Packagers need to evaluate:

easy-opening features	reclosure features	dispensing features
measuring aids	table packs	attractiveness level
instructions	cautions	disposal methods
use quantities	returnable packages	secondary uses
storage methods	special features	environmental status

Since your package will be in direct competition with other brands for the consumer's attention, you must know almost as much about your competition as you do about your own product. Market research should identify:

target markets	strengths	weaknesses
package types	unit	sales volumes
market share	pricing structure	marketing strategy

Targeting a market dominated by a single large competitor serving a population with high brand loyalty is a high-risk venture. In many instances, selling to a smaller niche market not served by the major players has proved to be a good strategy. Better to own 90% of a small market than fight for 2% of the large market.

More details on how to measure, quantify and evaluate market success—and how to design a package accordingly—appear at the end of this chapter.

CHAPTER 3

THE RETAIL ENVIRONMENT

The retail environment is increasingly varied and omnichannel. What constitutes a "store" has gone beyond simply online versus offline to encompass different types of social commerce, from regular social storefronts, shoppable videos (i.e., Instagram) to shoppable livestreams (Amazon, Taobao). E-commerce accounts for about 20% of total retail sales—and rising—while China is forecasted to have more than 50% of retail sales achieved online.

Offline shopping

The modern retail establishment is a sea of choices. A food supermarket can have upward of 40,000 products on display, each one clamoring for the consumer's attention. Hardware outlets may stock even more items. Market research indicates that the typical consumer notices fewer than 100 products and leaves the store with about 14.

The challenge facing the package designer is this: How do I present my potato chip bag, the 51st offering on the shelf, so it's seen? And if my chip bag is seen, how do I convince the viewer that, with 50 other choices, my brand is the one to purchase?

When the consumer is making the purchase decision at the store shelf, the package becomes the medium that influences which product goes in the consumer's shopping cart. Regardless of advertisements and promotions outside the store, the "moment of truth" is between the consumer and the package. Depending on the information source and the nature of the product, between 68% and 80% of purchase decisions are made in the store while the consumer is facing the product. Various estimates put the percentage even higher on impulse items.

Furthermore, today's consumer frequently doesn't have a specific shopping list. Many shoppers scan aisles for general classes of products or simply cruise the aisles for ideas that trigger impulse buys. Measurements suggest that a product has the consumer's attention for about 7 seconds (sec). During this time, it must convey a message that will motivate a purchase.

Cluttered graphic designs and contradictory messages cannot deliver the buying message in those critical 7 sec. Such products are simply not seen by the potential purchaser. And unseen is unsold. Sometimes, unclear on-pack messaging leaves the consumer confused about a product—even unclear about product differences across an entire category—and a confused shopper may default to the safety of not purchasing at all.

The most successful brand identities achieve "disruptive simplicity." They use significantly different colors, photographic styles, textures and design elements to cut through category clutter. Exemplifying the adage "One, two, too many" they control the number of brand messages on the face panel to the logo and no more than two additional elements. And yet, impact and differentiation are only half the game. Once you have grabbed the consumer's attention, the distinctive design also must be both compelling and relevant. Anyone can design an impactful identity (just look at the snack food category as an example). The true key is delivering a brand promise that is as meaningful as the brand identity is impactful.

Merchandising methods and the way consumers relate to products are undergoing rapid change. National brand loyalty has been dropping significantly in Europe and even more in the United States. The image of many store brands has changed

Figure 3.4
Pack imagery simplified for e-commerce on a smartphone.

from being the second-choice economy option to as good as or better than the national brand, at a better price. And more recently, a higher tier of store brand has emerged: the destination brand, exclusive to a retailer, that may exceed the national brand in quality or offer a different flavor option and may cost as much or more than the national brand.

Smartphones are enhancing the in-store retail experience, placing infinite information at the fingertips of shoppers. (See Figure 3.4) In addition to online research beforehand, the border between online and offline worlds while the shopper stands at the shelf is blurring. Smart shelf strip price tags, as well as on-pack codes, allow shoppers to instantly access multimedia product info with a simple scan with their smartphone.

Online shopping

To cut through the clutter, product and pack need to react to where they're placed. And online, dimensions of storytelling change—product images are smaller, but there's more space on the Product Detail Page (PDP) for immersive experiences. (See Figure 3.5) PDPs are multimedia and content-rich with videos increasingly playing the part of the visual hook to attract, engage and convince shoppers of purchase.

The key implication? Because functional messages can be "offloaded" elsewhere on the page, the packaging is free of its offline requirements to hold all info within "four panels." In terms of packaging, two trends emerge—simplicity for clarity and amped-up for shareability.

Product images on PDPs are usually small (averaging 800 x 800 pixels), with tiled images appearing even smaller in search results. Together with the prevalence of mobile shopping, this means that pack imagery needs to be simplified for clarity. Remove any smaller legal or marketing messages not key to communication and use all available space to increase the visibility of the four key elements—who, what, which and how. Note that in most cases, for products sold both online and offline, the physical packaging of the product can remain the same in real life, but pack imagery is edited for e-commerce. Figure 3.6 shows the differences between offline and online-only packs for Mizkan's vinegar drink.

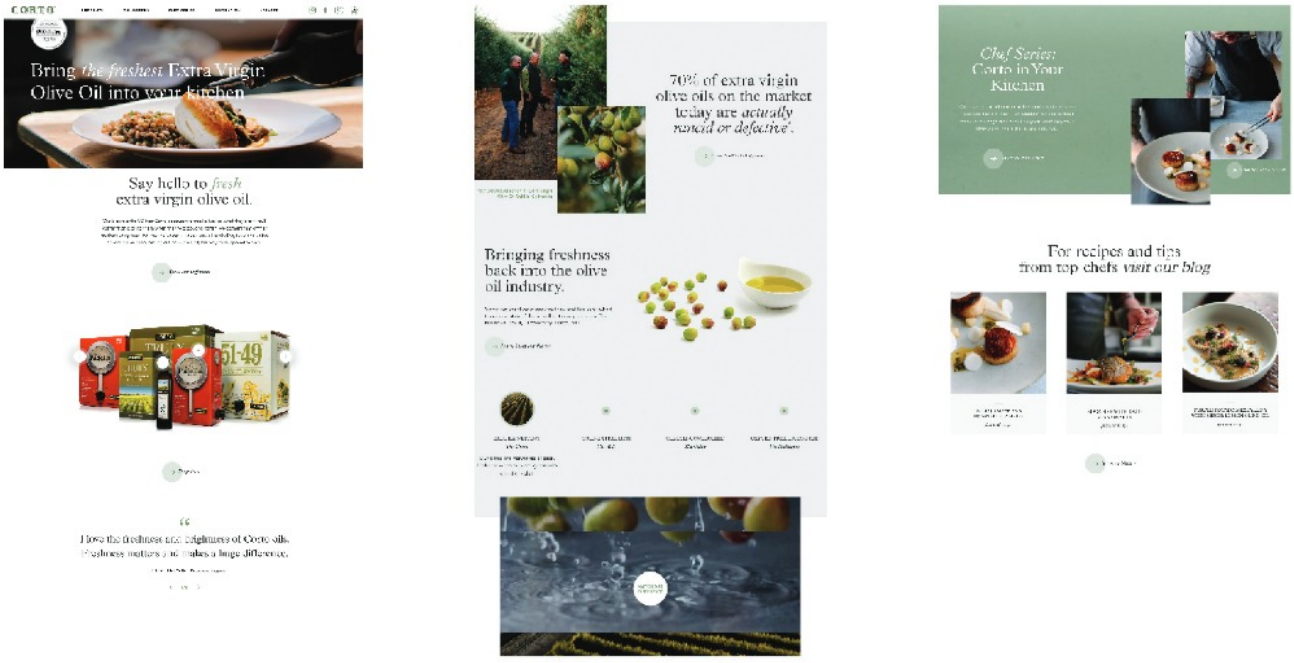

Figure 3.5
A typical content-rich PDP, prevalent in Asia and increasingly becoming the norm. The product story is enhanced with videos, usage, provenance, history, etc.

However, the rise of direct-to-consumer and digital-only brands opens more possibilities in terms of packaging. In an online world, packaging doesn't just play the role of "buyable." But increasingly, it must be sharable—not only distinctive and relevant but aspirational and unique.

Since they don't have to exist in offline retail, online-only packaging can be dialed up in terms of design to play more of a marketing role. Examples of online-only packaging are shown in Figure 3.7. Because functional mandatories are communicated elsewhere on the page (or at least not necessarily on the front panel), the design can be purer or exaggerated to go viral on Instagram or customized to speak to different lifestyles. The exciting possibility of online-only packaging is designing it to not only stand out as an object but to be a conversation piece that people talk about.

Virtual Reality

Designers can create virtual reality scenes on their screens that simulate what the product will look like on a shelf surrounded by other products. There is value in this capability, but the word "virtual" in this context means "almost real," that is, not the real thing.

Many leading retailing organizations have simulated stores where they duplicate the display shelving, access aisles, sightlines and lighting of an actual store. These

Figure 3.6
Mizkan vinegar drink's offline pack (left) and online-only packaging (right).

Figure 3.7
Three Squirrels' mega-sized nut-mix packaging (left) and Saturn's mini-instant coffee cups (right) are designed explicitly to go viral on social media.

provide a good opportunity to see the proposed packaging in a real, three-dimensional environment.

Actual test marketing with real product in cooperating retail outlets is the final test before a national market launch. Such test market studies normally are done in five or so locations, each representing some regional difference. As well as providing sales numbers, test markets provide information that can be used for associated advertising campaigns. Final decisions on a national launch are based on the results of these studies conducted in the real world.

FUNDAMENTAL MESSAGES

Even as retail environments and consumer shopping habits change, the fundamental messages that brands must apply to reach buyers are evergreen. Consumers' attention is divided across thousands of stock-keeping units (SKUs) in a store—multiply that number when a consumer is online. They can't possibly read each detail about every item. Therefore, what is the first thing shoppers want to know about a package when their eyes come across it on a store shelf? The answer is simple: "What is this?"

Recognizing the item is only the first part of the story. For many products, a consumer cannot perceive a tangible difference in the performance of the product itself, so the package must make this differentiation known. The consumer needs information to prompt a purchasing decision. With a hundred options clamoring for attention, the customer will want to know: "What is it about this product that makes it better than the others?"

Or maybe more specifically: "What are you going to do for me?" This point is variously known as "the significant point of difference" or "the unique selling proposition" or "the brand promise." It is the statement that differentiates one product from another.

The last factor that may contribute to the purchase decision is the answer to the question: "Who guarantees that?" In some instances, a highly respected company or brand name may influence the purchase decision.

Designers use these messages in various proportions, depending on the nature of the product.

The first message, "What is this?" (the chord of familiarity), is the single most important element. The consumer must be able to instantly recognize what he or she sees. Direct common names are the most familiar. For example:

alkaline batteries rice paper clips light bulbs cough medicine

Appropriate chords of familiarity are especially important with new products. They give consumers a reference point on which to base an understanding of the product. For example:

glue stick (not office helper, magic stick, etc.)
solid paint (not easy-wipe, spread-on, Gerry's Easy Paint)

Some products have established brand names that have become synonymous with the product. Procter & Gamble's Tide package, for example, states that it is a detergent in the smallest possible letters simply to meet the legal requirement. The brand name alone identifies the product. (See Figure 3.8)

The second message, "What is it going to do for me?" is the point of difference. Consumers must recognize some benefit or virtue that will come to them if they purchase the product. In a choice of 12 different kinds of rice, the chord of familiarity is "rice." The points of difference that characterize them might be instant rice or long-grain rice.

Without a point of difference, your product is just another package on the shelf.

However, stringent rules regulated by government standards limit the adjectives that can be used with common names to prevent confusion or misleading messaging. Certain words, for example, suggest specific virtues, such as organic or lite.

Figure 3.8
The brand name identifies the product so well that the words "Laundry Detergent" can easily take a secondary role.

Table 3.1
Examples of point-of-difference statements for shampoos.

Stated Difference	Presumed Appeal
Dry hair formula	Consumers who think their hair is dry
Gives extra body	Consumers who think they need extra body
Scalp treatment	Consumers who think they have a scalp problem

The virtue also may be purely imaginary, suggested in both language and visual cues. Perfumes and cosmetics are sold on the basis of romance. A popular breath mint implies that you will be kissed. A deodorant brand is sold on a "macho man" basis. Table 3.1 lists some point-of-difference statements that have been made for shampoos.

A final message that may be used successfully—"Who guarantees this?"—is the name and reputation of the maker, such as Kellogg's, Harley-Davidson, Nestlé or Apple.

A serious consumer is much more likely to try a new household cleaner by a recognizable brand such as Clorox than one labeled Dr. Plum's All-New Heavy-Duty Cleaner.

Not all companies use their corporate name as a selling aid. Most pharmaceuticals, for example, are known only by their brand names. (Quick: Who makes Tylenol and Alka Seltzer?) In other instances, the name becomes the purchase rationale, which is why you'll see so many celebrities with their own lines of clothing, liquors, fragrances and cosmetics.

The three basic messages are used in various proportions and can be delivered by text, graphics, shape or color The weight given to each message and the medium through which the message is delivered should be determined by careful and thorough market research. Particular care must be given to keeping the messages consistent throughout the package structure, graphic presentation and advertising message.

EQUITY AND BRAND NAMES

Over time, certain products and companies have built superior reputations. Typically, such products have graphic elements or icons that the customer easily identifies and relates to, hopefully in a favorable way. These may be the company name itself, a brand name, a symbol, a typographic style, a color or color pattern or any combination of these.

Kellogg's "K," Coca-Cola's bottle shape and color pattern, Campbell's red-and-white soup can label, the Betty Crocker spoon logo and McDonald's golden arches are icons that can be identified long before any text details can be recognized. (See Figure 3.9)

Such icons are said to have equity. Equity is built by establishing a reputation for consistently good product and service over a long period. Icons are highly recognizable symbols that have major motivational impacts on a consumer's purchasing decision. Icons with high equity are carried on new product lines to immediately establish heritage and trust.

Figure 3.9
The Betty Crocker spoon logo provides brand equity on its own.

Figure 3.10
Huggies uses visual cues to convey a message that diapers aren't only for utility, but for the emotional connection between parents and children.

Figure 3.11
While clearly different in design, the house brand on the left effectively communicates that it is similar to the national brand on the right, although it sells at a substantially lower cost.

Brand names can have a great deal of equity, and this equity can be an invaluable purchase motivator. Some of today's valuable consumer packaged brand names are:

Apple iPad, Absolut, Black & Decker, Chanel No. 5, Coca-Cola, Edy's Ice Cream, Frito-Lay, Gatorade, Kleenex, Lego, Minute Maid, Nestlé Crunch, Nike, Pantene, Perrier, Raisin Bran, Samuel Adams, Starbucks, Titleist, Tylenol.

Established brand names are valued possessions. For example, visual cues on packs of Huggies diapers create an emotional connection between parents and chil-

dren. (See Figure 3.10) Horizon Organic Whole Milk leverages distinctive visual features on its milk cartons to differentiate it from house brands. (See Figure 3.11)

The Coca-Cola trademark is probably worth as much as the company's other assets. Apple's brand is more valuable than the sum of all of its assets. Great care is taken to protect such names with trademarks or copyrights. Brand names, icons or any other representations may not create the impression that they have some real or implied relationship to another company or brand. At its lowest level, some companies will illegally produce identical or counterfeit products and pass themselves off as the real thing.

High-equity brands are treated more generously than lesser-known brands. A purchaser who tries Elmer's Cola because a friend recommended it or because it costs less than Coca-Cola and finds that it tastes flat is unlikely to ever buy another bottle of Elmer's. But if a customer drinks a bottle of Coca-Cola that seems rather flat, they presume that perhaps the closure was slightly loose and likely would remain loyal to the brand.

Fanciful brand names like Google and Swiffer, rather than descriptive brand names, can be most effective in creating a proprietary identity that the competition cannot infringe.

In a world that sometimes seems obsessed with "New!" it is easy to forget that some top brands have held that ranking for a long time. (See Table 3.2.)

Table 3.2
Market leaders from 1925 that are still in a leadership position today.

Product	Company or Brand
Bacon	Swift
Dessert	Jell-O
Batteries	Eveready
Biscuits	Nabisco
Breakfast cereal	Kellogg's
Gum	Wrigley
Mints	Life Savers
Paint	Sherwin-Williams
Razors	Gillette
Shortening	Crisco
Soap	Ivory
Soft drinks	Coca-Cola
Canned soup	Campbell's
Tea	Lipton
Tires	Goodyear

COLOR

Color is the first thing an observer notices about a package. It is recognized before shape. After shape come graphics and text. As such, color is one of the most important motivators of a purchase decision.

Color evokes an emotional response from the observer. Color is associated with moods, feelings, places and things. That we relate color to emotions is evidenced by the use of colors to describe particular emotional states. We say we are "feeling blue," "saw red," are "green with envy," had a "purple rage" or are in a "black mood." Red, orange, yellow and brown shades are "warm" colors, while greens and blues are "cool." (See Table 3.3)

Color has weight, size and movement. Generally, brighter colors appear larger than darker colors in bars of the same size. A yellow circle tends to move or radiate outward, while a blue circle conveys inward movement.

Color can influence perceptions such as size, quality, value and flavor. To demonstrate differences in product perception based on color alone, matched groups of people were asked questions about crackers. The crackers were identical, the only difference was the package color. Package color was shown to have a significant influence on perception of flavor. (See Table 3.3)

Color also has cultural and social associations. For example, in some Asian countries, white is the color of mourning. Green and orange combinations, rarely used in North America, are common in India, as they are the national colors. Red, white and green combinations are used on packages trying to create an Italian flavor. It's important to research color and its cultural meaning when designing brands, packaging or color systems.

Although colors can trend generally, certain colors tend to dominate the marketplace. A supermarket check will show a predominance of reds, browns and blues and limited use of purple, for example. Pantone LLC, which is known in the design

Table 3.3
Color and flavor perception.

	Package Background Color	
	Red Shade	*Yellow Shade*
Far too much flavor	13%	2%
A little too much flavor	11%	7%
About right	66%	50%
Not quite enough flavor	5%	23%
Not enough at all	3%	18%
Not sure	2%	0%

(Source: Opatow Associates Inc.)

world for its Pantone Matching System, a proprietary color system used in the fields of design, printing and manufacturing, announces a "color of the year" based on common colors currently being used in the industry.

There are few universal rules when selecting package colors. Color choices should be based on research, color theory and insights about when to leverage commonly used category colors or when to deliberately use unexpected color. Color can unite a brand's offerings at the retail shelf or highlight different flavors in a line of food products where flavor choices drive purchase.

