Corporate policy standards and specifications are those documents that govern the entire specification process and identify:

- A consistent corporate specification format.
- Who is responsible for writing specifications.
- How the specifications are written.
- How specifications are issued, recipients of copies and storage/filing locations.
- How a specification is revised and how a specification is withdrawn.
- Implementation.
- Courses of action when events occur that are outside of the specifications.
- Return specifications.

A good specification is a joint document drawn up in close consultation with the supplier. Procurement and engineering should identify suppliers capable of achieving required tolerances.

Material and manufacturing specifications identify the critical properties of all raw materials, packages and components used in the manufacturing process, as well as the production sequence that will lead to the desired quality level. Specifications ensure that every manufacturing step receives quality material from a previous step and forwards a quality item to the next production step.

The final group of standards and specifications details the sampling protocol and test methods used to quantify the attributes identified as being critical in the material and manufacturing specifications. For example, an adhesive material specification may call for an adhesive of a particular viscosity, open time and peel strength. These values would be determined using established test methods. This group of documents also should specify the instrument calibration methods that will be followed to ensure measurement accuracy. Such thoroughness is essential for International Organization for Standardization (ISO) certification or any other certification or accreditation.

Not only must critical values be defined, but the method(s) of measuring these values also must be agreed upon. In most cases, standard methods such as those spelled out by organizations such as ASTM International (ASTM) and the International Safe Transit Association (ISTA) should be referenced.

Causes for rejection of a supplier's shipment should be clearly spelled out. In some instances, where appropriate, defects may be classified into three categories:

A. **Critical defects.** These defects prevent the package component from fulfilling its purpose; for example, an incorrect dimension.

B. **Major defects.** These defects likely will seriously reduce the performance of the packaging component under stressed conditions, although it may perform adequately under most conditions; for example, a corrugated box with compression strength slightly below specified levels.

C. **Minor defects.** These defects are mostly aesthetic defects that do not substantially reduce a package function.

A specification may, for example, allow up to 1 % of category **C** defects, 0.01 % of category **B** defects and reject any deliveries with more than 0.01 % category **A** defects.

WRITING A SPECIFICATION

A specification for a new package typically begins with the specialists developing the product and those responsible for the packaging function. (See Figure 22.10) This initial draft often is based solely on the tests, observations and experience of the specialists. This draft will be subjected to a broad review by all the parties concerned with the project, and in particular in consultation with those who will be using it.

Work closely with your suppliers. They know their business best just as the product manufacturer knows its business. If the company is working with dedicated suppliers, the review would include supplier representatives. If a dedicated supplier is not being used, a corrected and updated draft should be forwarded to the best potential supplier(s). Since the launch of a product is usually a confidential matter, the prospective supplier(s) should have credible trustworthiness and reliability. Non-disclosure agreements usually are required.

In the normal sequence of events, the project might be on its third or fourth draft. By this point, the draft will have progressed as far as it can, given current knowledge. In some instances, a small number of the proposed package or package components might be made for purposes of a trial run on the actual production line. For such machine tests, the package may not need to be printed.

The formalized company specification with an appropriate identification system would be produced at the end of these activities, and the first full production run would be scheduled.

With product launches, particularly if new machinery is involved, it is not unusual for other issues to arise. Resolution may require adjusting a characteristic value, changing a quantification method to more realistically reflect actual conditions or adding a new requirement to the specification.

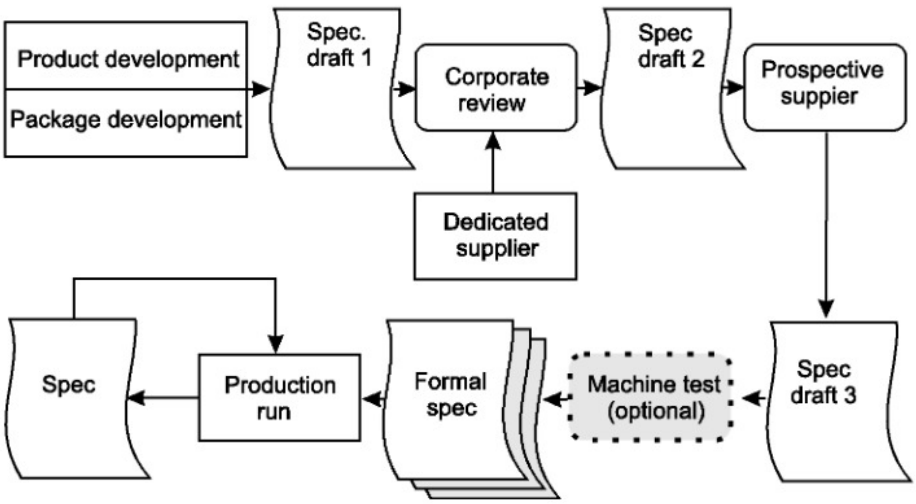

Figure 22.10
A representative package specification process.

A specification must provide sufficient detail to minimize the risk of failure while still being flexible enough to permit change and improvement. Details can't be open to interpretation; there can be only one version of meaning. Use numbers, drawings, visual samples (for graphic art) and photographs along with clear descriptive language to communicate the message.

Do not include nonessential details. In a few instances where selected background or explanatory notes are desirable, these should be in an appended section that is clearly not part of the specification.

Specifying material by a brand name, for example, *Superply 101*, limits you to purchasing from the company that owns the brand. *Stating Superply 101 or a comparable, equal performance metallized PP/mLDPE (polypropylene/metallocene low-density polyethylene) laminate*, opens the door to other suppliers that are able to produce such a material. Furthermore, what assurance is there that the manufacturer of *Superply 101* won't change product specs (for example, by changing their supplier of mLDPE or altering their manufacturing procedure in some way) without informing you?

Specify commodity or market-grade materials wherever possible. Clay-coated newsback (CCNB) is a generic description of a common folding carton stock made in large quantities and available from many paper mills. Altering the construction of a CCNB board in some unusual way would require a paper mill to reconfigure a $550-million machine—hardly likely, unless the order is for several hundred thousand tons a year or there's a willingness to pay a considerable upcharge. Similarly, metals are offered in industry standard alloys and tempers, corrugated boards are assembled from standard linerboard and medium grades.

And finally, a specification is a continuously evolving document; there is no such thing as a final specification.

Measuring Quality

The basic steps for writing a specification are:

- Identify those factors and characteristics that are essential to meeting acceptable machinability, performance and aesthetic levels.
- Identify the range within which the individual characteristics can vary and still meet acceptable machinability, performance and aesthetic levels.
- Select a test or evaluation procedure suitable for quantifying or otherwise describing each required characteristic.
- Specify lead time.

Material Specifications and Performance Testing

Material specifications provide indicators for materials that, with proper treatment, are capable of producing a quality product. A performance test verifies that the desired end result has been successfully met. One advantage of citing performance rather than material specs is that it transfers some responsibility to the supplier and encourages supplier input.

A material specification for a high-barrier plastic bottle might specify the density and glass transition temperature of the PP to be used; the thickness profile of the bottle walls; the grade of ethylene-vinyl alcohol barrier layer and its thickness, and so on, covering every detail of the material used to make the bottle. However, even with the best materials, it is possible to produce a deficient product. The real interest is to have a bottle with a given barrier level toward oxygen, adequate top-load compression and enough strength that it won't rupture if dropped on the floor.

A performance test would state the required barrier and compression strength and specify a drop test height from 1 meter to ensure proper material distribution and closure integrity. The performance test has the advantage of allowing the manufacturer the leeway to make whatever changes might be advantageous without compromising the desired performance levels.

Knowing when to use material or construction specifications and when to use performance testing is a skill in itself.

Specification Format

All specifications start with a common header page bearing the specification title, the intended application and pertinent dates as shown in the example header in Figure 22.11.

Sections following the header will vary depending on the material, package or process being described. A specification for a folding carton may contain the following headings and subheadings:

1. Scope (as described above)

2. Construction

2.1 Material description.

2.2 Testing

All paperboard testing will be conducted after conditioning for 24 hours at 23 C and 50% R.H. (Reference method ASTM D 685).

2.2.1 Paperboard caliper shall be _______ ± _______ (Reference method TAPPI T 410).

2.2.2 Elmendorf tear strength measured in accordance with TAPPI T 414.

Machine direction	Cross direction
______ ± ______	______ ± ______

2.2.3 Taber board stiffness measured in accordance with TAPPI T 451.

Machine direction	Cross direction
______ ± ______	______ ± ______

2.2.4 Brightness measured in accordance with TAPPI T 452 Minimum value *80 bright*.

2.3.5 and so on …

3. Carton dimensions

3.1 Carton dimensions shall be as specified in appended drawing D 5618—3A.

4. Graphics and printing

4.1 Printing shall be done with inks that are free of heavy metal-based pigments and meet requirements for levels of volatile organic compounds.

4.2 Color rendition shall be within the limits of the sign-off samples dated ________________________________

4.3 Printed cartons shall be able to withstand 500 cycles on the Sutherland Rub Tester.

5. Waxes, coatings and adhesives

5.1 If food is being packaged, waxes, coatings and adhesives must be considered acceptable for food contact by the FDA.

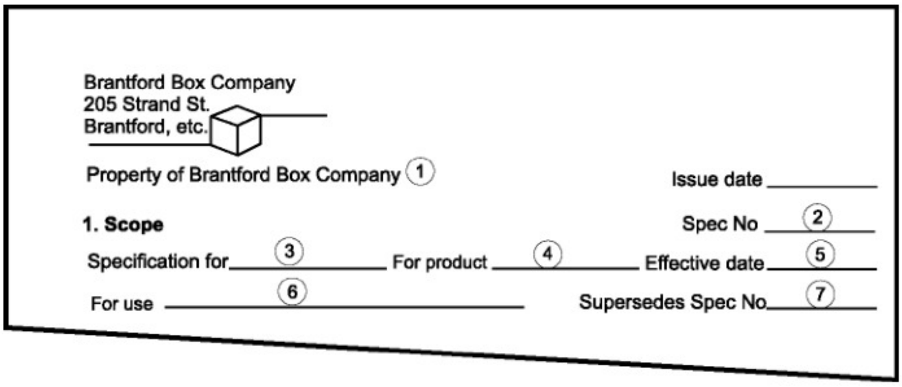

Figure 22.11
Example of a specification header page.

1. Statement that the specification is the sole property of Brantford Box Company. As the sole property of Brantford Box, the specification cannot be altered by the converter and may only be used for the specific order it relates to.
2. Every specification needs a unique identification number. A company with 400 products on the market might have upward of 2,000 specifications on file. A consistent coding system is essential for rapid identification, filing and retrieval.
3. A brief title identifying what packaging component the specification is for (e.g., diecut label).
4. A descriptor for the product that it is intended for (e.g., 300-mL bottle: Pepe's Chili Sauce). The product's UPC (Universal Product Code) could be included as a further identifier.
5. The exact date on which the specified labels will be put into production and remaining old labels removed from inventory.
6. Production locations and labeling machinery may vary and might require slightly different label treatments (e.g., different language and legal declarations for U.S. and Canadian plants). Some labels may be wet-glue-applied; others might be pressure-sensitive. Locations may have several labeling machines made by different manufacturers (e.g., Schild labeler, Minneapolis plant).
7. In the instance that this is a revised specification, the number of the specification that is being replaced should be identified. Normally a superseded spec is removed and filed in an archive record.

5.2 Waxes, coatings and adhesives shall perform under the environmental conditions the package will experience, e.g., heat, humidity, freezer, refrigerator case.

6. Consumer function

6.1 The tear strip shall pass the following performance tests …

7. Product protection

7.1 The packaging shall pass integrity testing performed in accordance with ISTA Procedures.

8. Packing and delivery

8.1 Cartons will be shipped within seven days of folding and gluing.

And other quantified factors as required.

The above example describes specifications that inform a supplier of what is required and for receiving staff to judge whether the specifications have been met. Another group of specifications and protocols is now necessary for within the packaging plant to ensure that the various packaging components and the product are brought together in a proper manner.

Manufacturing specifications for a bottled shampoo might include:

- All incoming materials checked and released for production by QA.
- Each product batch checked and released for production by QA.
- Production cleanliness standards.
- Fill-level tolerances, frequency of check.
- Application closure torque tolerances, frequency of check.
- Label placement accuracy and appearance, frequency of check.
- Recording of time, cause and duration of line stoppages.
- Removal of four bottles every two hours for 24-hour removal-torque test.
- Removal of two bottles per hour for archiving.
- Batch and fill date coding at beginning of every shift.
- Shipping box codes, pallet RFID (radio frequency identification) devices.
- Palletizing patterns.
- Stretch wrapping.

Specification Identification

Specifications could simply be numbered in the order they are written. However, for any manufacturer other than a one-product in two sizes operation, simple sequential numbering is not flexible and detailed enough to allow quick location of a specification or to accommodate cross-referencing.

Most specification-keeping today is computerized and allows for searches by package type or component, by product type, issue date, UPC or other attribute.

REDESIGN OF AN OIL BOTTLE AND SHIPPING SYSTEM

The following case study provides examples of how changes at one point in a system dramatically affect packaging at another point. The importance of package testing also is highlighted.

The initial project objectives were limited to optimizing an existing plastic bottle design. As data were developed, packaging material usage and other opportunities became evident. The most significant change, from corrugated board to a shrink-wrapped distribution container, was rejected initially. It was, however, reinstated as bottle performance improved.

Project Concept and Organization

A motor oil marketer had begun manufacturing its own high-density polyethylene (HDPE) bottles in-line with the filling department. As a short-term goal, the company wanted to optimize the performance of the existing design. However, an enthusiastic supplier had convinced a few staff members that switching from corrugated shippers to shrink-wrapped trays would reduce distribution costs substantially.

The initial project scope only covered optimization of current bottle production, using the bottle's top-load compression strength as a key indicator. A program was put into place to screen potential bottle-grade HDPE resin suppliers and determine the most efficient HDPE distribution within the bottle. However, as the project evolved, other opportunities became apparent, and the scope of the work expanded.

The project involved an existing product line in current production. All changes, of necessity, had to be calculated to minimize downtime. This required close contact with production and scheduling staff.

The company had installed a number of small blow-molding machines, half of which could supply the filling lines, while the remaining machines were on standby or undergoing preventive maintenance. Since blow molding bottles entails a large number of subtle variables, including the molding machine and the molds being used, care had to be taken to ensure that bottles submitted for testing were produced from the same molds and on the same machine.

Information Development

Initially, most information came from the manufacturing and engineering departments with input from purchasing. However, as the project's scope expanded, all major departments became involved in various aspects of the project.

The possibility of shrink-wrapping was answered fairly quickly. Distribution indicated that the pallets could be stacked up to three high for up to 90 days. Unlike corrugated boxes, shrink-wrapped trays of plastic bottles rely entirely on the compression strength of the plastic bottles. (See Figure 22.12) Since plastic is a vis-

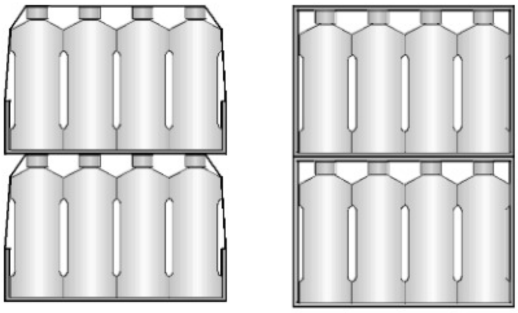

Figure 22.12
For shrink-wrapped trays (left), the primary package alone must bear the top load.

coelastic material, the material will flow and distort with time. As a result, the bottle's ability to hold a load will decrease with time.

To be able to hold a load for the stipulated time, the bottle compression strength would need to be at least three times the anticipated load, according to the SPI data for plastic bottles. (See Chapter 18, Shock, Vibration and Compression, Figure 18.19) The existing bottle's compression strength was not even close to this value. It was decided that this approach had no chance of success.

Development and Testing of Alternatives: Resin and Design

Selected HDPE suppliers submitted resin samples, and several hundred bottles were produced from each resin for evaluation.

Good communication had to be maintained between the testing group and manufacturing to ensure that inadvertent variables were not introduced. For example, manufacturing, in a mistaken bid to make identification easier, color-coded each supplier resin, adding master batch colors. Since different coloring pigments have a different effect on a bottle's performance properties, the entire bottle test run had to be repeated, using only the natural resins.

Top-load and environmental stress-crack resistance (ESCR) tests, conducted in accordance with standard ASTM procedures, were the main criteria for selecting the resin suppliers. Care was taken to ensure that each mold number was equally represented. The first round of ESCR tests revealed that the closure—rather than the bottle—was the most vulnerable part. The closure supplier and material were changed.

Several production runs, followed by top-load and ESCR tests, were conducted to ensure that consistent, repeatable data were being produced. The preferred suppliers and resins were specified based on these data. Having specified the materials, the project team now turned to programming the blow-molding machines to provide optimum material distribution. The general approach was to do a top-load test on the bottle, note the typical failure pattern, and determine areas from which material could be allocated to strengthen the weak point.