Pringles stackable potato chips, which are famous for their iconic shape, unique package and adventurous and unexpected flavors, differentiate flavors using a rainbow of colors. (See Figure 3.12)

Beyond flavor differentiation, some commonly used colors can evoke imagery and emotion in the consumer's mind:

- Blue is the color of the sky and thus the sea. It's said to be associated with logic, trust, thoughtfulness and serenity. It's quite common in the design choices associated with many visual identities.
- Red is associated with passion, strength, excitement and warmth. Red is common for food, lifestyle and many entertainment companies.
- Green evokes nature and the earth. It's soothing, natural, harmonious and projects sustainability. It often is used to communicate organic, healthy, environmental or the outdoors. (See Figure 3.13)
- Yellow is cheerful, optimistic and warm. Because of its light impression, it tends to be used in combination with darker or contrasting colors.
- Black often is chosen for premium, higher-end or strong, authentic brands. It's frequently paired with light or white elements.

Package design involves numerous elements, such as shape, materials and texture, but the color is crucial to success at retail. With strategy and insights derived from well-done research, you can create strong and breakthrough packaging leveraging smart color choices for both visual identity and flavor differentiation.

Figure 3.12
Pringles stackable potato chips are easily identified on shelf by their distinctive cans. Color differentiates the flavors in the line.

Figure 3.13
A combination of rich and vibrant greens gives MorningStar Farms a natural and authentic brand identity in the veggie foods marketplace.

GRAPHIC DESIGN ELEMENTS

A complete graphic design must communicate a mass of information on many levels. (See Figure 3.14) Some information, such as product descriptor, contents, manufacturer's domicile, National Drug Code, ingredient list and nutritional information, is required. In many instances, laws or regulations specify the location of this information on the package. The designer has the challenge of fitting the company's promotional messages within the required text. Designers also must be aware of how the content and positioning of legally required information varies depending on the product and where it will be sold.

A packager works with basic design elements to create the desired package appearance for viewing both in-person and online:

Shape The actual package outline or the outline of an illustration or body of text. Be aware of positive and negative shapes. Length-to-width proportions of 2:3 and 3:5 are the most pleasing. Length-to-width proportions of 1:1 and 1:2 are boring.

Size How large or small the object or design is. Size can be physical or perceptual.

Color Color can attract attention and affects the mood or persona of the package. Color also can add expense.

Figure 3.14
In addition to the information on the front panel, other panels carry the company's domicile, the Universal Product Code, ingredient list, nutritional information, a recycling symbol, social media logos and use instructions.

Texture Perceived or real smoothness or roughness. It involves the sense of touch. Consider the difference between a plastic bag and a paper bag. Texture can be created using graphic patterns or textured substrates.

Tone The lightness or darkness. Darker colors appear heavier than lighter ones.

Line Lines can be straight or curved, heavy or light, rough or smooth, continuous or broken. Certain line orientations can create different feelings:

Horizontal: calm	Vertical: dignity
Diagonal: vitality	Curved: grace
Converging: distance	Shadows: suggest volume

Icons Graphic design elements or symbols that convey meanings or messages. The most important icons are those that have equity.

Design principles are used to organize design elements into a composition having balance and unity. They apply to each element and to the design as a whole. A composition is a specific arrangement of design elements.

Balance and Unity

Each element of a composition has an optical weight. Lightness, darkness, size, shape and color control weight. The designer must recognize optical weight and be able to determine when two elements are balanced.

In addition, the following considerations contribute to a package's balance and unity:

- Symmetrical or formal balance centers elements geometrically. The elements of one side of the vertical center are repeated on the other. Symmetrical balance is easy but rather formal, although it sometimes can be used to create a particular persona.
- Asymmetrical or informal balance arranges elements by optical weight from left to right.
- Weight must be correctly distributed vertically. The bottom is normally given more weight to avoid a top-heavy look. This can be done optically by having lighter colors at the top and darker colors at the bottom. (A panel's optical center is slightly above the geometric center.)
- A theme or mood can create unity. This includes color, typography, substrate material and so on. A border can be used to create unity, but borders can act to reduce optical size.
- All elements must tie together in a sense of harmony or belonging. (Gestalt or holistic: The whole is greater than the sum of the parts.) Every element has to fit so that if one part is removed, it will be missed.
- White space must be handled with care. Hyper-simple design architectures with lots of white space go in and out of fashion. However, white is a common element in pharmaceutical packaging where it is associated with cleanliness and sterility.

- The combined elements must unite to create a persona. The created persona should match the psychographic/demographic profile (persona) of the targeted customer.

Direction and Dominance

In Western society, people see things in a set order: top to bottom, left to right, large to small, black to white, color to no color and unusual to usual. (See Figure 3.15) The design on the left that breaks up the normal flow of reading and can be clear only when viewed horizontally is not likely to be as readily identified as the design on the right. Good organization can lead the eye from one element to the next.

The designer can control eye movement and direct the eye in a circular path, diagonally or whatever. Designers direct the observer by using real or implied lines. Pictures have a direction in which they face, almost as an arrow does. Borders may be used to contain and mass several items into one element.

Packages must be kept simple because the typical consumer will not spend time hunting through busy or cluttered designs. Designs should have one dominant element. It can be emphasized by being larger, brighter, darker, faced in a different direction or anything else that imparts prominence.

When designing product packages for a range of sizes, it's best to design the smallest size first, as well as the most dramatic dimensions (thinnest, tallest, fattest). It's much easier to scale up to a larger size or a more expected dimension than to compress a large design into a smaller facing.

In Figure 3.16, the design on the left gives major prominence to Halo Top Creamery, which at the time of launch was not well-known and long before "healthy ice cream" filled the frozen-foods aisle. Actual product identity is given less importance, and a significant point of difference is relegated to the bottom of the package. The improved design (right) puts the product's unique selling point front and center.

Single design examples might look good on the designer's monitor screen, but should be reviewed in real or simulated displays. The candidate designs also should be compared with the competitors' offerings in real or simulated display settings.

Figure 3.15
The design on the left is busy, with multiple elements vying for attention. The design on the right is sleek and clear about product benefits. Its minimal design employs three colors with a specific usage ratio.

Figure 3.16
Examples of cluttered (left) and clearer (right) arrangements of on-pack messages.

Typography

There are many typographical fonts. The basic fonts can be classified as serif and sans serif. Serifs are the small, decorative extensions or the thick and thin line weights within the type elements themselves at the ends of each type element line. For most packaging purposes, sans serif fonts are preferred for descriptive copy. The fine lines in serif fonts tend to fill during printing, particularly with reversed-out printing. (See Figure 3.17, right) A larger serif font size could overcome this problem somewhat.

Another font category may be loosely described as "decorative." Such fonts usually are designed to project a certain character or mood. Script fonts, for example, may be considered feminine or romantic and are popular for personal-care products. Elaborate script fonts can be difficult to read; relatively simple script designs in a larger size are preferred. Figure 3.18 shows some type treatments designed to convey a message beyond the actual text.

The following considerations are important when deciding on typography:

- Typography must match the persona of the package and product. Each typographical style carries its own persona and message.
- Dominant typography must be readable from the normal observer distance at the point of recognition. For a retail display, this may be several feet.
- The population contains a significant number of people who are functionally illiterate and a large number who should wear glasses when shopping but don't. Text and typography should be selected with these facts in mind.

Figure 3.17
Examples of (top to bottom) sans serif, serif and script fronts. At the right is reversed-out type.

Figure 3.18
Typography can be designed to communicate more than just the word itself.

- Be cautious of reversed-out type, particularly on poor-quality substrates where ink tends to fill in. If reversed-out type must be used, increase its size and select fonts with wide strokes that won't fill in during printing.
- Avoid using text over illustrations or color areas that do not have enough contrast over some or all of the area to ensure the type is readable.
- Avoid long stretches of small type. The optimal line length for easy readability is about 39 characters. Use columns to break up long lines.
- Uppercase does not necessarily make a message easier to read. (See Figure 3.19)
- In some situations, such as the U.S. Food and Drug Administration's Drug Facts rules, typography is determined by regulations.
- Text and illustrations that cross over package joints, closures or seams may create unintended messaging or can be used as part of the creative messaging. (See Figure 3.20)

ALAYTMINIOM

Alaytminiom

Figure 3.19
Typographic styles must be chosen for legibility. Long, unfamiliar words are generally easier to read in lowercase. *(Source: H. Bossard.)*

Figure 3.20
Graphics and text must take package seams, joints and closures into account. Both examples here are memorable, but for different reasons. The example on the left is an error that elicited humor unintentionally, but the example on the right uses openings creatively to evoke humor deliberately.

PACKAGE DESIGN AND MARKETING STUDIES

Numerous reports have discussed the risks of a new product launch. Although numbers and experiences vary, it's clear launching a new product is a high-risk activity. One general rule of thumb says that for every 100 new products that consume development time, only 10 make it as far as test marketing (a limited offering in a few locations to assess consumer response). Of these 10, five earn a full commercial launch, and only two survive beyond a few years.

A study by the *Journal of Marketing Research* found that, of almost 9,000 new products that achieved broad distribution at a national retailer, only 40% were still sold three years later. The reasons can vary from poor pricing or positioning in the market to consumers not recognizing a product's point of difference. Therefore, designing a good package presents a greater challenge than designing a good product—but it also offers a great opportunity to reach the right consumers.

Several methodologies are used to evaluate a package design's effectiveness; each has its strengths and limitations. Understanding exactly what you are looking for is key to selecting the correct methodology. Common research methodologies used for packaging diagnostics are divided into several primary categories: qualitative, quantitative, behavioral and consumer ethnography.

Qualitative studies measure consumer perceptions. The most common process of this type of research is a focus group where a moderator asks a select number of respondents for opinions on strategic or creative stimuli. This can be done in person, but more frequently focus groups are being conducted via online video discussions, which can be a more comfortable environment and therefore provide more accurate insights.

Quantitative testing involves numeric diagnostics and typically is done with a larger group of respondents split into cells based on their demographics/psychographics and their relationship with the brand (i.e., heavy users, brand switchers, etc.). Surveys and eye tracking are among quantitative methodologies.

Behavioral measures do not ask questions but track how the consumer shops. Traditional in-store market tests or new virtual shopping environments analyze how consumers behave in a retail or simulated retail environment.

Consumer ethnography tracks behavior at home as consumers engage with the product and the package. Video blogs offered up by consumers or actual in-home observation tracked by a researcher are common ethnography measures.

Whatever the methodology, care must be taken to remove all bias in communicating with prospective buyers. Words and questions must be carefully chosen.

- The dictionary meaning is not necessarily the emotional meaning. (A "cheap" computer is not the same as an "economical" computer.)
- Response to the question "Would you be interested in a vacation in the Greek Islands?" will be different than to "Would you spend $4,899 for a vacation in the Greek Islands?"
- Leading questions must be eliminated. ("Would you be willing to pay a few cents more if this package were made from recyclable material?" elicits a positive answer from most people, but it is not necessarily true at the point-of-sale.)
- In qualitative research, the response should be primarily emotion-based rather than reasoned. Most purchasing decisions are made at an emotional or intuitive level and rationalized afterward.

Quantitative research responses should be numerical to remove any word ambiguity.

- Numerical data can be tabulated and averaged as necessary. Word answers cannot. How would you tabulate "fair," "good," "average" and "OK"?
- A preferred question format would be, "Rank the (appearance, brand name, design, environmental friendliness, price, etc.) of the exhibited designs on a scale of 1 to 10."
- An indirect way of doing the same thing would be: "Arrange the order of the five samples according to how much you think they cost."

Select your panelists carefully. They must represent some demographic/psychographic group that has relevance to your product and package.

- A panel of college students may tell you they associate mushrooms with pizza, while residents at a retirement home may associate mushrooms with soup.
- If you want to evaluate the design of a computer software package, then your panelists should own computers.
- If your design objective is to take market share from the dominant category leader, your panelists should be users of that leader's product.

Significant regional differences must be taken into consideration for any market or package design evaluation.

Market and Package Evaluation Methodology Examples

Here are some of the most commonly used methods of evaluating the marketing effectiveness of packaging:

- **Test market auditing:** The actual product is offered for sale in selected regions and outlets. It is an expensive process that is sometimes hard to control and difficult to interpret. ("The product didn't sell. . . . I wonder why?"). Test marketing usually is done after other more precise studies are completed. For example, you would use a focus group rather than a test market study to evaluate a brand name.
- **Mall intercepts questioning:** Mall intercepts seek quantitative level responses; they should not be used to qualify measures.
- **Focus groups:** Selected panels of consumers are assembled to discuss, rank, evaluate and otherwise consider some subject at hand. Focus groups are useful for gathering general broad-based information and for judging the overall appeal of a package design. Again, if the questionnaire and moderator are effective, then there can be some valuable results, but another valuable method is a virtual one-on-one qualitative consumer interview that results in more honest answers not influenced by "group think" or the loudest voice in the focus group.
- **Recall questioning:** One recall methodology shows panelists a picture of a marketplace shelf with an assortment of products. After a brief observation period, the panelists write down the product names they can recall. Recall questioning is good for judging a package design's shelf impact, but won't tell you what you should change.
- **Findability tests:** There are several approaches to findability testing. A broad-based test might measure the time it takes a subject to locate a product in the store. This version is useful for determining where a product should be displayed (Where did the subject go to look for dried tomatoes?), as well as finding it on the shelf. The more specific test would time how long it took a subject to locate a specific product when in the general product area. (In the breakfast cereal section, find a box of Jordan's Harvest Crunch.) The latter is a form of shelf impact evaluation.
- **Eye-tracking studies:** Unlike the previous methodologies, eye-tracking can be used to judge the individual elements of a package design. Eye-tracking uses instrumentation that can follow exactly what the eye is focusing on when observing an individual package design. When looking at a package, the observer's eye will focus immediately on one design element and then wander over the package, pausing on some elements and skimming over others. The subject is not conscious of these actions. In subsequent recall questioning, the subjects have poor recall of elements where the eye skimmed rather than paused. Eye-tracking provides detailed information on individual design elements and their placement. Similar procedures can be used viewing a full product shelf. Eye-tracking has the advantage of being objective rather than subjective and of being able to provide information on the relevance of individual design elements. However, it measures only findability (how quickly the consumer can locate the brand) and shoppability (how quickly the consumer can find a specific product within the brand architecture). This quantitative measure provides little insight on consumer engagement, how they feel about what they are seeing. As a result, this methodology often is followed by qualitative questioning.

Figure 3.21
A packaging redesign based on various forms of research and studies.

- **S-scope studies:** Like eye-tracking, S-scope studies provide detailed information on individual graphic design elements. Subjects are shown an image of the package, flashed at 1/100-, 1/50-, 1/25-, 1/10- and 1-sec intervals. After each interval, the subject notes what they have recognized. For example, at 1/100 sec, the subject may have seen a "red box." The average results provide a good understanding of the order in which the information is received and sometimes what information is not noticed.

  Various forms of research were conducted to rework the label and packaging to launch Magners Irish Ciders in the Asia-Pacific (APAC) market. (See Figure 3.21) Cider as a category is well-established in European markets. However, in the APAC market, it is still undeveloped, with little understanding or engagement.

  An extensive research audit was conducted across all key APAC markets. Efforts were led by Australia and New Zealand but also incorporated China, Hong Kong, Indonesia, Singapore, Taiwan, Thailand and Vietnam. The research included retailers, sales teams, directors and consumers.

- Research uncovered that the Irish cues didn't resonate with APAC consumers, so those visuals were decreased while the fruit imagery was increased.
- A new variant called "Juicy Apple" was specifically created for non-European millennial palettes seeking a sweeter flavor.
- Younger consumers sought easier ways to engage with the bottles, so the labels were simplified and caps were modernized and updated to simplify opening.

PACKAGING DESIGN BEST PRACTICES

- Lean into the power of simplicity.
- Study vintage packaging for design ideas.
- Nothing beats taking a mock-up and placing it in-store to see how it looks.
- Keep your shopper profile in mind and design to it—always.

- Look at other product categories for unexpected sources of inspiration.
- Design with the possibility of future variations, such as flavor additions or regional market launches.
- Be innovative without breaking basic design rules.
- Be empathetic to the needs of the consumer.
- Don't dismiss the use of humorous, lighthearted and playful graphics (for the right audience).
- Changing tastes direct the trends, but the basics of good design remain the same.

REVIEW QUESTIONS

1. A total package design consists of two separate components. What are they, and what primary roles does each component play?
2. Define demographics, and give six examples of demographic information. What are some sources of demographic information?
3. Define psychographics, and give examples of psychographic information.
4. Why is psychographic/demographic information important to a package designer?
5. What percentage of purchase decisions are made by consumers in the store while considering product choices? About how much time do you have to deliver a motivation to purchase?
6. How are smartphones leveraged today to enhance retail shopping for the consumer?
7. How can package design differ for products sold exclusively online or direct-to-consumer, compared with retail or omnichannel packages?
8. How is virtual reality used to test package design?
9. What are the two main messages that the consumer always looks for? What third piece of information might have a major influence on a decision to purchase?
10. Explain the importance of having an effective point-of-difference message.
11. How can the basic communication message be delivered to the viewer?
12. Define equity and icon.
13. What is the first thing a consumer notices about a package?
14. What is the human observer's typical relationship to color? Give examples.
15. Give examples of attributes that are influenced by color.
16. What design elements does a designer manipulate to create a final package presentation?
17. What is meant by the term "persona," and why is the concept important in package design?
18. How does a typical Western consumer "read" a package?
19. What errors might we make if we do not perceive the package as it might be displayed in groups?
20. What is the difference between serif and sans serif fonts, and which is more common in packaging?
21. Describe some good practices when selecting a package's typographic components.
22. Market studies can take many forms. Discuss the methodology of the following methods and the kind of information generated: Focus groups, recall questioning, findability tests, eye tracking, S-Scope studies and ethnography.

23. How is ethnography used in package design?
24. What are three of the 10 identified practices for package design? Why are they important in the design process?

Assignments

Assignment 1: Competing Retail Designs

1. Bar soap (for example Dial, Irish Spring, Zest, Dove and others)
2. Beer
3. Hair shampoos as sold in large grocery chain stores
4. Prepared breakfast cereals (for example corn flakes, Wheaties, Rice Krispies)
5. Cooking oil, as sold in large grocery chain stores. Note the sizes as well as the brands
6. Potato chips, party pack size, as sold in large grocery chain stores
7. Adhesives for wood as sold in a hardware store
8. Vitamin pills
9. Women's or men's perfumes or colognes
10. Ground coffee brands
11. Ice cream brands
12. Spices and condiments
13. Toothpastes
14. Vinegar, as sold in large grocery chain stores.

Select a product category from the above list. For that category, determine how many choices the consumer has in a typical shopping environment. List the product names as far as is practical. Note the price ranges within which the product sells.