Since the bottle had an off-centered neck, top-load forces traveled predominantly down one side. The typical failure point was across the end panel at the indentation that went around the bottle perimeter and constituted the bottle's labeling panel. (See Figure 22.13)

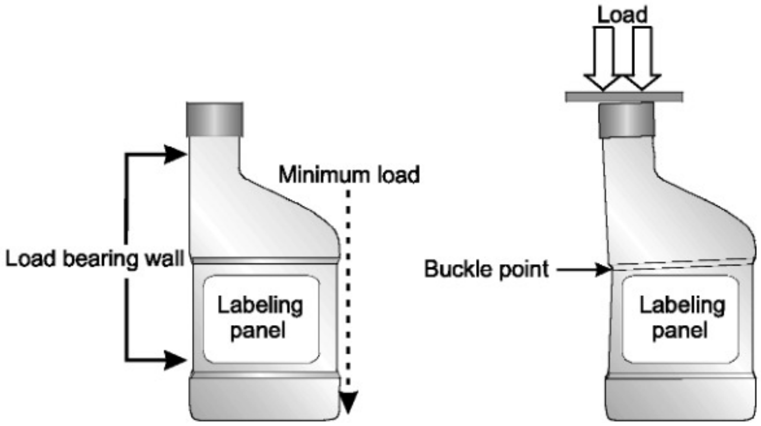

Figure 22.13
Typical compression load failure of a bottle with an off-centered neck.

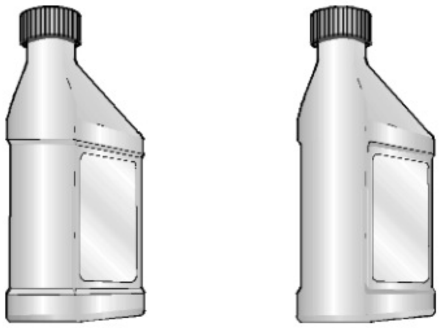

Figure 22.14
The new bottle configuration (right) eliminated the labeling recess across the bottle end.

The bottle was labeled front and back, but not across the ends. Removing the labeling recess across the bottle ends would not change the labeling, but would produce a straight load-bearing end wall. (See Figure 22.14) The mold manufacturer assured the company that the change could be made at minimum cost since it involved removal of metal from existing molds.

A single mold was changed to test the proposition. The redesigned bottle's top-load ability increased substantially without any impact on the blow-molding or filling process. An order was immediately placed to change all of the production molds. With increased top-load ability, the bottle weight specification could be reduced slightly, providing an economic advantage. It also was consensus that the redesigned bottle was more attractive.

This program phase ended with material specifications, a redesigned bottle and a specification for resin weight and distribution. The substantial increase in the bottle's top-load strength reopened the shrink-wrapped tray discussion.

Development and Testing of Shrink-Wrapped Trays

With the bottle optimized, investigators turned to examine the distribution impact on the package. The main question was: Could some of the redesigned bottle's increased top-load strength help reduce the corrugated distribution container's board weight? A second question, although still highly speculative, was: Could a shrink-wrapped tray be used?

Suppliers prepared samples of shrink-wrapped trays holding 12 oil bottles. The investigators were surprised to note that the top-load strength of 12 unitized bottles was significantly higher than 12 times an individual bottle's value. The immediately obvious reason was that the flat bottle sides, when pressed together in the unitized configuration, lent mutual support to one another. The sidewalls were preventing the longer panels from buckling, and therefore, the top load of a shrink-wrapped tray was higher than for 12 individual bottles. It was also determined that a tighter wrap increased the effect.

Subsequent development suggested that the theoretical minimum top-load requirement could be met by inserting a single vertical partition down the center of the tray.

Warehousing, however, was concerned. An overlooked fact was that the oil was filled hot, and it took considerable time for the mass of oil in a pallet load to cool to room temperature. Meanwhile, the palletized bottles would be detrimentally affected by the retained heat. Meetings were arranged with production, warehousing and development staff to discuss the problem. Production tests showed that fill temperature could be reduced somewhat with only minor effects on filling.

The package development team prepared a test protocol to determine the stack duration of hot oil bottles. During discussions of what top load should be used to simulate actual warehouse conditions, it was discovered that while company specifications called for a container capable of being stacked three pallets high, only a single regional warehouse used three-high stacks. The main distribution centers stacked two high or used racking. Distribution practice was immediately rewritten to limit stacking to two high. This considerably eased bottle compression performance requirements.

Shrink-wrapped trays were dead-loaded with a mass equal to two pallets high and stored at elevated temperatures. The vertical deformation of the loaded trays was observed over time, with the investigators knowing that failure would occur at about the deflection at failure of a standard dynamic top-load test. The bottles successfully passed the warm stacking tests. With this development, management elected to begin implementing a change from corrugated containers to shrink-wrapped trays. This involved some risk, since no data had yet been developed on how the shrink-wrapped trays would behave in a palletized load.

Development and Testing of Alternatives: Pallet Loads

The first top-load tests of full pallet loads were alarming; compression strength was almost a third lower than expected. The project could fail if this was not corrected. Different pallet patterns were tested, and although some were better than others, none achieved the required level.

Data to date were critically reviewed and the compression failure mechanism of the different pallet patterns was studied to answer the following question: Why are some pallet patterns better than others?

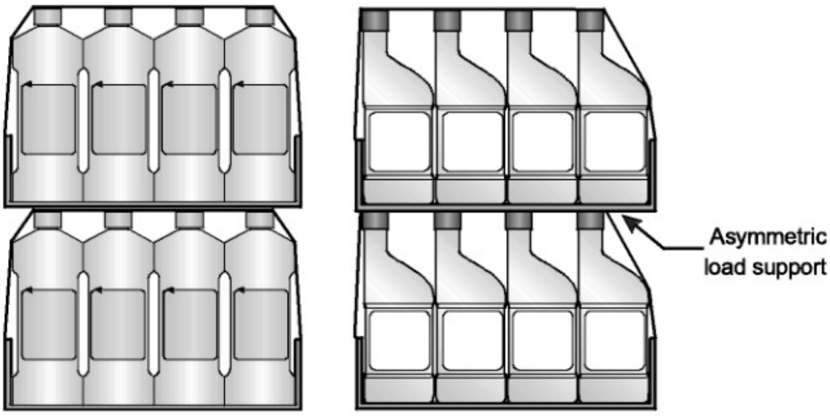

Figure 22.15
Symmetrical bottles (left) compress evenly. Asymmetrical bottles (right) tend to fail toward the less supported side.

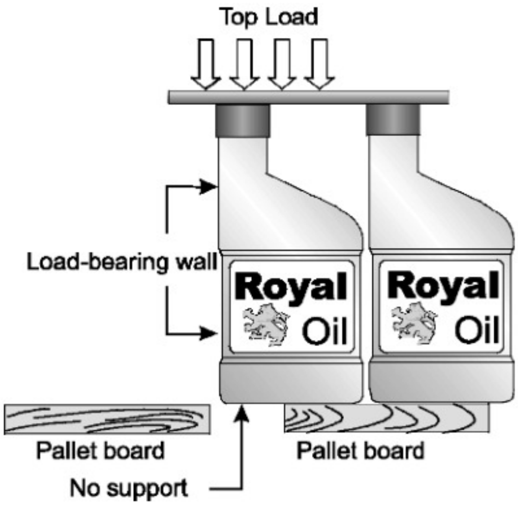

Figure 22.16
Critical support was lost when the palletizing pattern resulted in unintentional internal overhang directly under the load-bearing wall.

Since the bottle necks were off-centered, the trays buckled to the less supported end. (See Figure 22.15) An arrangement that turned every second row of bottles 180 degrees was tried, and it yielded a small but important improvement. The major breakthrough came with the observation that most pallet patterns had considerable unintended internal overhang. (See Figure 22.16) This created a condition in which many bottles on the bottom layer actually had the load-bearing wall hanging over empty space. This problem was eliminated by re-specifying the positions of the pallet deck boards so that all load-bearing bottle walls were fully supported.

Shrink-wrapped trays require different handling methods. In fact, early distributor tests revealed a negative view of the new system. To counter the perceived acceptance problem, an educational video was produced explaining the reason for the change, the many advantages and features of the system, and the most effective methods of handling the new trays. Shrink-wrap geometry was changed to leave a large, strong opening at each end, allowing a tray to be grasped by the end and pulled off a shelf or pallet.

Solving a Shipping Problem

A serious problem became apparent within a few weeks of distribution. Trucked pallets would arrive at their destination leaning, or "skewed," to one side. When two pallets leaned into each other, individual trays from the two loads interlocked, making easy movement and stacking almost impossible. (See Chapter 18, Shock, Vibration and Compression, Figure 18.9)

From previous experience, the development staff correctly surmised the problem was likely caused by vibrational inputs during transport. This was confirmed by placing a pallet load onto a programmable vibration table and sweeping through a range of typical transport frequencies. In short order, skewed loads were produced similar to those observed in the field. The vertical stacks of bottles acted as springs, and at particular frequencies, a minor stack resonance occurred in the top layer. This layer would "walk" or "float" to one side, dragging the rest of the stretch-wrapped unitized load with it.

Vibration concerns a spring/mass relationship. To solve a vibration problem, either the spring or the mass has to change. The load mass was relatively fixed within narrow limits, leaving only the spring as a major variable. Several avenues were tried:

- Increasing the amount of stretch-wrapping in order to create a "monobloc" load failed. No practical amount of stretch-wrapping seemed to be able to hold the resonating top layer in place.
- Inserting tier sheets at various points in the load improved the situation, but did not resolve it. In principle, sufficient isolating tier sheets or other isolating material would have solved the problem. (Incorrectly selected tier sheets also could make it worse.)

As at several other points in the program, detailed observation by development staff solved the problem. After several vibration tests, it was noted that the pallet load always seemed to skew in a particular direction. Further observation revealed that the direction was governed by the tray orientation in the pallet load and the orientation of the off-centered bottles. By reversing the orientations of selected trays, the trays could be made to "walk" into each other, canceling out potential displacement forces. A new pallet pattern was built up around the favored tray orientations, and the problem was solved.

The successful completion of this program saved millions of dollars.

AN EXAMPLE OF GRAPHIC DESIGN DEVELOPMENT

The following example is a hypothetical examination of the process a company might use to determine how best to position a product and create suitable text and graphics for the package.

Establishing Possible Product Positions

Mohawk Dairy Ltd. wants to enter the instant powdered milk market. The product must be identified, and so "Instant Milk" (the chord of familiarity) will appear on the package. The company also may choose to brand the product with the company name, Mohawk.

"Instant Milk" and "Mohawk" can be given equal graphic prominence, or one or the other can be made more prominent. Since Mohawk is not an established brand, it is not likely to be a major purchase motivator. It would make sense to give "Instant Milk" more prominence.

However, the main problem is to differentiate this product from the eight competitors on the shelf. At this point, Mohawk Dairy needs to decide how to position the product—it needs to decide who the target market will be. In consumer focus group studies, Mohawk discovers the following about consumers and instant powdered milk:

- Many consumers associate instant milk with economy.
- Instant milk is considered healthy because of its low fat and high calcium and protein content.
- Some consumers find it convenient to cook and bake with instant milk.
- Parents use it for baby formula, but are somewhat concerned about nutritional quality.
- Some consumers feel instant milk is too difficult to dissolve.
- Some consumers associate instant milk with dieting.

Examples of Positioning by Point-of-Difference Statements

With the above information and some added demographic details, target markets can be isolated and point-of-difference statements can be developed to attract the target audience. For example, "Fast Dissolving" could be added to "Instant Milk" to communicate a solution to a commonly voiced problem (providing, of course, that this could be developed).

To attract the economic demographic group, the package must meet their perceptions of economy. Graphics should be simple, using uncomplicated fonts and colors. Photographic illustrations might be counterproductive. Benefit or point-of-difference statements would be selected to emphasize the economic nature of instant milk powder, for example—a flash reading, "Makes 12 Full Quarts!"

To attract the health- and weight-conscious young urban professional demographic, "Good Dietary Source of Protein" and "Low in Saturated Fats" could be displayed. An accompanying illustration might feature obviously successful young professionals taking a pause from jogging, cycling or tennis to have a cool glass of milk.

Older people are more concerned about calcium, vitamins and minerals. "Excellent Source of Calcium" and "11 Added Vitamins and Minerals" could be featured to attract this group. The accompanying illustration would be the same as above, except the models would be obviously successful older persons.

Home bakers might be further encouraged by illustrations related to baking and "Bonus: Measuring Spoon in Box."

Those who prepare baby formula would be attracted by illustrations of healthy babies. "11 Added Vitamins and Minerals" and "Lots of Calcium for Growing Bones" would be appropriate messages.

The predominant package colors would likely be cool colors, probably shades of blue. White, often avoided on packaging, would be quite appropriate for a milk product.

What one would not do is try to appeal to all the mentioned psychographic/demographic groups. The box would be hopelessly cluttered, and no message would be properly delivered through the confusion.

PACKAGE DESIGNER'S CHECKLIST

- **Facts about the product's physical form:**

mobile fluid	viscous fluid	solid/fluid mixture
gas/fluid mixture	granular material	paste
free-flowing powder	non-free-flowing powder	solid unit
discrete items	multicomponent mix	

- **Facts about the product's nature:**

corrosive	corrodible	flammable volatile
perishable	fragile	toxic
subject to odor transfer	odorous	abrasive
sticky	hygroscopic	under pressure
irregular shape	easily marked	aseptic

- **Facts about the competition:**

strengths	weaknesses	unit sizes
target markets	sales volumes	pricing structure
package types	market share	marketing strategy
customer loyalty base		

- **Facts about the intended consumer:**

demographics	psychographics	preferred purchase unit
staple item	impulse item	durable good
seasonal purchase	gift item	

- **Facts about the merchandising method:**

self-serve	sales clerks	peg-board
shelf display	dispensing machine	door-to-door
mail order	warehouse outlets	department stores
specialty stores	e-mail purchase	inspect before purchase?

- **Facts about how the product is used:**

easy-opening features	reclosure features	dispensers
measuring aids	use quantities	table pack
need for instructions	need for attractiveness	need for cautions
storage method	disposal	returnable package
secondary use	environmental features	other special features

- **Transport, handling and storage details:**

truck	rail	aircraft
cargo ship	carrier rules	weight considerations
unitizing methods	stock-picking	handling methods

storage conditions	storage duration	cold/frozen storage
dimensional considerations		

- **Graphic design:**

brand name	product name	company name
logos or icons	package "persona"	visibility and impact
color selection	ingredient lists	price panel
UPC	opening instructions	use instructions
disposal instructions	emergency instructions	hazard warnings
legal text requirements	environmental information	number of facings
language requirements		

- **Specifics on what will cause loss of value (damage):**
  vibration *(determine resonant frequencies)*
  mechanical shock *(determine fragility factor, drop height)*
  abrasion *(determine how to eliminate or isolate relative movement)*
  deformation *(determine safe compression load)*
  temperature *(determine critical values)*
  relative humidity *(determine critical values)*
  water, oxygen, carbon dioxide *(determine required barrier level)*
  essential oils, solvents *(determine compatibility and required barrier level)*
  light *(determine whether opaque package needed)*
  spoilage *(determine nature/chemistry)*
  incompatibility *(determine material incompatibilities)*
  tampering *(determine method of providing tamper evidence)*
  sterility loss *(determine mechanism)*
  biological deterioration *(determine nature)*
  time *(determine required shelf life)*

- **Environmental considerations:**
  reduce packaging
  use recyclable materials
  use recycled materials
  eliminate heavy-metal pigments
  design for efficient area/cube utilization
  meet all environment rules and mandates
  provide recycling instructions

- **Legal requirements:**
  patents, trademarks and copyrights
  tamper-evidence requirements
  child-resistant packaging requirements
  ingredient listing
  nutrition facts listing
  product weight listing
  comply with hazardous goods codes
  avoid trade dress infringements
  make only supportable product claims

PACKAGE DESIGN BRIEF

IDENTIFICATION

Project Name

Date Prepared | Issue Number | Replaces

Prepared by

PRODUCT CATEGORY

New Product		Domestic		Institutional	
Line Extension		Export		Industrial	
Redesign		Retail		Other	

PRODUCT PACKAGE

Product will be sold by : Weight | Volume | Number   No. of sizes

Largest Size | Next Size | Next Size

Product units in primary | Primaries in secondary

Will the package be used to:

Dispense

Serve

Measure

Prepare

Possible convenience/unique features

Package type preferences or restrictions

Package material preferences or restrictions

Other package considerations

PACKAGE DESIGN BRIEF 2

SPECIAL REQUIREMENTS

Tamper evidence required? ______

Child resistance required? ______

Other ______

GRAPHICS

Proposed printing method: Flexography ☐ Lithography ☐ Gravure ☐

Additional decorating processes ______

Other graphic notes ______

OUTLETS AND DISPLAY (IF RETAIL PRODUCT)

Retail Chains		Mini-markets		Mom & Pop	
Vending Machine		Mail Order		Other	

Product display

Store location ______

Shelf location ______ Number of facings ______

Single units		Trayed		Case cut	
Racks		Pegboard		Bulk bins	
Linear stack		Vertical stack		POP display	

Retailer size limitations? ______

Other retailer requirements ______

LABELING

Required nutritional labeling ______

Use-before dates ______

DIN number required ______

Hazard or cautionary labeling required ______

Additional language requirements ______

Other legal requirements ______

PACKAGE DESIGN BRIEF 3

PRODUCT USE

Main use

How used or prepared

How/where will product be stored?