Submit a report outlining the unique selling proposition of three products selected to represent a variety of approaches, or targeted at different demographic/psychographic groups. In considering the targeted buying group, you may need to refer to advertising and promotional material as well as the physical package. How are the "points of difference" and icons used? What can be said about the brand's equity? Typography and color should be mentioned where it plays a significant role. What persona does the whole package design project?

Be prepared to give a five-minute verbal summary of your findings. You should have samples or photos of the packages you will be focusing on.

Assignment 2: Package Design Assessment

Locate a package you consider to be poorly designed. Poor design may relate to graphic components, structural components or both. Bring it or a photograph of it

to class, and be prepared to give a five-minute oral presentation on how you might improve the design of this package.

Assignment 3: Ethnography Study

Select a product from the retail shelf and perform an ethnography study with a fellow student or friend, whereby you can gain an understanding of their buying habits. The study should include what the consumer was thinking while searching the retail shelf, what was involved in the buying decision and how the product was used at home. Incorporate that knowledge into the redesign of the product's package. Submit a report outlining the original design and the modifications made, based on what you learned from the ethnography study.

PACKAGE PRINTING AND DECORATING

4

CONTENTS

Introduction

Objective, definitions of printing and decorating as used in this text.

Color

Human perception, what the eye actually detects in sensitivity, electromagnetic spectrum, additive synthesis, subtractive synthesis, hue, brightness, value, saturation. Viewing color, light source, graphic arts light standard. Reproducing color, pigments.

Artwork

Line art, color selection, continuous-tone and halftone illustrations, screens and color density, typical screen ranges and applications. Process printing, primary process colors, creating infinite color ranges, steps in process printing, moiré patterns, key color.

Preparation for Printing

Prepress work, keylines or mechanicals, color bleeds, trapping, number of plates needed for basic process printing, where additional plates are used, registration.

Proofing

Purpose of prepress proofs, differences between digital and analog proofing, examples and applications of common proofing methods.

Printing Methods

Relief (flexographic), lithographic, gravure and digital. Printing presses, general components and configurations, web-fed and sheet-fed presses, printing stations. Process selection factors.

Relief Printing: Flexography and Letterpress

Definition of relief printing, nature of the plate, rubber and photopolymer plates, general characteristics and applications of flexography printing, typical printing deck, stack and central impression press configurations. Applications and limitations.

Lithography

Basic principles, printing plates, typical lithography station, characteristics, applications.

Gravure Printing

Basic principles, gravure cylinders, typical station, characteristics, applications.

Digital Printing

Defining the digital process; digital printing methods; opportunities for labels, folding cartons, flexible packaging and corrugate; strengths and weaknesses.

Comparing Flexography, Lithography, Gravure and Digital

Identifying the printing method, flexography strengths and limitations, lithography strengths and limitations, gravure strengths and limitations, digital strengths and limitations, press types and typical packaging applications, wet ink thickness.

Other Package Decoration Techniques

Reflective metallics, heat-transfer and hot-stamp (foiling) printing, matte and gloss varnish, embossing, reverse printing, laser marking, inkjet printers.

Printing Dimensional Packages

Letterpress and offset letterpress, stencil or screen printing, applications and limitations; pad printing.

Labeling

Cut and glued-on labels, pressure-sensitive labels, shrink sleeves, in-mold labeling, workflow.

PACKAGE PRINTING AND DECORATING 4

INTRODUCTION

The objective of package printing and decorating is to consistently create a visibly identifiable image for a large number of impressions. Printing or decorating requires the ability to separate image and nonimage areas. This is done with a printing plate; the various printing or decorating methods are named after the nature of the printing plates used. Many techniques and variations have been developed. For the sake of this discussion, these techniques have been divided into two groups:

- "Printing," in the context of this discussion, refers to flexography, lithography, gravure and digital—the four methods that account for the vast majority of all packaging graphic art. Each of these methods has several variations.
- "Decorating" is used to describe special methods such as screen printing, hot-foil stamping, embossing and pad printing. In volume, these methods account for a small proportion of packaging graphic art. However, each can create decorative values not available by the mainline methods or can decorate substrates not readily decorated by other means.

Color is an important visual element of package design. Since the majority of package printing concerns the development of colored images, this discussion starts by reviewing the basic physics of color.

COLOR

The Electromagnetic Spectrum

The electromagnetic spectrum is described as a wave phenomenon. Waves at the long end of the spectrum are used in radio broadcasting and radar. Infrared radiation, perceived by the human body as heat, is shorter and is the region immediately

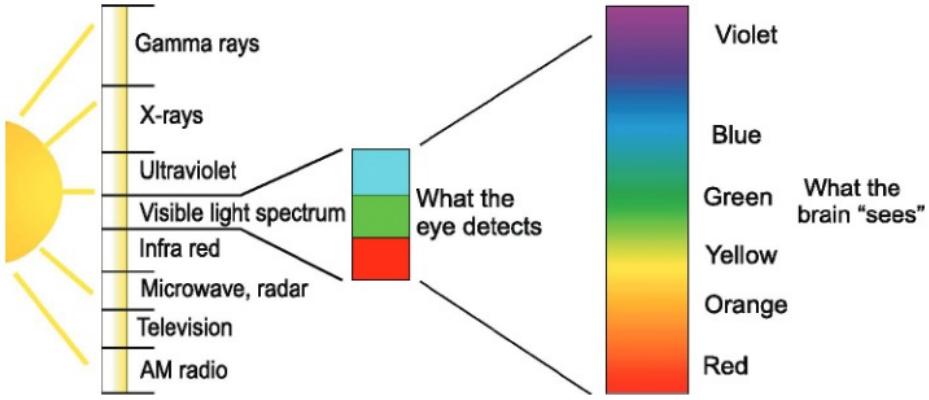

Figure 4.1
Visible light as radiated by the sun is that part of the electromagnetic spectrum between 380 and 760 nanometers (nm). The human eye can only detect red, green and blue (RGB)

before visible light. Visible light describes that part of the electromagnetic spectrum perceived by the human eye and is about midpoint in the wave spectrum between infrared and ultraviolet. (See Figure 4.1)

Ultraviolet, the next shorter wavelength after violet, is not detected by the human eye. X-rays are shorter yet, and powerful enough to penetrate matter and expose photographic plates. Gamma rays are powerful enough to disrupt molecular structures and are used to eliminate microorganisms in some food products and ensure sterility of many hospital supplies.

Color Perception

The eye is a complex organ that receives light and sends stimuli to the brain for interpretation. Color perception, therefore, depends on the eye's receptors and the psychology of how the brain interprets the message. We "see" with our brains, not with our eyes.

The normal human eye has a retinal structure with individual receptors sensitive to red, green and blue parts of the spectrum. (People who are said to be color blind have reduced sensitivity in one or several color receptors.) As well as detecting differences in wavelength, the human eye is thought to have a separate function that determines brightness or contrast levels. Any color in the spectrum can be matched by combining these stimuli in the proper proportions.

The human eye can differentiate several million colors. The problem of verbal color communication can be appreciated when you consider that there are only about a dozen specific color names. Furthermore, we have no "color memory." We can recall telephone numbers and recite poetry, but our color memory is vague. At best, we can recall the general name of a color and perhaps qualify it as light blue or greenish-blue, but we could never walk into a paint store a week later and precisely match a previously observed color.

The human eye does not detect all colors equally. Sensitivity falls off at either end of the visible spectrum. Yellows are the brightest colors to the human eye. The greatest perceived contrast is between black and yellow, not black and white, as might be supposed.

Perceived color depends on the proportion of stimulation given each color receptor. When all receptors are fully and equally stimulated, we experience the sen-

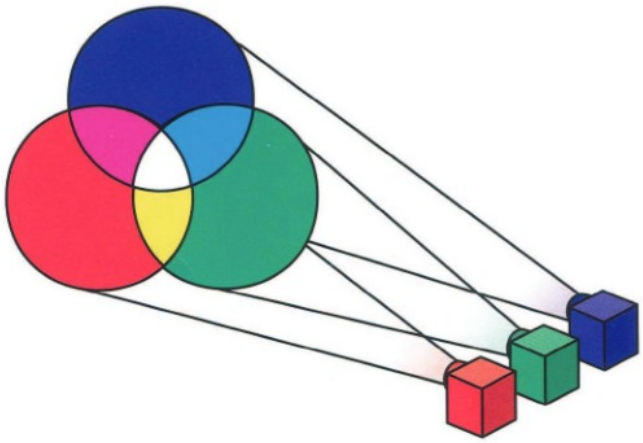

Figure 4.2
When equal proportions of red and green, red and blue or blue and green light are perceived simultaneously, we experience yellow, magenta and cyan, respectively. When the eye receives all three colors simultaneously, we experience white.

sation of "white." If no receptors are stimulated, we experience black, the absence of color. (For convenience, black is called a color.)

Additive Synthesis

Additive synthesis describes the addition of different light wavelengths to create a new color. (See Figure 4.2) Thus, if a red light and a green light were projected onto a white screen, the overlapping area would appear yellow. The various combinations of the three primary additive colors—red, green and blue—are as follows:

Blue + green = cyan
Red + blue = magenta
Red + green = yellow

Cyan, magenta and yellow, the products of additive synthesis, are the three primary process colors used in color printing. Other colors are produced by manipulating these three colors.

Color television screens use additive synthesis. The picture tube has separate generators for blue, green and red light. The eye receives and mixes them according to the laws of additive synthesis to give the entire color spectrum.

Subtractive Synthesis

Subtractive synthesis is the synthesis of printing inks where colors are produced by subtracting wavelengths from white light. (See Figure 4.3) Subtractive synthesis is achieved by using pigments that have the ability to subtract or absorb certain wavelengths while reflecting others. Thus, a transparent cyan ink printed over a transparent yellow ink appears green, yellow ink printed over a transparent magenta ink appears red and magenta printed over cyan appears blue. All three colors overprinted would subtract almost all wavelengths and would appear almost black. Subtractive synthesis is further illustrated in Figures 4.4 through 4.6.

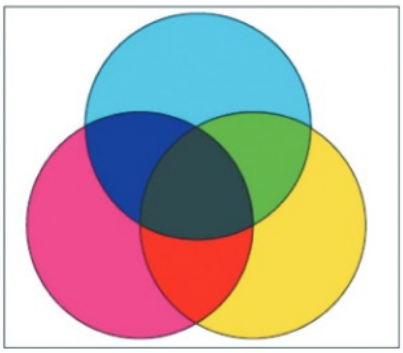

Figure 4.3
Subtractive synthesis is the synthesis of printing inks where colors are produced by subtracting wavelengths from white light. When all wavelengths are subtracted, we experience black—the absence of light. Subtractive synthesis is achieved by using pigments with the ability to subtract or absorb certain wavelengths while reflecting others. Subtractive synthesis is illustrated in Figures 4.4 through 4.6.

Figure 4.4
When all components of white light are reflected, the object appears white. If all light components are absorbed by the object, no light is reflected, and the object is perceived as being black, black being the absence of light.

Figure 4.5
When the green component of white light is absorbed by a printing ink, the reflected blue and red components are perceived as magenta. Similarly, when the red component is absorbed, the eye perceives cyan.

A colored object reflects some wavelengths but not others. (See Figure 4.5) Thus, if an object absorbed all the green light waves and reflected only the red and blue components, then by the rules of subtractive synthesis, the observer would see magenta. A cyan object absorbs all red components and reflects those that combine to give the sensation of cyan. Similarly, yellow is produced when blue is absorbed and

Table 4.1
Colors produced when different wavelengths are subtracted from white light.

Absorbs	Reflects	Color Seen
Red	Blue and green	Cyan
Blue	Red and green	Yellow
Green	Blue and red	Magenta
All wavelengths	Nothing	Black

red and green are reflected. Table 4.1 shows how light absorption produces reflected color.

Subtractive synthesis is the synthesis of the paint box. When red and green light mixes, we synthesize yellow. However, if red and green pigments are mixed, most wavelengths would be absorbed and the resulting color would be a dull brownish-black.

Color Terminology

Hue The color's position in the spectrum. The quality that differentiates between named colors such as red, yellow, green, blue and purple.

Value The lightness or darkness of a color relative to a gray scale starting at jet black at one end and ending with white at the other. A black-and-white photograph converts all colors to some shade of gray. Colors with similar values would be hard to differentiate in a black-and-white photograph.

Saturation How strongly colored the object is or how much the color differs in its strength of color from a gray sample of the same value. Sometimes referred to as chroma.

Saturation and value reflect the color differences when a base color is mixed progressively with more white for a lighter, less saturated color (a tint), and mixed with progressively more black for a darker value (a tone).

Brightness, when used to describe colors, describes the total amount of reflected wavelength particular to a color. When used to describe paper, brightness refers to the total amount of white light reflected compared to pure magnesium oxide, which was assigned a value of 100 units in days when it was assumed to be the whitest and brightest substance in existence; it is not a percentage. Since then, pigments such as titanium dioxide were found to have brightness values greater than 100. Photographic paper for example has brightness values on the order of 108 or 110. (See Figure 4.6)

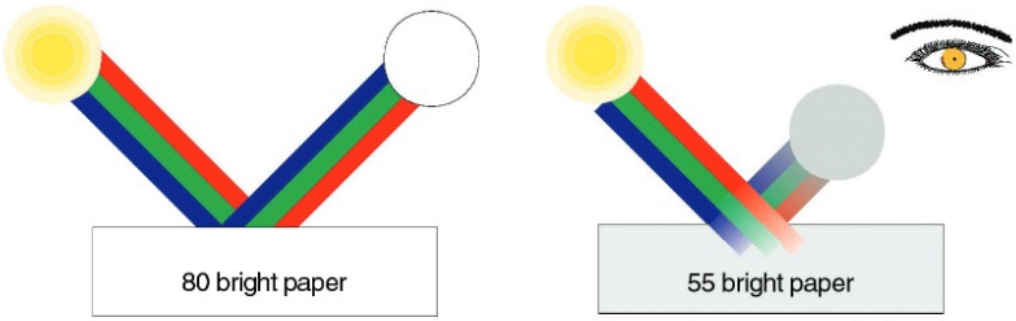

Figure 4.6
Brightness is a measure of total reflected light. In the illustration above, two papers exposed to the same light source both reflect red, green and blue wavelengths. However, the amount of red, green and blue reflected from the 55 bright paper is less than from the 80 bright paper. Although still described as white, the 55 bright paper appears less bright or duller.

Brightness is a key attribute when considering a substrate for printing. Most package printing inks are transparent; light passes through them and is reflected from the substrate surface back to the observer. If the substrate surface is bright, then all wavelengths not absorbed by the pigment are reflected. However, if the substrate absorbs some percentage of red, green and blue, then the perceived reflected color will not appear as bright.

Viewing Color

Color perception is highly subjective and depends on the:

- Light source illuminating the object.
- Nature of the object itself.
- Observer of the object.

Light source. Light from different sources has different wavelength compositions. For example, incandescent lights are rich in the red end of the spectrum, while most fluorescent lights are deficient in reds. (See Figure 4.7) Since color is an attribute of incident light, colors will look different under these two light sources.

To reduce color-matching problems, graphic arts industries have standardized viewing illumination to a light source that approximates northern daylight at about noon. This illumination is specified as a color temperature of 5,000 Kelvin. (At low temperatures, a heated object radiates energy in the infrared range, detected as radiated heat. As the temperature rises, more radiation occurs in the shorter wavelengths, and the eye detects a dull red. At high temperatures, the object radiates across a broad spectral band covering all visible wavelengths, and the eye sees "white heat.") All visual color comparisons should be done under these industry standardized conditions.

Object. The object itself influences color perception. Surface texture, gloss, geometry and surrounding or adjacent colors all affect judgment of the subject color. Some object effects promote optical illusions.

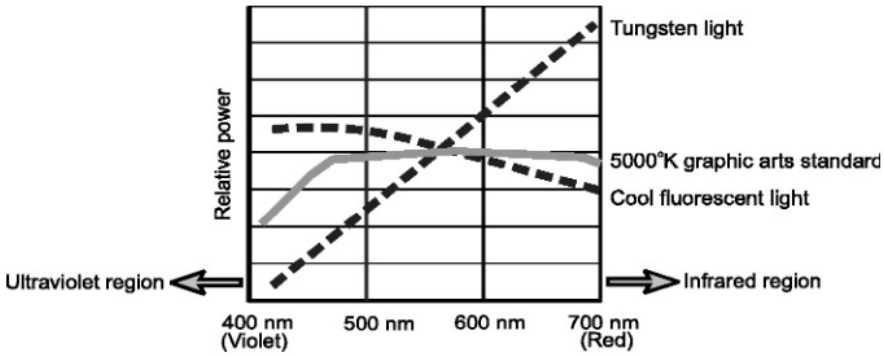

Figure 4.7
Relative wavelength distributions (in nanometers) for common light sources

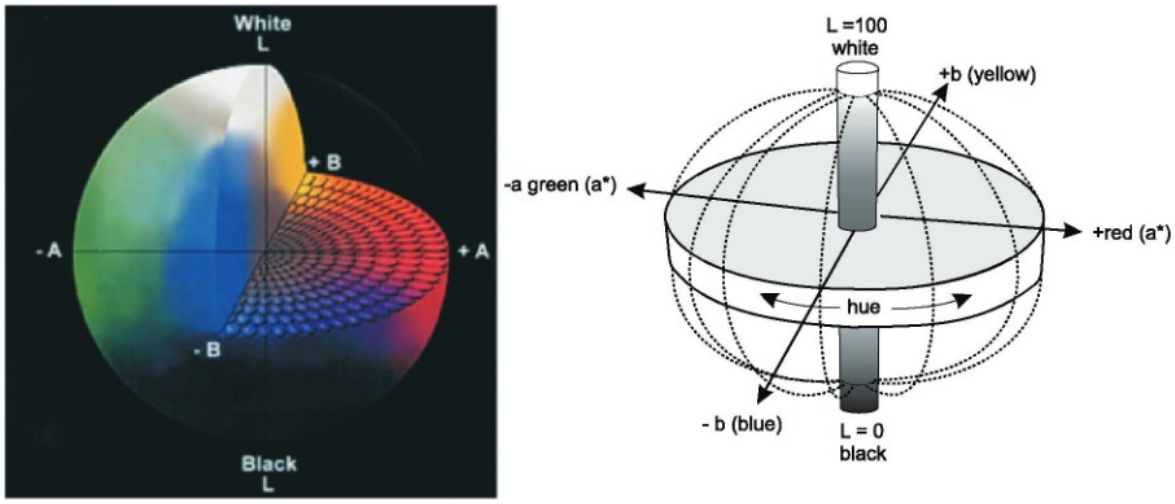

Figure 4.8
Visualizing and quantifying the multi-dimensional attributes of color are difficult. The L*a*b* globe is one of several methods that organize colors in a scheme that can be easily quantified. The globe has three axes: The A axis goes from green (–A) to red (+A), and the B axis goes from blue (–B) to yellow (+B). The perpendicular goes from black (L=0) to white (L=100) (white).

If the globe is sliced in half at its equator, the outer perimeter of the disk would be made up of pure colors or hues. If wavelengths other than the ones needed to make up the pure color are present, they reduce the level of saturation, and the pure color begins to lose its brilliance and moves toward the central L axis. Eventually, it will lose all traces of color and end up on the L axis as some level of gray.

If we decrease the spectral intensity of the wavelengths, the pure colors become darker as we move downward through the globe's successive slices until there is no light (L=0) ... that is, we will have black.

If the spectral distribution among the wavelengths becomes more even, the effect is that of adding white to the pure color. As we go upward from the equatorial layer, the colors become lighter. Eventually, there will be an exact balance of high-intensity wavelengths and L will be 100 (white). Figures 4.9, 4.10, 4.11 and 4.12 illustrate various saturation distributions and L values and the resulting colors.

Any color can be identified as to its position in the globe with three digits using the L*a*b* system.

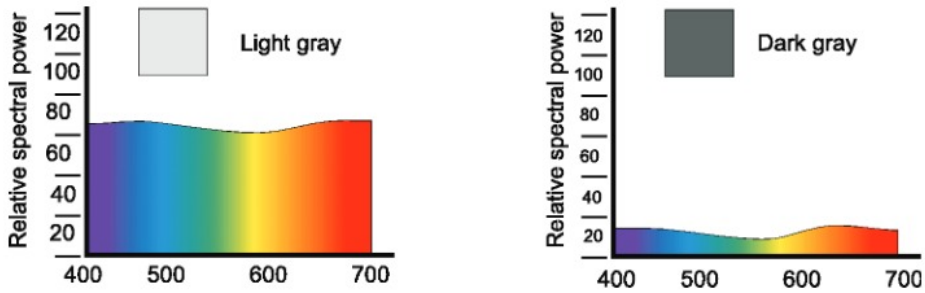

Figure 4.9
Saturation levels determine the lightness or darkness of a color. A flat curve will not favor any hue, resulting in levels of gray. The light gray (left curve) would have a high L value while the right curve would represent a darker gray and a lower L value.

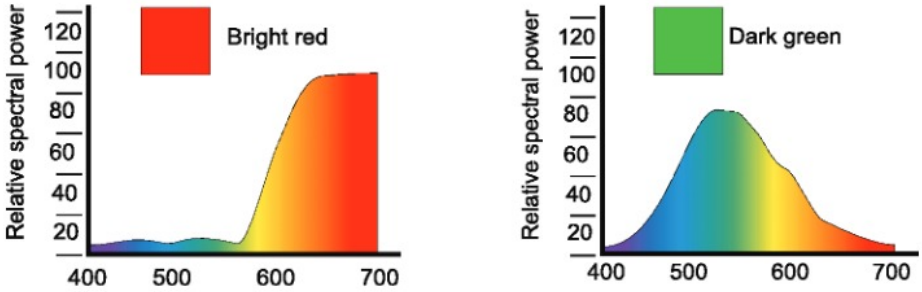

Figure 4.10
The location of the wavelength distribution curve's peak relative to other wavelengths determines the hue

Observer. The greatest variable of all is the person viewing the color. Even eliminating those who have poor sensitivity in certain wavelengths (i.e., color blindness) still leaves questions of personal emotions and preferences. A male genetic trait causes reduced reception of the red wavelength in about 8% of the male population. Deficiencies in other wavelengths are rare. Women, in general, have better color acuity than men.

The brain makes adjustments based on experience to the signals received from the eyes. An object viewed under a fluorescent light that has little red component will be color-corrected by the brain to make it look normal according to our experience. Photographs taken under the same fluorescent light tell the truth: The scene will have an overall green cast.

The brain alters color perceptions in ways that cannot be controlled, and the eye as the primary receptor suffers from irregularities, such as afterimage and fatigue. For this reason, the most objective color measurements are done instrumentally with colorimeters or densitometers. These instruments assign numerical values to the amount of each color component reflected. Figures 4.8, 4.9, 4.10, 4.11 and 4.12 illustrate the L*a*b* system for numerically describing colors.

The problem with "objective" instrumental color measurement, however, is that the instrument makes no allowance for shapes, adjacent colors, textures and other factors that affect human color perception. Such colorimetry will not tell us whether a graphic image "looks right." It can only verify that the inks and papers are the same as those used on the last job or are the same as in a selected control sample. More often, a color is first approved by a panel of human observers. Then a colorimetric instrument is used to quantify the color for specification or control purposes.

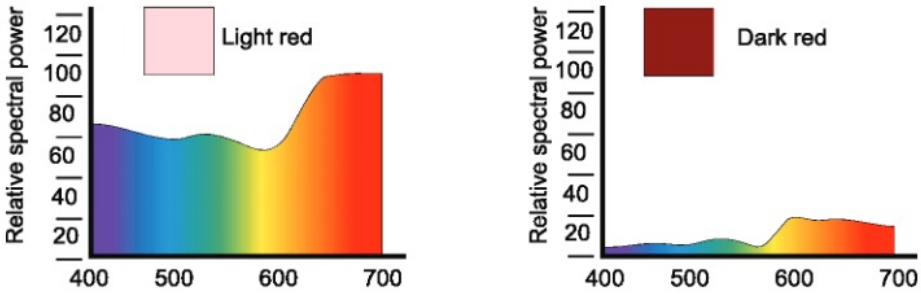

Figure 4.11
The amplitude of the spectral distributions high points determines the lightness or darkness of a color.

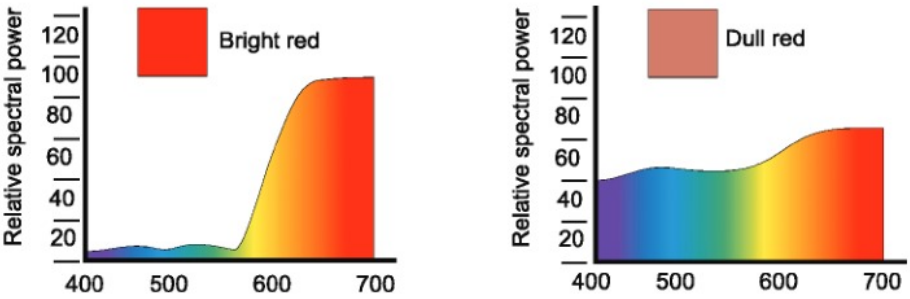

Figure 4.12
Saturation and hue are determined by the amplitude difference of the dominant high point and the remaining colors. This would represent a movement from the globe's perimeter toward the L axis.

Reproducing Color

In theory, any color observed in nature can be faithfully reproduced. In practice, this is not so. Printing methods compress tonal and color values. A printing method cannot reproduce all the tones and colors we see in nature or even the tone and color variation in a well-exposed photograph. In theory, any color observed in nature can be faithfully reproduced. In practice, this is not so. Printing methods compress tonal and color values. A printing method cannot reproduce all the tones and colors we see in nature or even the tone and color variation in a well-exposed photograph.

Colored pigments are composed of metal oxides and organic complexes. No ink has perfect absorption and reflectance of the relevant wavelengths. More typically, reflectance is spread over a wavelength range. (See Figure 4.13) Of the three pigments used in process color printing, yellow comes closest to the ideal.

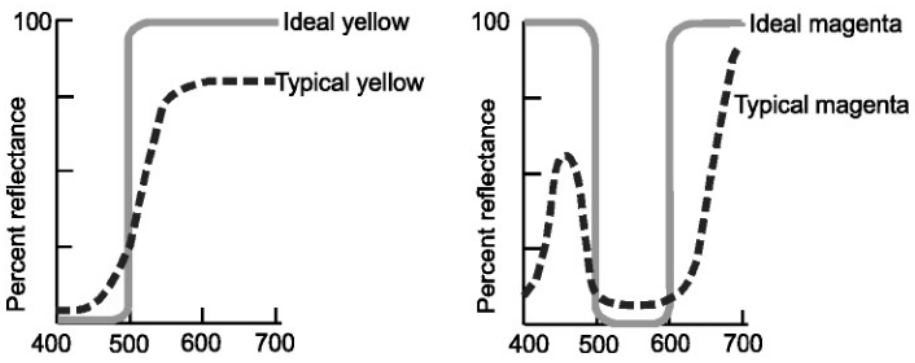

Figure 4.13
A comparison of ideal and typical reflectance curves for yellow and magenta pigments.

An ideal yellow pigment would reflect all green and all red wavelengths and absorb all blue wavelengths. The best yellow pigments, however, do not reflect all of the red and green wavelengths, while a small amount of blue is reflected. Typical yellow pigments have a slight orange cast.

Magenta and cyan pigments are even further from the ideal. An ideal magenta pigment, for example, should absorb all of the green and reflect all of the red and blue wavelengths. However, this is never the case. A typical magenta pigment absorbs most but not all green and reflects most but not all red and blue. The printer's challenge is to select inks and apply them in a manner that minimizes interference from these imperfections.

When several pigments are mixed to provide other colors, pigment deficiencies accumulate and can cause the final product to look dull or muddy. For this reason, printers often use inks other than the three primaries to achieve a particular hue and brightness. Thus, print jobs can be made up of seven or more inks, even though in theory, three colors should have been sufficient.

Black is an absence of color, and no combination of process colors produces jet black. At best, heavy lay-downs of the three process inks yield a dark, dirty purple-brown. Because of this difficulty, a printing plate for black or another dark color is added to the cyan, magenta and yellow already mentioned, in order to bring out shadows and dark lines and to add more depth and realism to the illustration. This additional printing ink is known as the key color or black printer. Thus, a minimum of four printing plates is needed to create a good full-color illustration using process colors: cyan, magenta and yellow, plus a key color. The four are abbreviated to CMYK.

ARTWORK

Artwork refers to any drawing, illustration or graphic effect imparted to a substrate. Printed matter is divided into three categories: line art, halftone art and process-printed art, based on how the color or colors are presented in the finished work. The different art categories need to be considered when preparing the printing plates that will pattern the ink and transfer the art to the surface to be printed.

Line Art

Line art consists of solid or monolithic ink lay-downs of a single hue, where hue and saturation are determined solely by the ink color used. A line-art illustration can contain several colors, but the colors are not mixed or superimposed to give color variations. Type copy, diagrams, line illustrations and illustrations with solid color blocks are line art.

Line art is the simplest and most economical image to produce. If done in one color, only one printing plate is required. Printing is accomplished simply by ensuring that the inked printing plate is in the correct location, or "register," with the sheet or object to be printed. A solid block of ink is transferred to the substrate.

If the artwork has more than one color, a printing plate is needed for each color. In addition to registering the additional printing plates with the sheet or object being printed, the plates also must register with the colors already put down.

Colors for line art are usually chosen from books of color chips, much as you would choose house paint. The Pantone Matching System (PMS) is the most fre-

quently used system for specifying colors for packaging graphic line art. PMS color guide books have a selection of more than a thousand colors, each identified by a number and an ink formulation key. Designers can conveniently communicate their color needs to printers with PMS numbers.

Specifying a PMS color does not guarantee that the final printed color will be exactly as in the sample book. Although PMS color guides are available printed on several different substrates, the packager's choice of substrates far outnumbers those in the PMS books. Since substrates affect color appearance, a final adjustment of the PMS recipe is done at the printer. A draw-down is a step in which the correct thickness of the specified formula is applied (drawn down) to the actual substrate to be printed. This color swatch is compared to the desired PMS color chip, and the recipe is adjusted to bring it closer to the desired color. A great number of other variables occur in the printing process. Generally, a printer is able to achieve exact replication of a PMS color only about half of the time.

Continuous Tone and Halftone Illustrations

Black-and-white photographs are continuous-tone images that use only black pigmentation. By varying the amount of black, a gray scale, going from white (an absence of pigment) to jet black, is created. In actuality, this process is combining varying amounts of black with the white of the paper to produce a range of gray values.

In printing, it is not practical to premix white and black inks in infinite ranges to produce a scale of gray values. However, the eye can be tricked. Artists discovered that by laying down fine patterned lines of black ink that covered varying percentages of the white substrate (paper), an optical illusion could be created that would fool the eye into seeing a range of grays.

Using fine lines or other intermittent ink patterns to create a scale of color saturations is the basis of single-color halftone printing. The engraved art on paper money is an example of colored halftone images using line patterns and several inks to create a range of colors. In package printing, it has been found that patterns of ink dots are more versatile than lines for creating varying color saturations and densities. Black-and-white newspaper illustrations are a common example of halftone printing using dot patterns.

Halftones can be printed in any color. Figure 4.14 (left-hand section) illustrates halftone dot patterns. Column 1 in Figure 4.14 illustrates a range of gray values obtained by varying the density of the black at the top of the column. The "K" initial stands for "key color," the designation used in the graphic arts industry for black or sometimes another dark color. The numbers following the K refer to the density or percentage of the white substrate that is colored with black ink. (The letter "S" following K stands for solid or 100%.)

Columns 2, 3 and 4 illustrate the effect of reducing density or saturation levels of cyan, magenta and yellow. For illustration purposes, only six halftones are shown. Modern computers can create a gamut of 256 halftone steps. No analog printing press is capable of printing such a gamut, but digital presses can. Converting a continuous-tone photographic image into a halftone dot pattern was formerly done by exposing a photonegative through a screen or grid, hence the term "screen" when referring to dot patterns. Today, screens are imposed electronically.

Figure 4.14
Color chart for four-color process printing.

Columns 1, 2, 3 and 4 are the four process colors. The top line represents the solid color:

KS = key, solid (black)
CS = cyan, solid
MS = magenta, solid
YS = yellow, solid

Looking down the column, you can see the effect of decreasing the dot size (reducing saturation). K40, for example, shows the gray achieved when the black or key color dot size is reduced to give only about 40% coverage of the white paper substrate. Each vertical column in this section shows selected halftones available using that color. Of course any percent coverage (saturation) can be printed, not just those shown.

Columns 5 through 8 illustrate selected colors made by printing two or three of the primary process colors at the indicated saturation level.

Colors 5A, 6A and 7A use solid combinations of cyan, magenta and yellow. These are very strongly colored. More pastel tones are made by reducing the saturation level of the participating colors.

Column 5 (down to E) shows combinations of magenta and cyan. Column 6 (down to E) shows combinations of yellow and cyan. Column 7 (down to E) shows combinations of yellow and magenta.

Notice that most browns require a combination of all three process colors.

Figure 4.15
The components of a full-color illustration, showing the effect of different screens.

Process color reproduction of a full-color original photograph. This one is printed with a 133-line screen.

magenta component

cyan component

yellow component

black component

magenta + yellow

magenta + cyan

cyan + yellow

magenta + cyan + yellow

Illustration printed with a 65-line screen.

Illustration printed with a 100-line screen.

When a picture is broken up into a series of dots, a small part of the picture is lost, and the eye is asked to interpret the remainder. Obviously, the finer the dots, the less the eye is aware of them, and the better the resolution of fine details in a reproduction.

Screens are specified by the number of dots per linear inch (dpi.) (In metric, the number of dots in a linear centimeter is specified.) A 65-line screen, for example, means that the image has been created using 65 dpi. While the entire image has 65 dpi, the size of the individual dots varies depending on the saturation, or color density, required at that spot in the illustration. A density of 20 would indicate that about 20% of the substrate surface is covered with the ink in question.

Substrate, illustration type and printing method dictate screen density. However, each printing method has other inherent characteristics that affect final image quality. Finer screens require smoother substrate surfaces. Rough surfaces such as kraft linerboard are usually printed using coarse screens. Smooth clay-coated paper is normally used to optimize appearance when using very fine screens. The general industry standard for full-color process printing is 133 dpi or 150 dpi. Gravure printing and on occasion, lithography, will print 200 dpi. Screens with more than 200 dpi are mostly used for extremely fine printing such as coffee table books and art reproductions.

Typical screen ranges representing the most common packaging applications are shown in Table 4.2. Finer screens have been used for special applications, but these are less common. Lithography and gravure printing plates can be made in screens having more than 400 dpi.

Ink colors for halftone printing are selected from PMS color selection books.

Screen Variations

Screen dots may be round, elliptical or another shape. In most instances, the shape of the dot has no great significance; however, some graphic features print better using a particular dot shape. Most dots today are not round.

Standard industry practice uses a fixed number of dots per linear inch and varies dot size (amplitude modulated) to produce different density halftones. An alternative is stochastic screening where a very small fixed-size dot is used. The number of dots is increased or decreased (frequency modulated) in random patterns to produce different density halftones. An advantage of stochastic screening's random dot placement is that moiré (pronounced "mow-ray") pattern problems are eliminated. (See Figure 4.16) Stochastic screening is sometimes used to create difficult vignettes.

Table 4.2
Typical screen ranges for different printing processes.

Printing Method	Typical Screen Range
Screen printing	40 to 110 dpi
Flexography	60 to 150 dpi
Lithography/gravure	133 to 200 dpi

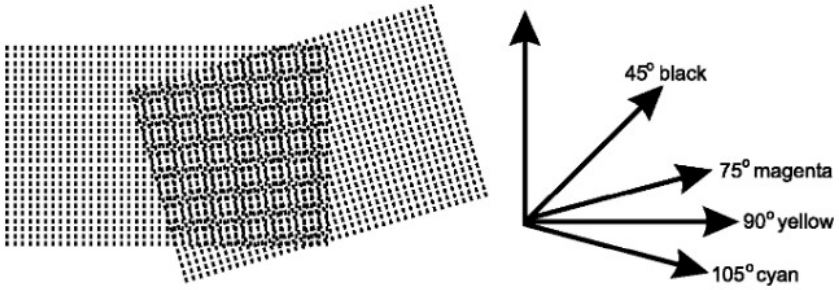

Figure 4.16
Moiré patterns (left). To avoid moiré patterns, the lines of dots for each process color are set at different angles.

Process Printing

The most complex printing task is to create a full-color illustration. This is referred to as process color reproduction or process printing.

Artists create infinite color variations by physically mixing paint on a palette. Physically mixing inks for printing is not technically possible, so the printer again resorts to fooling the eye with an optical illusion similar to halftone printing. Recall that with halftone printing, the eye in effect mixes individual black ink dots, which it can't actually discern, with the white background paper to give shades of gray. Similarly, a person observing a fine pattern of cyan dots printed over an equal pattern of yellow would not discern individual color dots, but rather some shade representing a mix of the two. A broad range of colors can be achieved by mixing the CMYK primary process colors in varying proportions. Columns 5 through 8 in Figure 4.14 show a selection of colors that can be created by combining the indicated densities of the primary process colors shown in columns 1 through 4. (Individual screen patterns can be discerned with a low-power magnifying glass.)