Package be used for long-term storage?

Does package require resealability?

Product visual/physical/sensory attributes

Considerations arising from how the product will be used

Unique product features that can be exploited on the package

TARGETED CUSTOMER Demographic/psychographic description

Gender/age bias

Seasonal bias

Fashion/sport bias

Ethnic skew or appeal

Regional or other bias

Other factors

Other information

PACKAGE DESIGN BRIEF 4

MARKET ENTRY

Details of introductory offers if any

Details of introductory displays if any

Details of advertising tie-ins

Are advertising layouts or storyboards available?

Are models/mock-ups needed for advertising?

DISTRIBUTION

Distribution cycle details

Area/cube utilization requirements

Proposed pallet patterns

Required warehouse stack height | Stack duration

Critical G or expected drop height

Other product fragilities

Special storage or transport conditions

Details of protective packaging if required

Applicable carrier rules

PACKAGE DESIGN BRIEF 5

CURRENT MARKET, CONSUMER, AND TRADE INFORMATION

Current target market

Repositioned target market

What is the main selling proposition of the launched product?

What are the objectives of this launch? (quantify)

Market position relative to competition

Major competitors in order of importance

Name	Market share/Comments

Market, product, or package research available?

If research is planned, nature and date available

Are packages needed for market research?

PRODUCTION REQUIREMENTS

Required annual production | Run on existing line?

Product/package required for trial runs?

Modifications or tooling required

Lead time required

New equipment required

Lead time for new equipment

ENVIRONMENTAL AND WASTE MANAGEMENT FACTORS IF ANY

REVIEW QUESTIONS

1. Package design is a very complex process. What are the factors that contribute to this complexity?
2. What is probably the single most important factor in designing a successful package?
3. What makes the success of a totally new product launch particularly difficult?
4. Why is it difficult to draw an orderly flow chart showing the exact steps needed to design a package?
5. A package design should start with a clear statement of what the package is supposed to achieve. What are some examples of package design objectives?
6. What is a package design brief? Why is it important?
7. What facts might you want to know about the competition?
8. Why is supplier contact early in a development program regarded as a good idea?
9. What will likely happen if you do not have adequate written packaging specifications?
10. What are the reasons for maintaining packaging specifications?
11. What are the consequences of having overly tight tolerances in a specification?
12. Why is it important for a specification to be jointly drawn up in consultation with the supplier?
13. What is the difference between a materials specification and a performance specification?
14. Specifications detail the attributes necessary to meet the required quality level in what three areas?
15. What issues are covered in the corporate policy portion of a specifications system?
16. Name and describe the three general classification categories of defects.
17. What are the three basic steps when writing a specification?

Assignment

Prepare a package design brief for launching a product of your choice. You may make a photocopy of the hypothetical design brief at the end of this chapter. Be aware that, depending on your product, special needs that are not mentioned in the design brief example may need to be addressed.

ANSWERS TO CHAPTER REVIEW QUESTIONS

Chapter 1—Perspective on Packaging

1. Packaging is a coordinated system of preparing goods for transport, distribution, storage, retailing and use.
2. Societal changes associated with the Industrial Revolution caused cities to expand as people moved from self-sufficient rural living to working in factories. Food, clothing and other items that used to be made at home needed to be transported to and sold in cities. Thus, packaging such as barrels, boxes, kegs, baskets and bags, was needed to allow these products to be readily moved and carried. Smaller packages also were needed to allow products to be stored in smaller family spaces in cities.
3. The term "branding" comes from the early form of product origin identification which was literally a brand—using a metal iron to burn a symbol representing a manufacturer or place of origin onto a barrel.
4. Prior to 1877, labels or brands were an identifier or pictures representing the product or pastoral life. In 1877, the American Cereal Company began representing its product with the Quaker person to represent purity, wholesomeness, honest and integrity, with those values extending to the product itself. The concept of the package "persona" was started.
5. Other persona examples are the Aunt Jemima brand, the Cream of Wheat chef, Procter & Gamble's Mr. Clean, Kellogg's Tony the Tiger, the Cocoa Puffs rabbit and the Energizer Bunny.
6. In the early 1900s, stores began offering self-serve options. Products needed to be prepacked in containers consumers could handle. The packages needed to inform the purchaser about what was in the package and encourage a purchase. As shops moved from proprietor-owned outlets to large retail stores, shopping evolved from service to individual self-service. Packaging was used to prepack items. Labeling and decoration became point-of-sale information—what the product was, how to use it and graphics to encourage purchase.
7. The 1970s and '80s brought on packaging changes—many related to safety. Child-resistant packaging was mandated for some products and tamper-evident closures for others. Ozone-depleting substances came under scrutiny and international agreements phased them out. Plastic packaging started to become more commonplace

and single-serve products became common. Microwave use expanded. Prepared foods emerged to meet the needs of single-person households.

8. In the 21st century, environmental concerns have begun driving product innovation to reduce packaging per use. Food waste concerns drive the need for improvements in the food industry. The rise of ecommerce has had a profound impact on packaging, as have the aging population and the emergence of technology such as QR codes.

9. A QR code is a 2D matrix barcode, composed of black dots on a square grid with a white background, that is an optical, machine-readable label. It may be printed on a package or label or attached to a product. It records information about the product. Consumers can scan a QR code with their smartphone to get additional information about a product than can be contained on the label itself. The code also can act as an authentication device for protecting an expensive product.

10. a. Packaging allows proper storage and transportation of perishable food that enables consumers ready and safe access to fresh milk, meat and other products throughout the year.
    b. Many durable goods are made overseas at lower manufacturing cost. Cost-effective packaging is needed to transport these items over long distances without damage.

11. Food can be more efficiently grown, packed and stored at specialized farms with more advanced processes. In less-developed countries, food product is more localized and less likely to be handled, packaged and stored in ways that preserve quality. Production is dependent on time of the year and natural resources available. As a result, higher food loss is common.

12. The United Nations is concerned that population growth, coupled with the aging population and climate change, suggests that food production might not keep pace with need. Packaging is critical to preserving food so less is wasted to ensure access to it globally.

13. Two key factors driving the growth of the packaging industry are general population growth and the growth of the middle class, driving the need for more consumer packaged goods.

14. The packaging industry is made up of two key divisions—suppliers and end-users. The supplier side consists of material manufacturers, machinery suppliers, converters, printers and decorators. The end-user side consists of fillers, brand owners, retail and transportation.

15. Private label brands have evolved from low-cost, generic alternatives to national brands to quality brands in their own right that compete directly with national brands. The packaging for private-label brands has evolved from plain and simple to high-quality graphics that suggest a premium product. Sometimes, store brands offer premium benefits to differentiate them from national brands. Some stores are evolving to offer two tiers of privately branded products.

16. The three marketing-related forces are: connected lifestyles driving consumer access to product information, online purchases and greater shopper engagement and customization; maturing and emerging retail channels driving a need for package customization for the specific demographics; and shorter product life cycles enabled by technology advancement.

Chapter 2—Packaging Functions

1. Contain, protect/preserve, transport, inform/purchase decision.
2. Primary package is the first containment of product that directly holds the product. Secondary package is the containment for the primary package. Tertiary package is the containment with the foremost purposes of protecting the product during distribution and providing for efficient handling.
3. Is the product a fluid, powder, granular, paste or solid? Is the product aseptic, corrosive, sticky, irregular shape or toxic? Is the product microwavable, is it single-use, elder-friendly, portable, shelf-stable or childproof?
4. Shock, vibration, compression, abrasion, temperature, water, humidity, tampering. These conditions can occur in warehousing, transportation, handling and at retail.
5. It is essential to know what will cause damage by knowing the general condition and the quantifying level at which unacceptable damage starts to occur.
6. Internal biological deterioration describes biological functions that continue after food has been harvested. External biological deterioration refers to the actions of microorganisms on food (mold, yeast and bacteria).
7. Abiotic deterioration—oxygen, evaporation, water vapor, temperature.
8. Red meat needs oxygen to keep a bright red color, fruit and lettuce/salad need oxygen to continue to ripen and respire.
9. Temperature, moisture, acidity (pH) and nutrient source.
10. Essential oils are volatile and are lost through evaporation and oxidation. They must be preserved for the food's full flavor and to protect the scent of non-food products such as perfume.
11. A high-oxygen barrier package material needs to be selected to protect the oily product from oxidization by preventing oxygen from entering the package.
12. Some vegetables require some oxygen, and sealed cans provide an oxygen-free environment.
13. Carbon dioxide.
14. Because these types of foods tend to lose moisture under typical atmospheric conditions. If that loss of moisture is stopped, it will create humidity inside the package and inhibit mold growth.
15. Reduce temperature—(freezing) it slows chemical activity and reduces/stops biological activity. Thermal processing—(hot fill, sterile, sealed cans) kills most, if not all, microorganisms. Water reduction—(drying) manages moisture content to control microorganisms. Chemical preservation—(acids, carbon dioxide, curing/smoking, antioxidants, oxygen absorbers) helps to extend the keeping of quality foods, Generally insufficient by themselves, they are used in conjunction with other preservation methods. Modified atmosphere packaging—involves the introduction of a gas mixture other than air into a package. That mixture is then left to equilibrate or change according to the nature of the system. Another type of MAP is vacuum packaging, which eliminates some or all oxygen that may contribute to product degradation. Irradiation—(ionization) disrupts complex molecules and leads to the death of living organisms.

16. Oxygen, carbon dioxide and nitrogen.
17. Bacteria already may be present, fish oils are unsaturated and easily oxidized and fish proteins are not as stable as red meat proteins.
18. Barrier material slows down or stops the movement of gaseous substances into or out of a package.
19. Molds propagate and spread much slower than bacteria do because of the reproduction method—sporting versus splitting.
20. Conditions listed by preferred reproduction environment: mesophilic = ambient, psychrophilic = cool, thermophilic = heat, aerobic = needs oxygen, anaerobic = no oxygen.
21. Clostridium Botulinum, found in sealed cans. It can cause sickness or death.
22. Pathogens can cause sickness or death. They can produce harmful toxins as byproducts in foods they infest, and those can then grow in humans and produce illness.
23. Pasteurization is mild—60°C to 70°C. Hot filling up to 100°C—jams/syrups. Ultra-high temperatures of 135°C to 150°C—milk/fruit juice. Canning 110°C to 130°C—soup/sauces.
24. Aseptic packaging is created when both product and package are sterilized separately and then combined and sealed under aseptic conditions.
25. The cake would grow mold because of the humidity build-up in the package, based on the water activity level.
26. Aw of 0.3 means this food will be equilibrium at a relative humidity of 30%, having less-stringent moisture-barrier requirements. Depending on the food, oxygen or other barriers still may be needed. Examples are crackers, biscuits and cereals.
27. Vacuum packaging eliminates some or all oxygen.
28. Retort pouch material is in roll form and saves on transportation and storage costs. In addition, thermal processing time can be reduced, which improves food texture and nutritional qualities.
29. How will it ship—truck, rail or air? How will it be handled and unitized? What are the measures of shock/drop, vibration and compression? What are the storage conditions and length of time? Are there any dimensional or weight limits?
30. A unit load is a group of distribution packages assembled into a single unit for mechanical handling, storage and shipping.
31. The material selected, shape, size, typography, symbols/icons, illustrations.
32. It is the “personality” of a package. To promote the contained product effectively, a package must appeal to the potential customer at all levels. A good package creates a “persona,” or personality. If the designer has done an effective job, that persona will appeal to the targeted audience.
33. It does not use elevated temperatures and pressures used in sterilizing, so packaging materials can have lower physical strengths and lower temperature tolerances.
34. Glass and metal.

35. Structure/shape, graphics, materials, colors, features.

36. Get and keep the attention of the shopper at the point of purchase.

37. Peanut butter can be packaged in a plastic tub with a plastic lid and two-color label and be considered a generic product. It can be packaged in a glass jar with an embossed metal lid and foil label and be perceived as a gourmet product.

Chapter 3—Brand Identity Strategy and Package Design

1. A structural component and a graphics component. The structural component's primary role is to fulfill the package's technical and physical requirements. The graphic component attracts and informs the consumer and motivates a purchase decision.

2. Demographics is numerical information about consumers in specific, easily quantifiable classifications. Examples are gender, age, education level, family size, ethnic background and religious beliefs. Demographic information can be obtained through the U.S. Census and surveys.

3. Psychographics studies how groups of people are motivated and how they behave. Psychographics is not as precise as demographics. Examples of groups that could be studied are baby boomers, yuppies and football fans.

4. Psychographic/demographic information is important to the package designer in analyzing future packaging needs for tomorrow's markets.

5. 68% to 80% of consumer purchase decisions are made in-store, according to various studies. A package can have a consumer's attention for about seven seconds to influence their purchase decision.

6. Smartphones can provide infinite information to a shopper in-store or prior to shopping and can even create an immersive experience. This allows access to much more information than what could be included on a label. Consumers are able to price-shop, snip coupons or get multimedia suggesting how to use a product.

7. Products offered on the store shelf or in the omnichannel environment (retail or etail) must include all the required information in a way that is easy for consumers to see and understand quickly on the front and back panels. This can diminish graphic design options. Products offered exclusively online can enhance the design experience and provide opportunities to simplify packaging since online purchases need protection for shipping but may not need point-of-sale components such as large blister cards or cartons.

8. It is possible to look at store shelf sets online using virtual reality without actually producing packages or building the shelf. This way, multiple designs can be evaluated quickly. Additionally, some market research may be done using virtual packages rather than real ones to screen options. One drawback is that virtual reality focuses on aesthetic design but can't actually test functional performance.

9. The two main messages a consumer looks for are: "What is this?" and "What are you going to do for me?" The third piece of information that might influence the buying decision is "Who guarantees it?"

10. The importance of an effective point-of-difference message is that it differentiates your product from the many other product options on the store shelf.

11. Through color, shape, text and graphics.

12. Equity is a value created in the consumer's mind based on establishing a reputation for consistent quality and service over a long period of time. An icon is a highly recognizable symbol.

13. Color usually is the first visual aspect a consumer notices about a package.

14. Emotional state, such as moods, feelings, places and things, is the typical human relationship to color, i.e., "feeling blue," "seeing red" or "green with envy."

15. Attributes that are affected by color can be size, quality, value or flavor.

16. Design elements used by designers in creating a package are shape, size, color, texture, tone, line and icons.

17. Persona is the psychographic/demographic profile of the targeted consumer. The package elements must unite to match this persona.

18. A Western consumer reads information on a package from top-to-bottom and left-to-right.

19. Unfortunate color or incomprehensible word patterns may confuse consumers or make reading difficult.

20. Serifs are small, decorative extensions on letters. San serif fonts more commonly are used than serifs on packaging to improve legibility.

21. Match the persona of the package and product. Dominant typography needs to be readable at the normal observer distance. Consideration must be given to the population mix relative to illiteracy and vision issues. Be aware of pitfalls with reversed-out type. Know the impact and requirements of federal regulations on labels. Don't allow text and illustrations in the design to cross over package joints and seams.

22. Focus groups are useful for gathering general, broad-based information and for judging the overall appeal of a package design. They rely on a panel selected to discuss, rank, evaluate and consider a subject. Recall questioning involves a panelist having a brief observation time to view a picture. The panelist then writes all the product names he or she can recall, and this option can help in assessing a package design's shelf impact. Findability tests can come in several ways: for example, the time it takes a subject to locate a product or where a product should be displayed. It is a broad-based test for shelf impact evaluation. Eye tracking uses an instrument that can exactly follow the eye's movement patterns and identify what the eye is focusing on. Eye tracking can provide detailed information about individual design elements and their placement on a package or store shelf. Eye tracking is an objective test to measure findability and shop-ability, but it provides little insight on consumer engagement. S-scope studies provide detailed information on graphic design elements at rapid rates and offers a good understanding of the order in which information is received. Ethnography is the study of consumer buying habits. Ethnography observes a person as he or she goes about their day or performs a specific task. For example, it is used to observe a consumer's buying preferences, as well as how that person interacts with the package and product at home.

23. Ethnography can be used to understand functional solutions that a package design can provide, based on how a customer uses the product. It also can be used to understand what the consumer is thinking as he or she makes their buying decision, and then incorporates those learnings into the structural or graphic package design.

24. Here are three of the 10 discussed design best practices. Lean into the power of simplicity to enable the consumer to find information on pack faster and enhance communication. Design for your shopper profile to ensure your primary consumers will embrace a new design. Look to other categories for unexpected sources of inspiration to help your package/product stand out on the shelf.