To achieve the full-color effect, the photographic original must be separated into the three component colors plus the key color (CMYK). Depending on the technology being used, either a photonegative or a digital record is made for each color. A screen pattern, as is done for halftone printing, is imposed on each of the photonegative or digital images. The color-separated and screened records are used to develop what is essentially a halftone printing plate for each process color. Thus, a cyan printing plate is made to print the cyan component, a magenta plate lays down the correct amount of magenta ink and a yellow plate does the same for yellow ink. Printed alone, each plate would produce a halftone of the respective color. However, when the individual halftone images are superimposed over one another, the eye blends the CMYK colors to give the illusion of a full-color continuous-tone image. The eye cannot discern the millions of tiny individual dots that go into making the colors.

Figure 4.15 summarizes the entire process. The full-color illustration represented by the image at the top of the figure is separated into its four halftones representing the three color components and the black component of the original image. (The image representing the original photograph is actually printed with a 133-line screen, typical of package printing.) These separations are used to produce the four respective printing plates, one for each color component. If printed separately, they would produce the images shown on the second line of the figure.

Combining two or three of the colors would produce the variations shown in the third line. Finally, by printing all four components in perfect register over each other, a reproduction of the original can be made. The reproductions in the bottom row of Figure 4.15 have been printed in 65- and 100-line screens to illustrate the difference in appearance associated with different screen selections.

The difference in resolution and image quality can be readily seen by comparing the top image at 133 dpi to the bottom 100-dpi image. Note that a ripple in the water off the tip of the paddle and some bubbles below the paddler's leg can be seen clearly in the 133-dpi image. At 100 dpi, the resolution is not good enough for these details to be visible. In the 65-dpi image, the dots are large enough to be seen with the unaided eye. Note also in the black component image that the ripple is defined by the black printing plate.

With the rapid changes that microprocessor technology has introduced, a mix of traditional and advanced technologies is available in packaging graphics and printing. Most, but not all, packaging graphic production uses digital workflow. Analog workflow using photonegative films for plate-making is becoming rarer and eventually will vanish completely as printers that have yet to adopt digital printing technology gradually switch to digital.

Computer-to-plate (CTP) digital technology is rapidly replacing photonegatives. Digital workflow imposes the graphic record directly onto the printing plate, eliminating all intermediate steps and photographic materials. Gravure printing cylinders have been produced using CTP technology since the early 1990s. With the resolution of some complex problems, CTP technology is now being used for both flexographic and lithographic platemaking.

Direct-to-press (DTP) technology, where the plate is formed directly inside the press, is the next step up. Direct-to-press technology can be likened to giant desktop printers where the designer presses a "print" key and the press immediately prints 10,000 labels. The printing of small numbers of packages for test marketing and consumer studies is one application, as are small runs of labels and tags. The ink used in such presses is costly and, to date, these presses would be classed as narrow-web presses, typically up to 610 millimeters (mm) (24 inches) wide. Printing a large order of labels at 10 images per cycle is very slow compared with a lithographic press that might carry 200 labels on a single press sheet. Current costs restrict these presses to special applications where speed is of the essence and the number of impressions required is small. However, it may be expected that as costs come down, the use of this technology will grow.

Simply superimposing the four colors as described would not produce a high-quality image. Dot rows in the different colors would periodically line up in orderly formations called moiré patterns that would interfere with proper product appearance. (See Figure 4.16) To minimize moiré patterns, screens for each component color are placed at angles as shown in Figure 4.16 to minimize pattern formation.

Earlier in this chapter, it was mentioned that printing inks are not perfect and that printers can match a specified PMS color exactly only about half of the time. A similar situation exists with CMYK-based four-color process printing. The Hexachrome system is an alternative that adds a vivid orange and green to an enhanced CMYK set. It is claimed that the Hexachrome system can provide a good match for upward of 90% of PMS colors. Some publications are using Hexachrome, and it is being used more often in packaging as many converters are switching to it. Two reasons for this limited packaging use concern the added cost of two additional printing plates and

that the six-color process would occupy most or all printing stations on common package printing presses. This would allow little leeway for additional PMS and other special colors. However, as converters invest and 10- and 20-color presses, this is becoming less of an obstacle.

PREPARATION FOR PRINTING

Prepress

Creating a printed package requires the cooperation of many groups of people. For printing specifically:

- The graphic design department that develops the art.
- The prepress department that converts the art into a form ready for plate-making.
- The printer that prints the package.

Regardless of the printing method or design composition, the art department must be supplied with a "keyline" layout showing the exact position and size of each element in a proposed design. The keyline tells the designer where the package borders are. For a folding carton, the keyline also would show the creases, windows and other features that the graphic would have to accommodate.

As artists, graphic designers prefer not to have constraints put on their imaginations. A design on the computer screen for a cosmetic carton may be a thing of creative genius; bringing that design into being meets the limitations of the real world and what actually can be done on a printing press.

Prepress is the critical work of turning a concept on the computer screen into a form that can be satisfactorily and economically printed by the millions. It is at the prepress stage where we may realize that the cosmetic carton as proposed requires 11 printed colors but that the available press prints only eight, or that the metallic gold border is impossible to print using lithography.

Digital workflow directs the work through a number of computers, and checks must be made to ensure the information is flowing correctly. The first is a preflight check of the digital graphic as it arrives from the graphics department.

The moving parts of any machine must have some slack or play to move. The practical printing implication of this slack is that you cannot achieve perfect register. If you tried to print a single dot on a hundred sheets, you would find not one dot but a group of dots within, for example, a 125-micrometer (0.005-inch) circle.

Each printing method and press have a tolerance within which it is able to register a color. For example, the plates in a lithographic printing press might move 100 micrometers (0.004 inch) about the set position during printing. If two colors are positioned so that they just touch, or "kiss," at the proper press setting, then as the plates move during the print run, a white unprinted line will periodically appear between the two colors. (See Figure 4.17) A "trapping" allowance is a slight extra margin of color where two colors come together so that the inks overlap even at the extremes of plate movement. (Trapping also is used to describe the ability of a wet ink to adhere and transfer to a previously applied undried ink.)

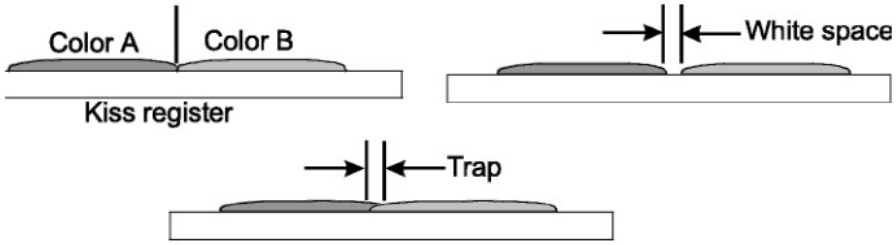

Figure 4.17
Some printed colors are overlapped slightly to compensate for printing press movement. Traps can range from 100 micrometers (0.004 inch) for lithography to 350 micrometers (0.014 inch) for flexography. Gravure trap allowance is about 175 micrometers (0.007 inch).

A similar registration problem occurs when the printed sheet is put through a die-cutting machine. Color "bleeds" are margins of color that extend beyond the package borders, so that full color always is visible within the tolerance of the printing press and die-cutter. (See Figure 4.18) A decision on how large the bleeds should be is another prepress responsibility.

Printing is not placed over gluing areas or areas that will be concealed when the package is assembled.

Package designs composed entirely of line art only need to have the number of colors counted and specified. The only provision is that the available printing press must have sufficient printing stations. (There must be one station for each ink color.) Common configurations have six or eight printing stations, and a few have 10. A composition with more colors than the number of available stations would need two passes through the machine with the attendant increased costs.

Most packaging graphics have both line art and process color segments. The CMYK process colors are used for the process art segment, and these colors also can reproduce line copy. However, large, single-color blocks will be more consistent if applied as a specified PMS ink rather than as a process ink mix.

Additional printing plates might be needed for other special colors and effects. For example, fluorescent or metallic colors must be applied as separate inks. Browns

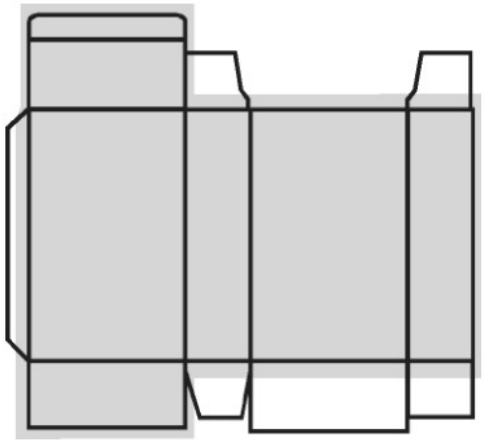

Figure 4.18
"Bleed" compensates for printing plate, substrate and cutting-die movement. The printed area on the paperboard carton blank bleeds, or extends, slightly beyond cut or visible edges.

require blending of at least three and possibly all four of the process inks. This is hard to control at the printing press, and it requires a heavy ink lay-down. Thus, brown inks often are applied with a separate printing plate to control color consistency. Graphics requiring colors that are particularly bright or pure also are applied from a separate plate. For example, brilliant greens and bright oranges often are best achieved with PMS colors rather than process ink colors.

Some corporations have taken ownership of a color. Since it is part of their corporate identity, it is especially important to them to maintain a consistent color. Corporate colors rarely rely on the art of mixing at the printing press and are usually a specified ink formula.

Sometimes, designs are created that require more than one printing or decorating method. The majority of printing machines are dedicated to one type of printing plate. A design that needs both lithography and gravure either will need the services of one of the few printing companies that feature a mixed-station printing press or require passes through two separate machines. In most instances, decorating processes also are performed offline on a different machine.

Each offline operation needs a separate press setup, or "make-ready," and a number of printing trials to register and bring the machine up to production readiness. Additional make-readies can add significantly to project cost and should be considered at a design's inception. A folding carton that is hot-stamped with gold foil, embossed and windowed likely will need three additional make-readies with all their associated costs.

The platemaker must know the intended printing method in order to give the right orientation to the plate. For example, a conventional flexographic plate image is reverse reading so that when the inked image is applied to the substrate, a proper reading image is produced. (Think of an ordinary office stamp.) However, when printing clear plastic films, it is common to put the ink on the side opposite from the one that will be viewed (referred to as reverse printing). A plate intended to reverse print a clear film would be made to read correctly.

Offset lithographic plates for printing on paper are always right reading. Some elements, such as Universal Product Codes (UPCs), two-dimensional barcodes and other codes used for automated product identification, must have special distortions built-in so the final product falls within exact finished dimensional tolerances. Most of these are added as the final step in the process to further avoid distortion of the final image.

PROOFING

The electronic image on a designer's computer is made up of red, green and blue light imposed on a glass or plastic screen whereas the final printed product will consist of CMYK plus assorted PMS colors printed on plastic, paper or metal. Not surprisingly, the graphic will appear quite different when printed on the intended substrate and viewed under actual use conditions. Accordingly, a variety of prepress proofing systems have been developed to produce a hard copy that approximates the appearance of the finished piece. In most instances, a brand owner will want to view several proofs at various stages of the design's travel through prepress activities.

Typically, proofs are wanted:

- During the design stage to approve copy and position. This proof is used primarily to ensure that the graphic fits the project's keyline, that the text is correct (including spelling and postal codes), the placement of the colors is correct and all legal declarations requirements have been met. This first proof is frequently printed in black and white.
- During the design stage to verify general color correctness and placement. After copy and position have been verified as correct, another proof in full color might be made. Depending on the system being used, the colors will be close approximations of what will be printed but not necessarily exactly the same.
- For a final contract proof before printing plates are made. Again, depending on the system being used and the brand owner's wishes, there may be a more advanced color proof that is signed off for approval to print. In some instances, final approval is given at the press after a few repeats have been printed.
- For a press proof and approval before committing to production.

The cost of proofs can be considerable, and judgment needs to be made as to which ones are essential. Generally, the closer it is to production, the higher the cost of the proof.

Creating a digital proof that closely matches what will come off the press is a challenge because:

- Digital printers use CMYK inks while press images may include a range of PMS colors.
- Digital printing employs line patterns, whereas process-printed halftones use dots.
- The proofing image might be applied to a different substrate material.
- Digital proofing may not accurately duplicate press characteristics such as gain and trapping.
- Individual printing presses have their own variables that affect the final outcome.

The problem is not whether the digital color proofs are good; some of them look better than what can be printed on a press. The problem is to have an image that provides a high confidence level of what the press output will be.

The elimination of photonegative film for platemaking made it essential to have a digital proofing system that offers print buyers a high level of confidence in the final result. DuPont's Digital WaterProof or AQ4 and Kodak Approval systems, for example, fingerprint individual presses by having them print a test sheet with up to 1,000 color-specific blocks. A scanner analyzes the printed color blocks to determine exactly how that press produces each color and incorporates that information into its file when it makes the digital proof. In essence, the digital proof is altered to imitate the actual colors that the press can print.

Color Keys. A Color Key, despite appearances, is not really a proofing system. Approximate colors are exposed onto relatively thick clear base sheets that are overlaid (not laminated) in register. Some press operators find them useful for setting up the

printing press because they allow the operator to see what each plate is supposed to print. The use of Color Keys is likely to decline with the advent of more advanced proofing and printing technologies.

Printers include a variety of printed devices on the press sheet, usually along trim margins or in areas that will be covered by a seal, that help make the initial setup easier and that serve as monitoring targets during the print run. Registration marks are usually crosses that appear on each printing plate. When all printing plates are in perfect register, the plates print directly on top of one another and the cross will appear black. If any color is visible, it means that a color printing plate is out of register. Other devices are tonal scales and gray balance charts in various screens, star-shaped elements to show "slur and drag," and devices to record gain for barcode monitoring.

It is common practice for the printer and customer to agree on the acceptable print quality during the first press run, and for specimens showing the desired print quality and color tolerance ranges to be retained as references.

PRINTING METHODS

Printing an image requires the ability to transfer fluid ink or another marking medium onto the substrate in the desired pattern. There are many ways of doing this, but the bulk of package printing can be grouped into three basic categories based on the fundamental geometry of the printing plate:

Relief	Variations include flexography (commonly referred to as flexo), letterpress and offset letterpress (commonly referred to as dry offset).
Planographic	The process is known as offset lithography and commonly referred to as lithography, offset or litho.
Gravure	The process is rotogravure sometimes called roto and occasionally referred to as intaglio.

Digital printing is gradually catching on in the packaging industry. It doesn't require some of the steps involved with traditional printing, so turnarounds are quicker from design concept to completed package. Among other advantages, that makes a host of product marketing strategies possible.

Each of the three traditional printing methods has a different way of creating, carrying and transferring ink patterns onto a substrate. In most instances, the device used to create the ink pattern for lithography and flexography is generally called the printing plate. In the instance of flexography and lithography, the plates are made in the flat but then attached to round rolls inside the printing press. The print image for gravure is engraved directly into the surface of a round metal roll or cylinder and referred to as the gravure cylinder.

Printing presses have the following features in common, regardless of the actual printing method used:

- An accurate material feed system that presents substrate to the printing station in precise register.

- An ink reservoir or ink fountain and a method of introducing ink into the printing train.
- A means of metering ink so that the amount applied is consistent over the print run.
- A way of configuring the ink to the required pattern. This is done by the printing plates, one for each color.
- A means of transferring ink to the substrate by pressing the substrate between the ink-bearing surface and an impression roll.
- Since inks are applied as fluids, a means of drying or solidifying them.

Printing presses are variously configured, depending on the print method and on whether the machine is fed with individual sheets or by a continuous length of material unwound from a large roll. The latter is known as a roll-fed, or web-fed, press.

Light materials—and those that are extensible (very stretchy) or have low strength or dimensional stability (tissue, for example)—must be web-fed; the material is supplied from a roll and is usually rewound into a roll after it is printed. Web-fed machines typically run faster than sheet-fed machines.

Printed materials in roll form fit nicely into packaging operations. The many varieties of form-fill-seal machines and most wrapping machines must be supplied with packaging material from a roll. These materials usually require registration marks, or "eye marks," that indicate cutting or sealing points.

Most papers can be web- or sheet-fed, in which case, other factors must be considered. For instance, corrugated board and other stiff or rigid materials that cannot wrap around feed rolls must be sheet-fed.

In-line presses, typical of lithography and gravure applications, arrange the individual printing stations in a straight line. Stack presses, more typical of flexography, cluster printing stations on vertical frames.

While in principle most art can be printed with four stations, printing presses with eight or more printing stations are not unusual. The added stations allow the printer more options and flexibility on how to produce exacting designs of the highest quality. Examples where added stations may be used are:

- Fluorescent and metallic colors that cannot be printed with standard CMYK inks.
- Line art, or process art combined with line art, that requires a large number of PMS colors
- Double applications of the same color needed to develop desired depth.
- Corporate colors (often specified PMS or proprietary formulations).
- Protective or decorative coatings such as high-gloss lacquers or varnishes.
- Difficult-to-duplicate colors such as orange, dark browns and some greens.
- Exceptionally bright colors.
- Large solid (line art) areas.
- Pattern-applied adhesives.

The printing process that is selected for a particular task depends on many factors:

- The volume or number of impressions desired (10,000 or 10 million impressions).
- The art type and desired effect (line art, process color, vignettes, metallic sheen).
- The substrate (paper, plastic film, surface quality, colored, porous, flexible, rigid).
- The substrate's physical shape (rollstock, sheets, discrete items, round, irregular).
- Special package process or use conditions (chemical resistance, thermal resistance).

RELIEF PRINTING: FLEXOGRAPHY AND LETTERPRESS

Plate Production

Relief printing, the earliest printing method, uses a raised surface (one that stands out in relief) to hold the ink. The raised surface is inked by passing an inked roller over it or by pressing the plate against an inking pad. The simple office rubber stamp is an example of relief printing. The first relief plates were hand-carved from wood. Later versions were engraved into metal or used movable metal type.

Relief printing plates have been made from rubber, photopolymer or occasionally metal, depending on the application. Rubber printing plates are the oldest of the flexographic plate technologies, but use is declining. The majority of modern flexographic plates are made from photopolymer, a polymeric material that cures or hardens where exposed to ultraviolet (UV) light. Unexposed areas are soluble and can be washed away. Plates are modest in cost and can be made quickly. (See Figure 4.19)

New ablation technology using digital CTP processing is replacing traditional photonegative-based image imposition. Ablation technology uses conventional photopolymer except that the surface of the photopolymer sheet is coated with an opaque, carbon-based black coating. A laser "ablates" or burns away the carbon following digital design information. In effect, an ultrathin photonegative is created attached to the photopolymer. The sheet is then exposed to UV light, and the uncured photopolymer is removed by washing.

Photopolymer plates can hold a smaller screen than rubber plates and generally produce better process art images.