Chapter 4—Packaging Printing and Decorating

1. Yellow.
2. Decorating round or oddly-shaped items, items requiring heavy ink laydown, when printing on textiles, rigid substrates or corrugated.
3. The second application of color that needs to have good coverage, coating and adhesives applied on-press, line colors (PMS), fluorescent or metallic inks.
4. A photonegative created for each of the four colors, it is imposed on a screen pattern, at the proper angle for each respective color and finally, plate is made.
5. Red, green and blue.
6. It means there are 133 dots per linear inch.
7. Reverse printing means printing on the back side of a transparent substrate (clear plastic film). This technique is used to protect the ink from abrasion, so the sheen of the substrate contributes to the overall appearance.
8. Registration between colors, the possibility for dot gain and limitations in screen range.
9. Four.
10. Six—CMYK plus orange and green.
11. Object, observer and light source.
12. Oil and water don’t mix.
13. Flexographic printing.
14. Cyan, magenta, yellow and a key color (usually black).
15. Relief, planographic, gravure and digital.
16. An illustration where the colors are not blended; each color is a single hue.
17. 100-line screen. The numbers represent the numbers of dots per linear inch (dpi).
18. To prevent moire patterns.
19. Registration between colors, which is resolved by offset letterpress because all the colors are transferred to a blanket cylinder, which then applies the ink to the container.
20. Sheet-fed presses run cut blanks of substrate; web-fed presses run the material directly off a roll. Gravure is always web-fed, but litho and flexo can be either one.

21. Web-fed central impression flexo.

22. Hot-stamping; embossing; and producing glossy, reflective metallics.

23. Black, or another dark color, used in process printing, to add depth and contrast to an image.

24. Ink is not applied directly to the substrate from the plates.

25. Silk screen or offset letterpress.

26. A press in which print stations are grouped around the central impression drum.

27. At 5,000 degrees Kelvin—northern daylight at noon; defined so that variations due to lighting are not a factor in color matching.

28. The amount of light reflected. It is important in printing because most inks are transparent, so the brighter the substrate, the more light that is reflected back thru the ink.

29. A blanket cylinder accepts ink from the plates and transfers it to the substrate (lithography). An anilox roll accepts ink and transfers it to the printing plate (flexography). An impression cylinder puts pressure on the backside of a substrate so ink can be transferred from the blanket or plate cylinder (lithography, flexography and gravure).

30. Advantages of gravure: Heavy ink laydown, print station is mechanically simpler, process is not as vulnerable to operator and environmental variables, simple makeready, high volumes, high speeds, good halftone reproduction, cylinders can be reused. Disadvantages of gravure: expensive cylinder, cylinder takes longer to make, needs high volume to justify cylinder cost, needs smooth substrate, very fine lines are difficult to achieve.

31. Continuous tone.

32. Deliberate overlap of adjoining ink colors to compensate for press movement and ability of ink to adhere over undried ink already applied.

33. Shrink sleeves can be removed for container recycling, they can decorate a high-contour bottle and provide tamper-resistance in one step, they can be used to consolidate several items into a multipack.

34. Offset lithography.

35. Black and yellow.

36. Advantages of screen printing—heavy ink laydown; good opacity; low-cost plates; flexibility in screen shape and size, allowing screen to conform to unusual shapes and large sizes; can print a variety of substrates. Disadvantages of screen printing—slow speed, limited complexity of artwork, high ink consumption.

37. Hot-stamping.

38. “Bleed” occurs when extending a printed area beyond the dieline to allow for press movement.

39. Reasons include different substrates, CMYK inks used for digital. Compared with PMS inks used for other processes, process printing uses halftone dots whereas digital uses line patterns and differences in dot gain and trapping.

40. A series of photographic transparencies of the color separations in generic color used to show how the color image will be assembled.

41. Inks, substrates and press characteristics are all closer to reality of printing on an analog press, as long as the final printing is not done on a digital press.

42. Some advantages of in-mold labeling: Eliminates the need for labeling equipment and flame treatment and can reduce bottle wall thickness. Some disadvantages: Paper labels can cause problems when the bottle is recycled, film labels are more costly, high tooling cost, slow cycle rate, bottle shape limitations, predecorated bottles are kept in inventory.

43. Least shrink, OPP; highest shrink, PETG.

44. Pad printing.

45. Digital printing advantages: Eliminates plate-making process, short runs are more economical, no dot gain, material waste is virtually eliminated in set-up and production. Disadvantages: Large production runs are much more expensive on a per-piece basis compared with other printing methods, ink opacity may be less since inks are laid down thinner, ink is much more expensive compared with other printing methods.

46. Colorimeters or Densitometers measure color and assign numerical values to the amount of each color component reflected. The L*a*b system for numerically describing colors is used. Limitations are that the instruments don't allow for shapes, adjacent colors, textures and other factors affecting human color perception. It can only verify that the inks/paper are the same as the standard which is programmed into the equipment.

Chapter 5—Environmental and Sustainability Issues

1. Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs.

2. Sustainable packaging.

3. **Reduce:** Package designs should use the minimum amount of material consistent with fulfilling their basic function. A reduction in material use diminishes further considerations of reusing, recycling or recovering other value.
Reuse: Where practical, containers or packaging components should be reused.
Recycle: Where practical, packaging should be collected and the materials recycled for further use.
Recover: Finally, before consigning packaging to a landfill, consider the potential for recovering other value from the waste.

4. Energy can be recovered through incineration and "recovery" of packaging materials by the manufacturer and distributor.

5. The cascade model refers to the life cycle of incineration of polyolefin plastics, where even after several incinerations, it still contains a large amount of energy.

6. Five sustainability drivers are: shrinking global forests, depleted fisheries, water shortage due to changing weather patterns, reduced crop land and depletion of petrochemicals and other global energy sources.

7. The pillars of a circular economy are protecting the environment, reducing waste and GHG emissions, systematizing recycling and ending planned obsolescence. In addition, dependence decreases on imported resources such as raw materials, water and energy.
8. In a circular economy, as it relates to packaging, unwanted packaging is eliminated to ensure that packaging material stays in the economy and doesn't become waste.
9. The packaging goals of the circular economy are to eliminate unnecessary packaging; develop innovative approaches in which all necessary packaging is designed to be safely reused, recycled or composted; and ensure that materials produced for packaging remain in the economy and avoid becoming waste or pollution.
10. Creating a complete picture of the material energy and process flow path for a particular product, from raw materials to the end of life.
11. COMPASS is a software tool used for performing a Life Cycle Assessment (LCA) using life cycle inventory data.
12. Following the nine-step procedure described in the chapter.
13. Design for the Environment (DfE), Restrictions on Hazardous Substances (ROHS) Compliance, EPA's Product Stewardship/Extended Product Responsibility (EPR) and Product Stewardship Institute (PSI).
14. Cradle-to-Cradle design, multiple end-of-life options, packaging that easily can be broken down into recyclable components, recycling standards and capabilities, reuse and take-back programs.
15. Economics, marketing, protection, performance and consumer information.
16. Step 8.
17. ISO 14020.
18. Impact reduction strategy, biodegradability, recycled content, recyclability and greenwashing.
19. Product stewardship describes whoever designs, makes, sells or uses a product; they take responsibility for minimizing its environmental impact.
20. Applicable regulations are in force at the destination of the package.
21. Green-washing occurs when a provider tries to make a product look more environmentally preferable than it really is.
22. "Unfair or deceptive advertising, acts or practices in or affecting commerce. A claim must tell the truth and not mislead consumers."

Chapter 6—Paper and Paperboard

1. Different fiber lengths and different properties.
2. Mechanically cutting the wood is the fastest and cheapest method, but it breaks the fibers and reduces their effective length. The least fiber damage occurs when chemicals are used to dissolve the natural lignin binders in wood, leaving the fiber bundles intact and undamaged, but it is expensive.