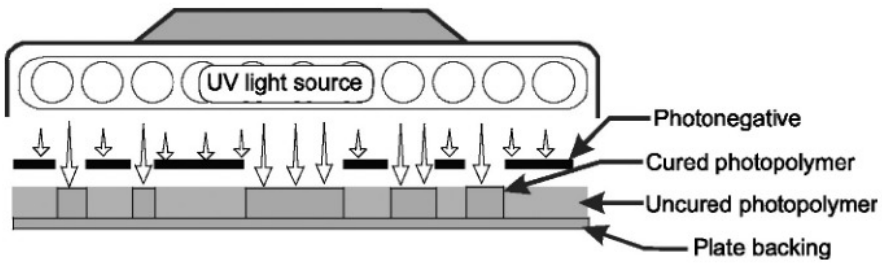

Figure 4.19
Ultraviolet light projected through the image photonegative cures photopolymer. Uncured photopolymer can be washed away, leaving the raised image areas.

Another laser engraving technology is able to engrave a rubber sleeve mounted on a metal cylinder to produce a seamless printing cylinder. The methodology is used mostly where a continuous repeat is desired.

Completed printing plates are mounted with adhesive onto a metal cylinder that rotates against the substrate during printing. Of necessity, a joint exists where the ends of the plate meet on the cylinder.

Printing by Flexography

In a typical flexographic printing station, excess ink is applied to an engraved transfer or anilox roll. (See Figure 4.20) The engravings on the anilox roll meter the correct amount of ink, depending on the engraving geometry and depth. The ink is transferred to the raised surfaces of the printing plate attached to the plate cylinder. Line-art printing plates have a solid, smooth surface. Halftone and process printing plate surfaces are composed of small dots standing out in relief. The substrate is passed between the plate cylinder and the impression cylinder to achieve ink transfer.

Flexography, by definition, uses a flexible printing plate and pressure to create an image. Accordingly, flexography tends to be sensitive to small pressure changes, which can cause images to spread, or "gain." Pressure variations appear as color variations in finished work.

The flexible plate material used in flexography limits the screen that can be used for process printing and the reproduction of fine lines. Flexographic screens are normally between 65 and 133 dpi, although improved plate-making materials and techniques can make 150-dpi plates. Ink squeeze-out, producing a light "halo" effect along solid edges (line art), is a common characteristic of flexography and letterpress.

Fine screens or fine copy and blocks of solid color on the same plate should be avoided when designing packages to be printed with flexography. The pressure needed to print the solid area will squeeze and distort the fine screens and lines. Vignettes or gradations (images in which color gradually fades to the paper), soft-focused images and subtle, moody subject matter are also more difficult to reproduce using flexography because of screen limitations and pressure differences between dark and highlighted areas.

Flexography's rubber-stamp nature, being more forgiving of surface irregularities, makes it the process of choice for rough or textured surfaces. Most corrugated fiber-

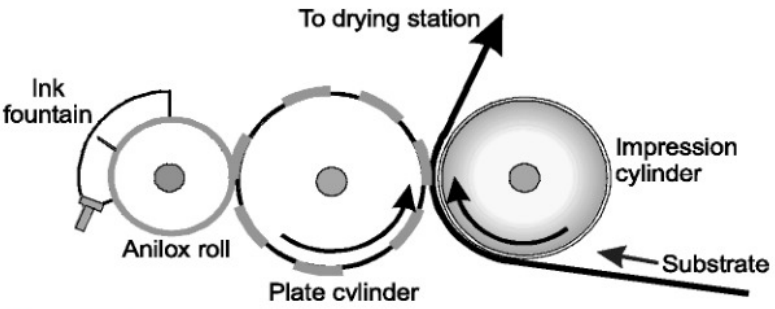

Figure 4.20
A typical flexographic print deck. Here, a chambered doctor blade ink fountain applies ink to the anilox roll. In other systems, ink is applied with rolls rotating in the ink fountain.

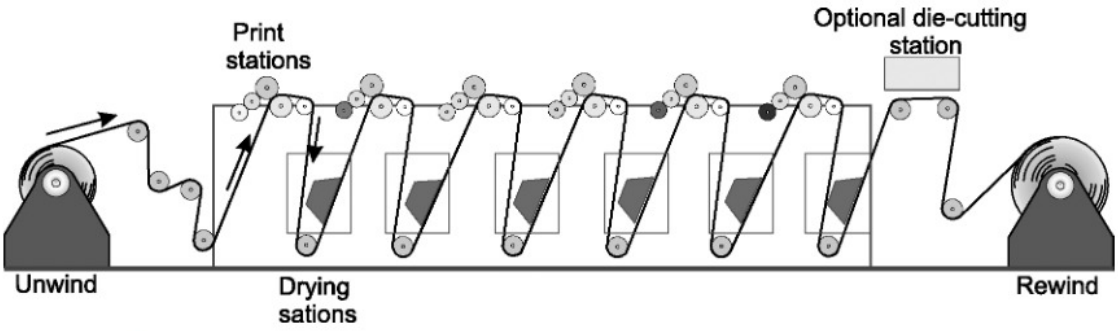

Figure 4.21
An in-line flexographic press.

board and kraft linerboard are printed flexographically. Flexography is usually the choice for printing flexible plastic rollstock intended for package-forming machines, pressure-sensitive adhesive labels and wrappers. The soft polymer inking surfaces do not cut or damage the substrate.

Recent flexographic printing improvements have encouraged growth in printing paperboard stock for folding cartons, an area that was dominated by lithography. Presses for these applications usually have an in-line configuration. (See Figure 4.21). The advantages over sheet-fed lithography are:

- Speed, roll-fed presses are faster than sheet-fed.
- Ink is dried in the press, allowing printed material to go directly to post-print operations.
- Die-cutting can be done directly in line with the printing press.

Flexographic press stations can be arranged in different ways. (See Figure 4.22) The stack press has individual color stations stacked one above the other, with drying zones between the stations. Each plate cylinder has its own impression cylinder.

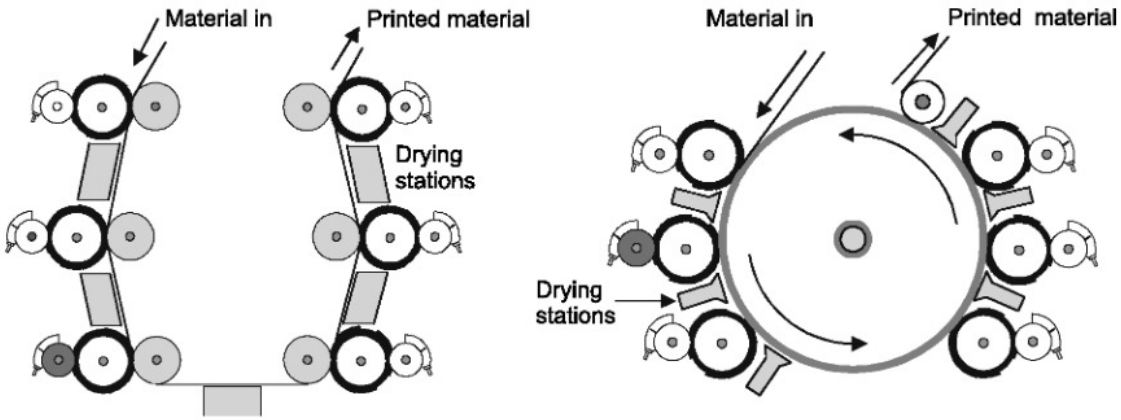

Figure 4.22
A six-color flexographic stack press (left) and a six-color flexographic common impression press (right). Common impression presses also are called central impression presses.

Table 4.3
Strengths and limitations of flexographic printing.

Flexography Printing Strengths
Prints well on rough and uneven substrates.
Able to print low strength and lightweight substrates.
Has wide ink formulation latitude, including good water-based inks.
Prints large solids evenly and with good color consistency.
Printing plates are low in cost (slightly more than lithographic plates but considerably less than gravure) and are readily made.
Considered to be better than lithography for printing large solids, but not as good as gravure.
Flexography Printing Limitations
Sensitive to changes in printing pressure.
Subject to halo effects around the edges of line copy.
Screen dot sizes cannot be as fine as available with lithography or gravure.
Halftone "dot gain," defined as the spreading of ink beyond the physical dimensions of the dots on a printing plate, is greater than in lithography and gravure. Dot gain can cause process colors to be inconsistent and can fill in fine lines or make UPCs unreadable.
Highlight halftone dots tend to disappear, while shadows tend to fill in.
Difficult to make smooth transitions of dot size in vignettes.
Considered to be not as good at reproducing fine lines as lithography, but better than gravure.

Stack presses are an older design and have been replaced by central impression (CI) presses in most applications. The CI press has printing stations grouped around a single, large central impression drum. Extensible webs, such as polyethylene, are best printed on a CI press since the central impression drum minimizes web distortion.

The strengths and limitations of flexographic printing are summarized in Table 4.3.

LITHOGRAPHY

Lithography is a planographic process, meaning that printing and nonprinting areas are on the same plane. Unlike a relief plate, a lithographic printing plate is flat and smooth. Lithographic principles were discovered when a greasy crayon was used to write on a porous stone. The stone was then soaked with water, wetting everything except the greased area. An ink made from oil, wax and lampblack, applied to the stone's surface, was naturally repelled by the water-wetted area and adhered to the greasy area.

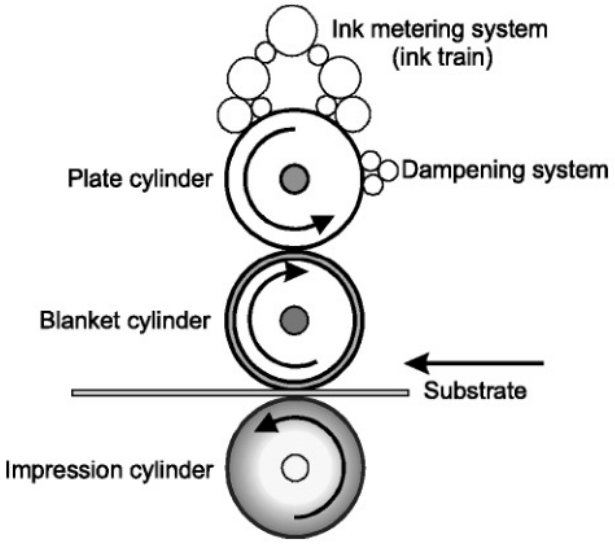

Figure 4.23
A lithographic printing station.

The mutually exclusive nature of oil and water forms the basis of modern lithography. Lithographic ink is, by definition, always oil-based. It is a heavy paste and is metered to the plate cylinder by a train of inking rollers. Another group of rollers applies a thin film of water to the water-receptive areas. (See Figure 4.23)

Aluminum alloy plates with chemically developed oil-receptive and water-receptive areas have replaced stones. Plate costs are the lowest of the three printing processes, and lead times are short. Lithographic printing plates are mounted onto a plate cylinder similar to that used in flexography. The inked metal image plate is not resilient enough to follow minute substrate surface irregularities. Transferring, or "offsetting," the ink image from the metal plate to a rubbery blanket roll provides for better ink transfer to the substrate and reduces plate wear. An impression cylinder provides the contact pressure required for transferring ink from the blanket to the substrate.

Offset lithography is the most common paper-printing process, used to print folding carton stock and can and bottle labels. Labels often are produced in composite sheets, sometimes carrying a dozen or more orders on one press sheet. Small buyers pay only for the plate area used for their label, thereby reducing printing costs. This practice is not permitted for pharmaceuticals to avoid the possibility of mixing labels.

Paper for lithographic printing needs to have a certain amount of water resistance because some water may be transferred from the plate-dampening system. Paper stocks also need a strong, clean surface with good anchorage of surface fiber and clay coatings to resist being picked or pulled apart by the heavy paste inks as the blanket roll lifts from the substrate surface. Any fiber or contaminating material adhering to the blanket will mar the printed image. The oil-based nature of lithographic inks and the necessity of dampening the printing plate with water make printing on plastic substrates difficult.

Unlike flexographic and gravure inks, lithographic inks are not dried between printing stations. Good trapping of an ink applied over a previously applied ink that is still wet is very important. The press sheet exits the press with the ink still wet, and usually, a stack of printed sheets is left to dry for 24 hours before further pro-

cessing. The heavy paste nature of the wet ink minimizes smearing. Many lithographic printers coat the printed sheet with an aqueous surface varnish that is UV-cured instantly as the sheet leaves the press. The varnish protects the ink layer and also allows for immediate handling of the sheet even though the lithographic inks are still wet under the cured varnish.

Most lithographic presses for packaging applications are sheet-fed. The planographic nature (having a smooth plate rather than a raised surface) of the process requires that the substrate surface be reasonably smooth to achieve good ink transfer. Lithographic plates can be made with 200-line and finer screens, although 133 and 150 are more common in packaging. Accordingly, the lithographic image is sharp and has excellent detail. It does not have the problems with ink squeeze and halo effect that flexography has. The edges of line art are sharp and straight. An advantage of lithography not available with the other methods is that some color adjustment can be made on-press.

Table 4.4
Strengths and limitations of offset lithography printing.

Lithographic Printing Strengths
Plates are economical and readily made.
Replacement or corrected plates are easily made.
Economical for small runs.
Capable of fine lines and of holding highlight halftone dots better than flexography or gravure.
Capable of exceptionally fine halftone screens.
Prints well on metal surfaces.
Low halftone dot gain and excellent registration.
Some color adjustment available on-press.
Lithographic Printing Limitations
Paper stocks need to be exceptionally clean.
Heavy paste inks make printing lightweight substrates (thin papers or films) difficult.
Oil-based inks dry slowly.
Ink formulations are limited because the operating principle is based on the mutual repellency of oil and water.
Color can vary across a sheet or from sheet to sheet.
Oil-based inks and the requirement for dampening can make the printing of plastic substrates difficult.
Relatively complicated compared with flexography and gravure, requiring higher press crew skill levels.
Does not produce large solids as well as flexography or gravure. Sheet-fed lithography is slower than web flexography or gravure.

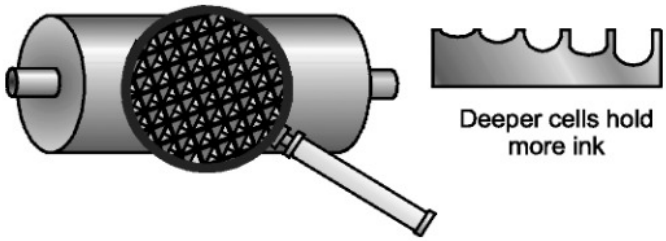

Figure 4.24
A gravure cylinder may have millions of tiny cells, or wells, whose volume can be controlled to carry different amounts of ink.

A particular application of offset lithography is the printing of flat metal sheets destined to be formed into metal containers. The inks used in this application are heat-cured, or solidified, by being treating with UV light.

The strengths and limitations of printing by offset lithography are summarized in Table 4.4.

GRAVURE PRINTING

Gravure printing uses engraved copper-plated steel cylinders to measure and apply patterns of ink to the substrate. (See Figure 4.24) In the most common process, a stylus controlled directly by digital information engraves the desired cell pattern into the cylinder's soft copper surface. The cylinder is then chrome-plated to give it a hard, wear-resistant surface.

While flexographic and lithographic printing processes are limited in the ink thickness that can be applied to a substrate, gravure can provide heavier ink lay-downs. Cell patterns are simply cut deeper to hold more ink. This is an advantage where a heavy ink lay-down is desired in order to achieve good hiding and depth of color. Metallic gold or silver ink formulations also must have heavy applications for a good effect.

Normal gravure printing is always done from rolls and in web form. The gravure cylinder's entire surface is flooded with low-viscosity ink and then wiped clean with a straight-edged metal doctor blade. After the cylinder has been wiped, only the ink

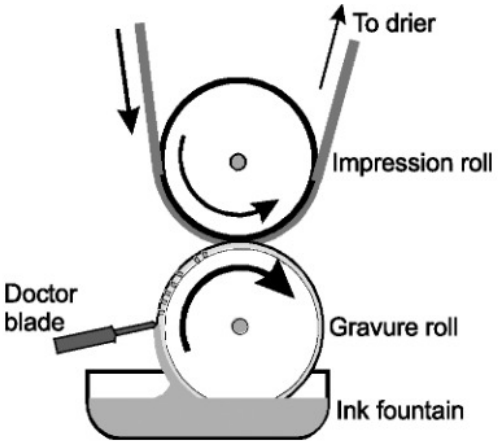

Figure 4.25
A gravure print station is mechanically simpler than either flexography or lithography.

inside the recessed cell pattern remains on the cylinder. (See Figure 4.25) The substrate to be printed is nipped between the impression roll and the gravure cylinder, and the ink is pulled out of the cells and deposited on the substrate. Often, the substrate and the gravure cylinder are given opposite electrical potentials to give ink removal an added electrostatic assist. Gravure printing needs a smooth substrate surface to ensure contact with the minute ink cells.

Unlike the other printing methods, gravure always lays down ink as a dot pattern, even for line art. Gravure can typically be recognized by the slightly ragged edge on the borders of line art. Very fine lines such as scrolls or pin-striping are difficult to achieve for this reason.

Gravure printing gives superior print quality and unmatched control over long production runs. The amount of ink delivered by a gravure cylinder is metered and fixed by the engraving itself, and therefore, gravure printing is not as subject to op-

Table 4.5
Strengths and limitations of gravure printing.

Gravure Printing Strengths
Very high printing speeds and productivity are possible.
Exceptionally fine halftone screens are possible.
Excellent color consistency over long print runs.
Ink cells can be engraved to different depths, allowing for the application of different ink thicknesses.
Heavy ink applications can be used to produce exceptionally bright and glossy colors.
Can print heavily pigmented metallic inks.
Considered to be superior for printing skin colors and uniform heavy solids.
Gravure cylinders are capable of printing several million repeats; flexographic or lithographic plates might need to be replaced several times for long runs.
Press make-ready is fast and production costs are modest.
Gravure cylinders can be stored and remounted for repeat runs.
Continuous repeat is readily available.
Gravure Printing Limitations
Cylinder preparation requires a long lead time.
Cylinders are several times the cost of flexographic or lithographic plates, making the process economical only for long runs.
Does not print well on rough substrates such as uncoated paperboard.
Does not give good resolution of small type, fine lines and other small details.
Inventory and storage of base and engraved cylinders are costly.

erator and environmental variables as other processes. Make-ready is simple. Since there is no plate joint on a gravure cylinder, it is possible to print continuous patterns.

Gravure cylinder preparation is an exacting and time-consuming procedure, so lead times for gravure printing are longer than for other print methods. The cost of a set of gravure cylinders is several times that of plates for flexographic or lithographic printing. However, a gravure cylinder will last for several million impressions, whereas flexographic and lithographic plates will need to be replaced after well under a million impressions. A prime requisite of gravure printing is a large enough production run to offset the higher initial cylinder costs. Gravure printing is used on a variety of high-volume web-printing applications such as labels, cartons, carton wraps and flexible packaging materials.

The strengths and limitations of gravure printing are summarized in Table 4.5.

DIGITAL PRINTING

In digital printing, the digital art file is processed into ink separations. The printer decodes the data to enable printing on a package surface, without the need for creating plates or cylinders prior to printing. Digital printing does not require film, photographic plates or the related chemicals. All the colors are printed in a single pass, eliminating the need for a separate plate for printing each color.

There are three primary digital printing methods—inkjet, liquid electrophotography and dry electrophotography. In the inkjet method, very small ink droplets are ejected through a printhead directly onto the package surface. Ink options include water-based, solvent-based and UV-curable. In electrophotography, either liquid ink or dry toner is placed in the image area using an electric charge. The press puts a charge in the image's shape for a given color or a special imaging plate surface. Either the liquid ink or the dry toner creates the image with its attraction to the charged portion of the package surface. The charged particles in each color are transferred to the package surface via an impression roller that takes the image from the plate or blanket and applies it to the package surface.

Digital printing has a strong presence in the labels market, and emerging larger-format, higher-throughput presses are making the process more suitable for folding cartons and flexible packaging. These new-age presses also allow for higher output than ever before.

By eliminating preproduction steps, digital printing shortens speed-to-market time and gives designers more creative latitude. With product manufacturers thinking of packaging more strategically, digital printing is presenting new possibilities in supporting business objectives. Digital printing allows for what the printing industry describes as "revision control." This capability enables frequent changes in packaging graphics and messaging that keep products relevant and updated at all times on store shelves. That is an advantage in markets with high obsolescence, such as those in which product formulations or brand messaging changes frequently and requires package decoration updates. On digital presses, printing changes on labels, bags or folding cartons can be completed in a fraction of the time required on traditional presses, and with virtually zero waste coming off the press.

The strengths and limitations of digital printing are compared in Table 4.6.

Table 4.6
Strengths and limitations of digital printing.

Digital Printing Strengths
Eliminates the plate-making process.
Shorter-run printing is made easy.
No dot-gain allows greater design freedom.
Material waste is virtually eliminated in both set-up and print run production.
Printers can view first press proofs in minutes on the production substrate. What you see on the proof is equal to what the production run will deliver.
Enables the ability to print only what is needed and where it's needed (just-in-time manufacturing).
Variable content data allows each product decoration to have its own unique identity.
It's a sustainability- and environmentally-friendly alternative to conventionally printed products.
Product versioning options are possible at lower cost down to a run of one piece.
System savings beyond piece price are possible through the elimination of remnant scrap by the brands, tool cost avoidance as well as production inspection time and travel costs.
Digital Printing Limitations
Large production runs are much more expensive on a per piece price, compared with other printing methods.
Ink opacity may be less than other printing methods because inks are laid down thinner.

COMPARING FLEXOGRAPHY, LITHOGRAPHY, GRAVURE AND DIGITAL

The quality of printed images varies widely among flexography, lithography and gravure. It is easy to distinguish between the three processes when the printing is not done to the highest of standards, but the process is identifiable only by careful examination with a magnifying glass when the printing is of the first quality. (See Figure 4.26) The UPC is usually the best line art to examine to identify the printing process.

Competition between the three printing industry segments is fierce, and as each segment incorporates more advanced technology, predictions are made regarding the ascendancy of that segment at the expense of another. The result of this competition has been a remarkable improvement in graphic quality and turnaround time, but relatively small changes in market share.

Figure 4.26
The printing method often can be determined by examining the edges of line art under magnification.

The most typical press configurations and applications for relief and offset lithographic printing are shown in Table 4.7. Gravure printing presses are always web-fed and are used primarily for large volume runs on any smooth-surfaced stock. A limited number of combination presses are available that combine lithography and gravure or flexography and gravure in order to take advantage of the strengths of the combined processes

Each printing process deposits a different thickness of ink on a substrate. (See Table 4.8) Heavy ink lay-downs increase ink consumption and cost on the one hand, but also can provide better opacity and greater depth of color and gloss. Table 4.9 is a summary comparison of the flexographic, lithographic and gravure printing processes. The strengths and limitations of digital printing are compared in Table 4.6.

Table 4.7
Typical flexographic and lithographic press configurations and applications.

Press Type	Typical Applications
Flexographic, web	Most plastic films used for bags and wrappers, paper wraps, some pressure-sensitive labels, gabletop milk cartons, some paperboard folding carton stock, preprinted linerboard for corrugated boxes.
Flexographic, sheet	Post-printed corrugated board stock.
Letterpress, web	Mostly narrow-web label and tag applications. Not common.
Offset letterpress (dry offset)	Round containers such as metal cans, plastic tubs and collapsible tubes.
Offset lithography, sheet	Most common press for printing paper stocks used for cut labels, folding cartons and other paper and paperboard constructions. Most common press for printing flat metal stock for three-piece metal cans.
Offset lithography, web	Used in applications similar to sheet-fed offset lithography. Not as common.

Table 4.8
Wet ink film thickness for typical printing methods.

	Wet Ink Film Thickness	
Printing Method	*Inch*	*Micrometer*
Offset lithography	0.0002 to 0.0005	5 to 12
Flexography	0.0004 to 0.0008	10 to 12
Gravure	0.001 to 0.0015	25 to 40
Screen	0.001 to 0.005	25 to 130

Table 4.9
Printing processes compared.

	Lithography	**Flexography**	**Gravure**
Short runs	best	good	not suitable
Long runs	good	good	best
Plate lead time	shortest	medium	longest
Fine lines	best	good	poor
Large solids	good	better	best
Register	best	lowest	intermediate
Gain	lowest	most	intermediate
Uncoated paper	good	best	not suitable
Plastic film	not suitable	good	good
Screen range	200+	133 to 150	200+
Ink formulation	oil-based paste	widest latitude	low viscosity

OTHER PACKAGE DECORATION TECHNIQUES

Not all package decorating and marking requirements can be met with flexography, lithography or gravure. For distinctive effects, special substrates or irregular shapes, many additional processes and variations can be called upon. Some decorating processes are almost exclusive to the plastics industries, where preformed parts need to be decorated.

Additional decorating of printed stock is rarely done in-line with the printing press. This means that conventionally printed material would be moved to a separate operation if it required hot-stamping. Still another operation would be needed if the design also called for embossing. Some of the already-printed material would

need to be used to set up each added feature, and a method of registering between machines is essential.

Reflective Metallics

No printing ink can produce glossy reflective metallic. All such effects are based on aluminum either in its foil form or in a vacuum metallized form. Only a continuous metal surface can provide a reflective glossy metallic sheen. In the instance of printed aluminum foil, the graphic will have a hard, glossy surface even in those areas printed with opaque ink.

Golds and other reflective metallic colors are created by coating aluminum with a transparent yellow or another appropriate color varnish.

In most decorative applications where localized reflective metallics are called for, the aluminum layer will be transferred from an aluminum vacuum-metallized sheet. (See Chapter 15, Flexible Packaging Laminates) Metallizing is a full-web process; metallized designs and patterns are not practical.

There are several ways of creating patterned reflective metallics. Hot-stamp printing is the most common method and generally is used where only small areas of metallic print are needed. In this application, a metallized carrier, or release sheet, typically polypropylene (PP) or polyethylene terephthalate (PET), is coated with a heat-activated adhesive material. The carrier is brought into contact with the substrate and the hot die is applied to the back of the carrier sheet. The adhesive material melts and in adhering to the substrate, pulls the aluminum metallizing with it. As with aluminum foil, gold and other reflective metallics are produced by transparent inks of the desired color over the metallized surface.

Another option is to preprint a web before metallizing, thus providing for colored art with a metallic background. As a final option, a demetallizing process using a caustic solution applied by a printing type roll will dissolve the aluminum and open up clear windows in a metallized film.

Hot-Stamp and Heat-Transfer Printing

In some instances, printing ink or other material is applied to a carrier sheet by conventional printing methods and then the ink or material is transferred to the container.

Both hot-stamp and heat-transfer printing use heat to transfer images from a carrier web to the substrate to be decorated. These are clean processes since there are no inks to dry. Both processes require a substrate that is reasonably tolerant to heat.

Hot-stamp printing (sometimes called leaf printing) uses a carrier web made of release-coated PET. Decorative and protective coatings are applied against the release-coated carrier web and then covered with a final layer of heat-activated adhesive. The web is placed against the substrate to be decorated, with the adhesive side facing the substrate. A hot, engraved die is brought against the back of the PET carrier web, activating the adhesive that then adheres to the substrate. The adhesive pulls an image duplicating the die profile from the release-coated carrier web and bonds it to the substrate. (See Figure 4.27)

This describes an analog foiling process that requires a manufactured die containing the desired image.

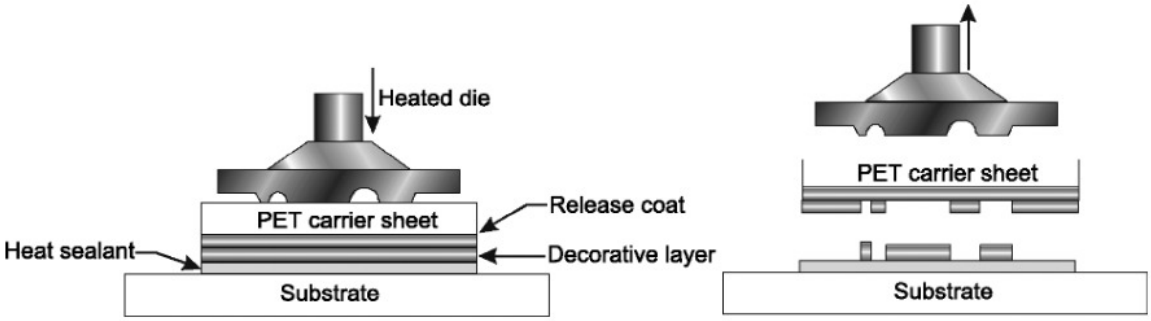

Figure 4.27
Hot-stamp printing uses a heated die that has the image engraved into its surface. Hot-stamp printing transfers only one color.

Metallic decoration is the principal hot-stamp application. To produce the metallic sheen, the decorative coating is created with a vacuum metallized aluminum layer. (See Chapter 15, Flexible Packaging Laminates)

Unlike hot-stamp printing, heat-transfer printing has a full, preprinted image applied to the carrier web. The desired design is printed with thermoplastic inks on the carrier web by whatever process is most suitable, thus giving substantial design flexibility. The heated die does not have an image engraved into it; it only has to conform to the overall design shape. Heat-transfer printing is primarily used for decorating plastic bottles and articles. Therimage, Di-Na-Cal and Electrocal are proprietary names for heat-transfer printing..

Digital Hot-Stamp (Foiling)

Digital foiling processes can provide the same decorative effect described in the analog process. The benefit is that no tooling is needed, much like digital printing.

Matte and Gloss Varnish Coatings

Printing inks alone do not normally have a high-gloss surface. Clear surface coatings are applied where such an effect is needed. UV-cured coatings exhibit a particularly good surface sheen. Graphics have evolved to containing at times both matte and gloss varnish effects. These can be printed and registered to graphic printed elements and have both analog and digital methods for achieving such effects.

Once again, the analog method to produce matte and gloss varnish requires a specific tool to carry the varnish. The digital method does not require a tool and can apply variable matte and gloss varnish from one image to the next.

Embossing

Embossing is the practice of pressing a substrate, usually paper, so that a design stands out in relief. A key requirement of embossing is that the substrate is capable of deforming under pressure and holding the newly created contour.

Embossing dies are made by direct engraving or by casting from a master engraving. The embossing die is pressed against the substrate that is backed by a resilient material or by a matching anvil. Most embossing is done in register with a printed pattern already laid down in previous steps. Web stock can be embossed continuously by embossing rolls to impart an overall texture to the substrate. Aluminum foils often are embossed this way.

Reverse Printing

Clear plastic films frequently are "reverse printed," or printed on the back so that the image shows through the film. The film surface provides gloss and protects the ink from surface abrasion. In most reverse-printing applications, the reverse-printed film is laminated to a backing film or sheet. The backing film can be clear or colored. Many snack food packages back the reverse-printed sheet with a metallized film to provide a reflective metallic background for the print.

Laser Marking and Ink-Jet Printers

Laser marking is different from that produced in common office laser printers in that the image is burned into the substrate surface rather than developed by the application of ink. The surface to be marked must be receptive to the laser. Substrate surfaces that are transparent to lasers can be coated with a laser-receptive material. Laser marking is exceptionally fast and is used to mark lot numbers, dates and similar information at speeds up to several thousand per minute. Laser printing, as used in coding, has a limited font size.

Inkjet printers eject a train of ink droplets that are deflected into the desired patterns when they pass between electrically charged plates. Inkjet printers are commonly used to print variable information on packages and labels.

PRINTING DIMENSIONAL PACKAGES

For those packages that are flat at some point in their manufacture, flexography, lithography and gravure are used to economically print quality text and graphics directly onto the packaging material at high speeds. Three-dimensional packages such as cans, bottles, jars and boxes cannot be easily decorated by these options. While printing directly on dimensional packages is done, there are usually some limitations.

Letterpress and Offset Letterpress (Dry Offset)

Letterpress refers to relief printing processes that use stiff polymer or sometimes metal printing plates made in relief. Where flexographic printing inks are fairly fluid and can be metered with engraved rolls, letterpress inks are heavy pastes similar to lithographic inks and must be metered by a complicated series of rollers. Packaging printing by letterpress is not common; the method is used mostly for printing labels and tags. The plate is more durable but also more expensive to make than a similar

flexographic plate. The stiff plates are dimensionally more stable than flexible polymer (flexographic) plates, and a finer screen pattern can be used to provide a better-quality image.

Cylindrical objects such as two-piece metal cans have no circumferential register point against which to register printing stations. This problem is resolved by a process modification variously known as offset letterpress, dry offset or letterset. (See Figure 4.28)

In offset letterpress, the inked images from the letterpress printing plates are transferred onto an intermediate resilient rubber blanket roll, where all the colors can be assembled in register. A heavy paste consistency prevents letterpress inks from running or spreading while the image is being assembled. The blanket roll is then rolled against the round object, and all the colors that make up the image are transferred at one time and in register.

The colors applied to the blanket are wet and must stay wet until transferred to the container. Inks used in these applications are cured by heat or UV light. Colors cannot be easily printed over other colors with this printing technique, and a fine unprinted line between colored areas usually can be seen with magnification.

Offset letterpress is used to decorate drawn-and-ironed metal cans, round plastic tubs and plastic or metal collapsible tubes. Because of the difficulty of overprinting wet inks, offset-letterpress-printed beverage cans and collapsible tubes usually are decorated with simple line or halftone art. Process color printing, while possible, tends to be restricted for more upscale applications. A characteristic darker margin can be seen on most containers at the point where the printing plate has to overlap itself slightly.

Stencil or Screen Printing (Serigraphy)

Many glass and plastic bottles are screen printed. The heavy ink application provides good opacity where a background color needs to be covered, and the plates are inexpensive. The process is slow and limited in the complexity of art that can be produced. The advantage of a "no-label look" on glass bottles is being successfully reproduced with clear plastic pressure-sensitive labels.

The term "silk screen," while commonly used, is technically incorrect because modern screen printing uses fine metal or plastic screens. The screen is masked off into a pattern that leaves porous screen areas where ink is desired and sealed areas where

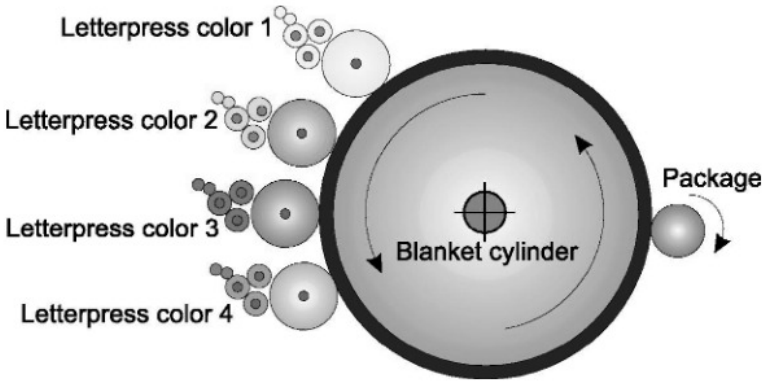

Figure 4.28
Offset letterpress (dry offset) assembles the entire image on a blanket roll and transfers it to a round container in one rotation of the container.

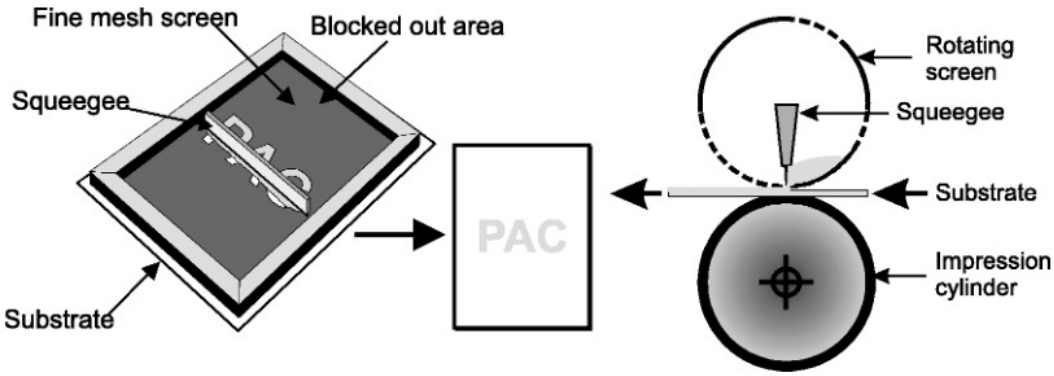

Figure 4.29
Flat, framed screens (left) are used for very large area application, such as point-of-purchase displays. Printing can be done on flat or round objects. Rotary screens (right) are used for smaller, higher volume applications.

no ink transfer is indicated. The screen is placed against the surface to be printed, and a wiper blade moves an ink puddle across the screen. (See Figure 4.29) Where the screen has been left porous, the ink drops through onto the substrate. Stencil screens are easily and economically made by exposing a screen coated with photosensitive material in a manner similar to that used in lithography and flexography.

Screens can be configured to a variety of shapes and sizes, making it possible to decorate round bottles and other items that would be difficult to print any other way. (See Figure 4.30) Screen printing is best for line art, although process art can be printed. Halftone screens are limited to about 85 dpi, giving fairly coarse halftone reproductions. The strengths and limitations of screen printing are listed in Table 4.10.

Screen printing lays down an exceptionally heavy ink layer. Normally, this would be viewed as unfavorable and costly. However, in some instances, heavy ink lay-downs are needed. Applied ceramic lettering (ACL) and decorations applied to glass bottles, for example, need fairly heavy ink applications and are normally screen printed. Heavy ink lay-downs also can be beneficial when printing over colored backgrounds. Colored plastic containers are screen-printed to provide complete opaque coverage of the substrate color. The brown kraft of corrugated board can be successfully concealed with screen printing.

Other typical applications include textiles, point-of-purchase displays, stiff boards and rigid plastic and metal parts that cannot be printed in other ways.

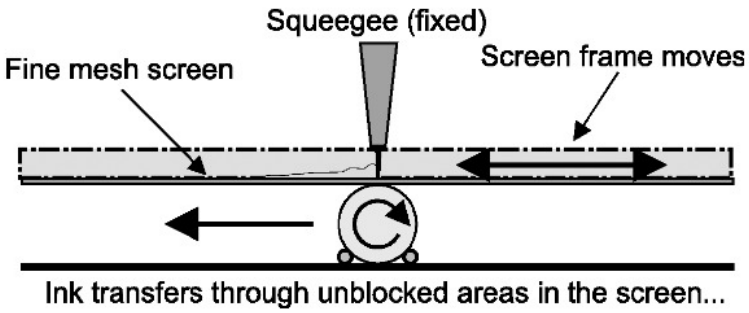

Figure 4.30
Screen printing is easily done on round containers.

Table 4.10
Strengths and limitations of screen printing.

Advantages of Screen Printing
Image carrier (printing plate) is inexpensive and quickly prepared.
Able to print with the greatest variety of ink formulations.
Can print any substrate, including metal plates and some textiles.
Capable of the heaviest ink lay-down of any process and of producing brilliant colors.
Heavy ink lay-down provides high opacity on colored substrates.
Large solid areas are uniformly opaque.
Can be readily adapted to print cylindrical or tapered shapes.
Very large image carriers are possible.
Screen Printing Limitations
Production speeds are very low, compared with other printing processes.
Heavy ink lay-downs increase ink consumption and cost.
Not able to produce fine halftones.

Pad Printing

Pad printing is a relative of gravure printing. The inked image is created on a flat, etched plate (the cliché) in a manner similar to gravure. A large, resilient silicone pad is pressed against the inked cliché. The ink pattern is transferred to the pad, which is subsequently pressed against the substrate. (See Figure 4.31)

A feature of pad printing is the ability to print highly irregular surfaces. The resilient pad transferring the ink can conform intimately to surprisingly asymmetric and uneven surfaces. (Golf balls are printed this way.) Multicolor printing can be accomplished by using several printing stations in sequence. Pad printing is most commonly used to decorate molded plastic parts such as closures and cosmetic containers.

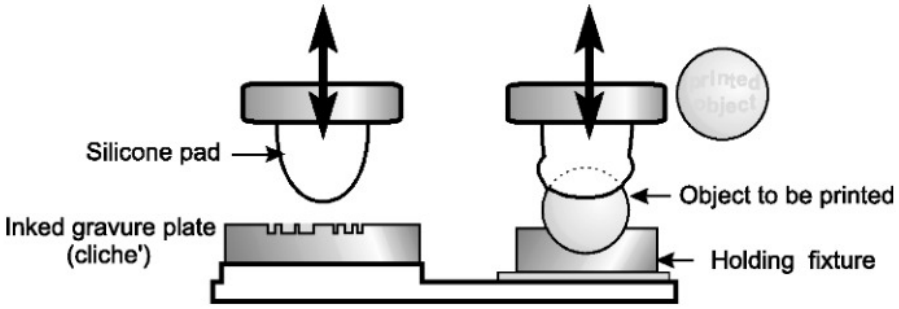

Figure 4.31
Pad printing is used to decorate irregularly shaped objects. The pad is first pressed against the inked cliché and then moved over and pressed against the object to be printed.

LABELING

Labeling generally refers to communication matter that is printed on a separate material and subsequently attached to a package by means other than direct printing. The entire gamut of decoration and printing methods is available because the text and graphics are applied while the label material is in the flat.

Cut-and-Stack Labels

Cut labels are printed paper or laminate stock sheet, cut to size and stacked for shipment. Coated high-quality paper stock enables high-quality graphics. The labels are attached using adhesives applied to them or the container, most commonly in line with filling and closing. The adhesives are usually water-based emulsions, although hot-melts and combinations of adhesives also are used. Their single biggest application is for canned food and similar products. They are the least expensive labels to purchase. However, labeling operations using wet glues require constant attention, so some of these economies can be easily lost.

Nonetheless, in mass-production situations where a company may be producing 40 or 50 product varieties, inventorying one can type and 50 boxes of labels is more economical than inventorying 50 varieties of prelabeled cans.

Cut-and-stack labels are not used in the pharmaceutical industry, where it is necessary to account for every label. In addition, the risk that equal-sized loose labels could be mixed up is not acceptable.

Cut-and-stack label disadvantages are:

- Limited material options.
- In-line gluing is messy.
- Longer set-up and clean-up times, compared with pressure-sensitive labeling.
- Potential for label mix-ups.

Pressure-Sensitive Labels

Pressure-sensitive (PS) labels can be paper- or plastic-based. The unprinted side of the label has a pre-applied pressure-sensitive adhesive, and the whole is mounted onto a release paper. The label is removed from the release paper immediately before application to expose the adhesive. PS labels avoid the need for adhesive application systems at the point of application. Unlike most glued-on labels, PS labels are delivered in rolls or in fan-fold form that makes application, inventory counts and auditing more reliable for those industries where this is required. Although initially more costly than glued-on labels, in many instances, the overall operation for PS labels can be more economical.

Clear plastic labels (typically PP or PET) can produce a “no-label” look.

PS labels can be applied to the container via several methods. Wipe applicators pull the liner with the attached label around a sharp-nosed peel tip at which point the label peels away from the liner. (See Figure 4.32) A rubber squeegee directs the

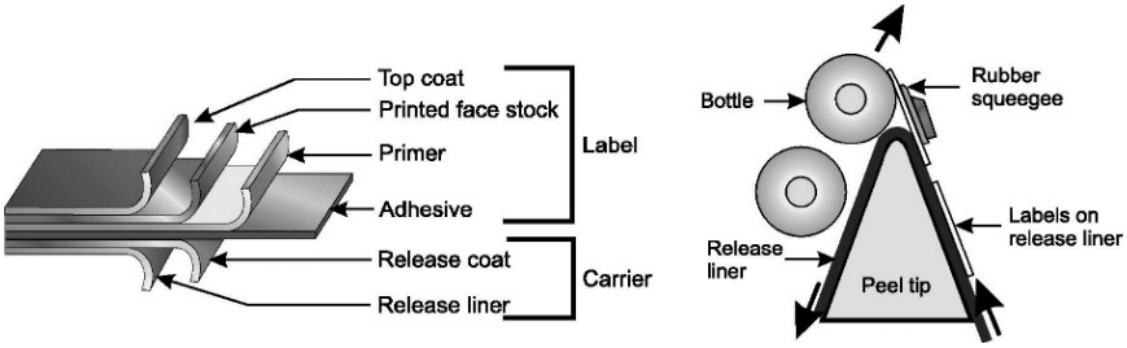

Figure 4.32
Typical pressure-sensitive label construction. The label peels away from the liner when it passes around a sharply angled peel tip.

free end of the label into contact with a bottle and establishes the initial bond. The motion and rotation of the bottle continue to draw the label from the liner while the squeegee wipes out any air pockets. The bottle may be rotated past additional squeegees or pads to ensure a smooth application.

Blow-on or noncontact applicators transfer the label from the liner to a vacuum grid from which a puff of air blows it into contact with the container. Blow-on applicators can apply labels to packages that have a recessed label panel.

Similar to blow-on applicators, a tamp or pad-style applicator transfers the label from the liner to a vacuum pad. However, in this instance, the pad is mounted on an air cylinder that extends and places the label on the container.

Shrink-Sleeve Labels

Shrinkable labels are printed on a plastic material that shrinks when exposed to heat. Tubular sleeves can be produced by either extrusion blowing the film tube or by solvent bonding flat extruded polyvinyl chloride (PVC) or polyethylene terephthalate glycol film into a sleeve. Extrusion-blown tubes are typically a single color and used for shrinkable neck bands and other applications where decorative qualities are not needed.

Flat film stock that will be bonded into a sleeve is first printed while in the flat. Printing in the flat allows for using the full gamut of printing methods and multi-color capabilities available, with the caution that excessive heat cannot be used in the ink-drying step. The labelstock normally would be reverse printed to provide a glossy label face. Depending on the application, the film might be vertically or circumferentially perforated to provide tear strips or other features. Full-body shrink labels can be perforated to accommodate a tamper-evident feature.

The tubular shrink sleeve is dropped over the container and heat, typically in the range of 135°C–149°C for a few seconds, causes the film to shrink and conform to the container's contours. Most often, the container contour is such that label-to-container adhesives are not necessary. Some distortion of the graphics must be factored into the label design when high shrinkage ratios are required. Shrink-on sleeve

labels have the advantage of being able to decorate a bottle completely from finish to heel. Shrink-band labeling can be used to consolidate several items into multipacks. Shrink sleeves also have been used to provide the window material to show contents in folding carton designs. It is generally accepted that the labels can be separated for recycling.

Table 4.11 lists the materials most commonly used for shrink labeling. Regional prohibitions may affect material choice. For example, PVC represents a major share of the shrink-label market in North America, but many European countries and Japan either restrict the use of PVC or ban it entirely because of its perceived toxicity. Most labelstock is between 38 and 75 mm (0.0015 and 0.003 inch) thick.

Marketers and designers favor shrink-sleeve labels because they give packages such as bottles and cans a 360-degree branding billboard and a lot of decorative flexibility. Drawbacks of shrink sleeves are:

- Heat sensitivity can impact on storage.
- Printing can require complicated prepress.
- Reduced line speeds.

Labeling sleeves are dimensioned in the order lay-flat by cut length, with lay-flat being the dimension in the flat across the sleeve. Length is the dimension between the open ends.

An alternative to shrink sleeves is stretch sleeves. Low-density polyethylene-based material can be made to stretch up to 30% to fit over a container. Benefits include low material cost and no need for a shrink tunnel.

Table 4.11
Comparison of common shrink-label materials.

Material	Maximum Shrinkage	Cost	Comment
Oriented polypropylene	22%	Low price	Low clarity, low shrink, used on basic containers
Polyvinyl chloride	66%	Good price	High clarity, high shrink
Oriented polystyrene	50%	Moderate price	Moderate shrink, medium clarity, requires temperature-controlled storage
Polyethylene terephthalate glycol	78%	Highest price	Highest shrink, highest clarity, enables best design freedom

Source: Klöckner Pentaplast.

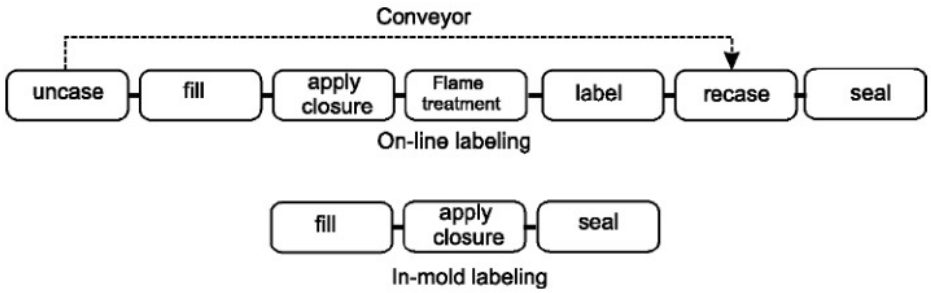

Figure 4.33
In-mold labeling can significantly reduce required production space. The simpler line and the elimination of a labeler increase line efficiency.

In-Mold Labeling

In-mold labeling describes a process of applying labels to plastic containers during the actual molding process. Fully decorated paper or plastic labels have a heat-activated adhesive (typically based on ethylene-vinyl acetate) on the backside. In a typical operation, robotic pick-and-place devices place the label into the mold where they are held in place by vacuum ports. As the mold closes, the heat of the extruded or injected plastic melts the adhesive material and bonds it firmly to the container. The label displaces a volume of plastic equal to the volume of the label and is flush with the surface of the container

Film labels are more expensive than paper but have the advantage of being recyclable if they are of the same material as the container. Paper labels can cause recycling problems since they cannot be easily separated from the container body material. In-mold labels are unaffected by moisture, and the flush surface gives the appearance of not having an applied label. (The "no-label" look).

In-mold labeling has gained popularity as a method of decorating blow-molded plastic containers. Significant advantages are the elimination of all labeling equipment, including flame-treating, as well as staffing and maintenance costs. (See Figure 4.33) Since the label becomes an integral part of the bottle, plastic container gram-weights often can be reduced. In-case filling also becomes an attractive possibility.

The disadvantages of in-mold labeling are:

- Higher tooling cost.
- Slower molding cycle rate due to slower cooling.
- Regrind is contaminated with label debris.
- Bottle shape limitations.
- Inventory cost of pre-decorated containers.

REVIEW QUESTIONS

1. White light is beamed onto a surface that absorbs the blue wavelength. What color does the eye see?
2. Name two applications of screen printing.
3. Printers can theoretically duplicate all colors using CMYK process inks, but printing machines often have six or eight stations. Give three examples of how you might use the other stations.
4. List the steps necessary to create a halftone printing plate from a color photograph.
5. What three colors does the human eye detect?
6. Your printer informs you that a 133-line screen will be used for a particular job. What is this telling you?
7. What is "reverse printing," and why use it?
8. What are some limitations of flexography?
9. What is the minimum number of printing plates needed to print a good-quality process color illustration?
10. A toy box will have a full-color action illustration. The illustration will be framed in a fluorescent orange and green border. How many printing plates are needed?
11. What three factors influence the human perception of color?
12. What is the operating principle of lithography?
13. Dot "gain" is a problem that is particularly associated with what process?
14. Name the four process colors.
15. Name the four principal printing methods.
16. When referring to an illustration, what is line art?
17. Which will produce the better illustration: a 65-line screen or a 100-line screen? What do the numbers represent?
18. Why are printing plates for separate colors set at different angles for printing?
19. What printing problem must be resolved when printing round containers? What is the printing method called?
20. What is the difference between a web press and a sheet-fed press? Which printing processes are most typically web-fed and which are most typically sheet-fed?
21. What kind of press would be best for printing a highly extensible web such as a thin polyethylene?
22. What decorative effects cannot be achieved with conventional four-color printing processes?

23. What is the "key color," and why is it used?

24. What is meant by a printing process described as being "offset?"

25. What decorating process would you choose for plastic bottles?

26. What is a central impression press?

27. All graphic artwork should be compared under standard light conditions. Why and how is this light specified?

28. What does the term "brightness" describe? Why is it an important characteristic of a surface being process printed?

29. What are a blanket cylinder, an anilox roll and an impression cylinder?

30. Name one advantage and one disadvantage of gravure printing.

31. An illustration that is printed in one color but that has variations in saturation of that color is called a _____.

32. "Trap" is used to describe what two conditions?

33. Name two advantages of using shrink-sleeve labeling.

34. What printing process would not be suitable for printing plastic bread bags?

35. What two colors provide the greatest contrast to the human eye?

36. Name one advantage and one disadvantage of screen printing.

37. A hard metallic sheen can be printed only by what process?

38. What does "bleed" mean?

39. What are the reasons that make it difficult to get exact replication of a printed image using digital proofing methods?

40. What is a Color Key, and what is it used for?

41. What factors make an analog proof closer to what can be printed than a digital proof?

42. Name one advantage and one disadvantage of in-mold labeling.

43. Which shrink sleeve label plastic offers the least amount of shrink, and which offers the highest amount?

44. What printing method would you choose for decorating the top of a dome-shaped plastic closure?

45. What is one advantage and one disadvantage of digital printing?

46. What is the purpose of a colorimeter or densitometer? What principle do they use to work? What are limitations of using them?

Assignment

You are a packaging designer developing graphics for a new product that must be exceptionally eye-catching on the store shelf. While it might be tempting to throw every trick in the book at this package design, including bright colors, metallic treatments, embossing and a shiny surface, what considerations must you give to the limitations and consequences (timing and cost) of each of the processes that could be used?

ENVIRONMENTAL AND SUSTAINABILITY ISSUES 5

CONTENTS

Consumer Perceptions

Packaging's place in the waste stream, raised awareness about environmental issues.

Concepts and Challenges

Sustainable packaging as a moving target, the four Rs hierarchy, recycling realities, global sustainability issues, sustainability definitions, global warming.

Sustainability and Packaging

Cradle-to-Grave; Cradle-to-Cradle; the Circular Economy with information resources; life cycle assessment, ISO 14044:2006 life cycle assessment requirements and guidelines, Society of Environmental Toxicology & Chemistry, GaBi and Sima Pro life cycle assessment tools; biodegradability; compostability.

Defining and Producing Sustainable Packaging

Advantages of packaging that is developed to be sustainable; steps for establishing a company environmental policy—Step 1: Identify environmental goals and initiatives; Step 2: Identify the destination of the package; Step 3: Identify applicable regulations; Step 4: Identify mode(s) of shipping; Step 5: Identify company-specific requirements; Step 6: Identify applicable customer requirements; Step 7: Select raw materials; Step 8: Design the package; Step 9: Communicate environmental characterization.

Environmental Labeling and Declaration

Environmental labeling principles from ISO 14020, FTC *Green Guides*.

Environmental Packaging Procedure Template

Nine steps to assist in formulating the right questions when incorporating environmental considerations with minimal impact on design time.

ENVIRONMENTAL AND SUSTAINABILITY ISSUES 5

CONSUMER PERCEPTIONS

A discussion of packaging today includes environmental issues as a focal point. Packaging often is blamed for a host of ills, and a perception exists in some circles that if only the packaging industry would stop doing something or, conversely, start doing something, all landfill and pollution problems would go away.

Although packaging waste is less than the typical consumer imagines and U.S. residential waste is less than half of what is in a typical landfill, consumers see the package as that part of the shopping trip that is thrown away. Hence, packaging is garbage. No home decorator would dispute the necessity of a paint can or a caulking tube. Yet, when empty, these, along with other household packages that have fulfilled their function, are suddenly perceived as garbage—unnecessary and a problem. The act of discarding the package is a reminder of material loss, functional loss and guilt (since recycling, though improving, is not yet what it could be).

Producers are speaking to this sense of guilt and loss with on- and off-shelf sustainable communication, bringing consumers' choice or lack thereof to the forefront of their minds. This increase in communication has raised awareness about environmental issues with the sustainability movement that has increasingly become part of everyday life. The most widely recognized and accepted sustainability definition comes from the United Nations (UN):

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*
>
> 1987, Brundtland Commission, UN General Assembly

CONCEPTS AND CHALLENGES

Environmental and sustainability considerations related to packaging continue to be a moving target as new material, technological and regulatory developments, and