3. 23 °C and 50% relative humidity.
4. The fibrous nature and color of natural kraft paper does not lend itself to fine printing.
5. Hygroscopic means that paper absorbs and loses moisture according to the ambient relative humidity and temperature.
6. MD = machine direction. CD = cross direction. The properties of paper differ in MD and CD.
7. The longer the fiber, the better the fiber entanglement and the stronger the resulting paper. However, long, course fibers produce a rougher surface texture.
8. Fourdrinier and Cylinder papermaking machines. Fourdrinier makes thinner paperboard and the Cylinder makes thicker paperboard and has definite layers.
9. 0.020-in. board.
10. Caliper in metric is in micrometers "µm", caliper in inch/pound units is weight in pounds per 1,000 square feet, the "basis weight."
11. Clay fills in irregularities between the fibers to produce a smooth printing surface, as well as improve gloss and brightness.
12. "Hard-sized" paper is very water-resistant. "Slack-sized" paper has little or no water hold-out capability.
13. The benefits of postconsumer wastepaper as a fiber source are that it is plentiful and also reduces the cost of papermaking. However, every repulping process degrades and reduces the fiber length, and some extraneous contaminants may appear as bits of color, "grease spots" and "shiners" on the paperboard.
14. The strongest papermaking pulp is chemic and the weakest is mechanical.
15. SUS-SUB.
16. That it was produced on a cylinder papermaking machine.
17. Brightness is a measure of the total reflectance of white light. Whiteness is a color description.
18. Kraft pulp is made using the chemical process and is brown in color and provides maximum strength.
19. Paper is less than 300 micrometers or 0.012-in and paperboard is more than 300 micrometers or 0.012-in. thick.
20. Some extraneous contaminants may appear as bits of color, "grease spots" or "shiners" on paperboard.
21. Mechanical softwood.
22. It is impractical to add more headboxes to produce thick paperboard because the water from each successive addition must drain through fibers that already have been laid down.
23. Different units of measure may be used for different mill products.

24. It means that the paper will expand when it absorbs water and shrink when it dries. This causes issues for printing and die-cutting registration.
25. Hardwood—aspen, maple. Softwood—pine, spruce.
26. Use the Elmendorf Tear Test.
27. It might not absorb the ink printed on the folding carton.
28. Chipboard is made from 100% recycled fiber. It is useful when appearance and foldability are not critical.
29. The Cobb test measures the amount of water absorbed by a given paper area in a specified time. It is used on sized papers and paperboards.
30. Glassine is paper that has had the maximum fibril separation and is semi-transparent, greaseproof papers, such as those used for cracker bags.
31. Improve caliper consistency, smooth out surface and provide a glossier surface.
32. Refinement affects tear strength, absorbency, burst strength and tensile strength. Low refinement—high-tear strength; high refinement—decreased absorbency.
33. Tear.
34. Formation is the evenness of the fiber distribution on the papermaking screen. The length of the fibers contributes to the formation on the screen. Poor formation can lead to uneven ink absorption or erratic adhesive bonding.
35. 7.8.
36. The hygroexpansive nature of paper. When paper is laminated to a material that is not affected by moisture and the humidity changes, it may curl.

Chapter 7—Paperboard Cartons

1. The type of product being packaged and the packaging operation are the first two factors to consider. Additional factors come into play for a self-contained package: Will there be one entry or repeated entries into the package? Will the consumer wish to see the product before purchase? Also consider the nature of the packaging operation.
2. Weight, is the product wet, is the product greasy or oily, will the product tear or burst the package.
3. Tuck or glue ends, vertical or horizontal loading, size of opening required and an irregular shape.
4. Does the product need to be supported or held in the package? How will the product be delivered and displayed in the store?
5. The working scores normally are the pair not adjacent to the glue flap on the carton.
6. Double gluing is the gluing of both the inner closure panels and the outer closure panels to provide a complete sift-proof seal. It is specified for a product that requires sift proofing.
7. Paperboard coated with either polyethylene or wax.

8. The front, or principal display panel, is the panel situated between the two side panels on the carton blank (i.e., the main panel not adjacent to the glue flap).
9. An airplane-style tuck carton has only minimum friction fit, and both cut edges face the front display panel of the carton.
10. Manually assembled cartons for heavier products.
11. Beer trays are knocked down for shipping. Brightwood trays are nonflattening once erected.
12. The advantages of a set-up box are: upscale image, many types of decoration possibilities and appearances, they make a convenient long-term storage unit and serve as a low-cost shipper. Some disadvantages are: boxes cannot be knocked down flat and empty boxes in storage occupy as much space as when they are full. Also, set-up boxes are not designed for high-speed manufacturing.
13. Scored paperboard is folded away from the valley side of the score.
14. Carton dimensions are given in the order of length, width and depth, with length and width defined as the carton opening. Depth is perpendicular to the opening. The first carton is 90 mm in length, 20 mm in width and 40 mm in depth. The second carton is 20 mm in length, 40 mm in width and 90 mm in depth.
15. Most tube-style folding cartons have grain, or "paper machine direction" (MD), running around the carton perimeter (i.e., crossing the carton body scores).
16. Though irregular shapes may provide a distinctive shelf appearance, they are more difficult to pack and ship. Obtaining machinery that will handle eye-catching shapes also can be a problem. Approach irregular carton shapes with caution.
17. A heavy, low-grade chipboard.
18. Horizontal end-loading tube-style cartons essentially are the same as vertical end-loading tube styles, except that the filling orientation has changed. Top-loading cartons are shipped as unglued blanks. Horizontal end-loading cartons are for products such as food trays for pizzas and cakes. Vertical-loading cartons are for products such as granular or powdered items.
19. Slit-lock closures incorporate small slits between the tuck flap and the top closure panel. (See Figure 7.15) When the carton is closed, the slits engage shoulders cut into the dust flaps, securely locking the flap into place.
20. Depending upon the nature of the product and the customer's and supplier's policies, the following normally are the minimum "sign offs" requested in a carton project: a) structural design, hand samples, CAD sample; b) one up die sample, production die sample; c) digital proofs, artwork layout on carton dieline; d) on press for final production approval.
21. It should be clearly understood that each sign-off constitutes a legally binding contract, and it is the customer's responsibility to ensure that every detail is correct at every stage of production.
22. As with carton sign-offs, the product process will vary by project and the customer's and supplier's policies. The carton design process starts with an in-depth review of the customer's needs and objectives. The customer needs to share all technical and

marketing expectations. The carton designer will develop one or several designs to meet the customer's stated objectives. The customer inspects the hand sample and gives approval to proceed to the next step. The customer's approval, or sign-off of a hand sample, starts the carton production process. Digital-dimensionally correct records of the approved design are forwarded to graphic arts and die-making departments. At the same time as the dies are being made, the art department develops the graphic image that will appear on the carton. When proofs have been approved, printing plates are made and mounted in the press. The customer usually is called in to provide final press approval.

23. Cartons are best run within 90 days of manufacture.

Chapter 8—Metal Cans and Containers

1. Steel, three-piece can bodies can be mechanically seamed, bonded with adhesive, welded or soldered. Mechanical side-seaming, or clinching, is used for containers intended for dry product, where a hermetic seal is not important. Adhesive bonding is an attractive body-assembly method for applications when the can will not be subjected to thermal processing. Unlike welded cans, adhesive-bonded constructions can have full wraparound lithography. The welded seam line is about 30% thicker than the two base metal sheets. Cans shorter than 75 mm (3 in.) are too short to be welded individually and are made by welding a body twice the required length and cutting it into two cans. Soldered food cans are no longer permitted in North America. Some soldering is still done for nonfood applications. All solders have eliminated lead content.

2. Immediate advantages are reduced metal usage, improved appearance and the elimination of two possible leakage locations—makers end and side seam. However, while three-piece cans easily can be changed in length and diameter, two-piece cans require more elaborate tooling that is dedicated to one can size and shape.

3. Alloy type "medium residual" (MR), referring to the amount of residual metal elements other than phosphorous, is the most common can-making steel. Types L and LT have low residuals and are used for acidic foods and other corrosive products. Type D alloy has improved ductility and is used in applications where deep draw is required. Double-reduced (DR) steel is rolled once, annealed and then cold-rolled again. These DR steels are used whenever maximum stiffness is required.

4. Impact extrusion forms ductile metals such as tin, lead or aluminum into seamless tubes (and cans and bottles).

5. "Tin can" is not strictly correct terminology, since low-carbon steel is the predominant can-making material.

6. Today, black plate is electrolytically tin-plated, allowing substantial reductions in the amount of tin used, as well as offering the ability to put different thicknesses of tin on either side of a steel sheet. The tin layer is extraordinarily thin, about 0.38 micrometers (0.000015 in.). Manufacturers identify differential tinplate, as to both the amount of tinplating and the side having the thicker tin content, by embossing an identifying pattern onto one side of the sheet. The heavier tin deposit goes to the inside of the container where greater protection is needed.

7. Double-reduced (DR) steel is rolled once, annealed and then cold-rolled again. These DR steels are used whenever maximum stiffness is required.

8. (a) T57 (b) T50 (c) T52.

9. Metal tubes' advantages over laminate and plastic collapsible tubes: They are absolute barriers to all gases and flavors. They have excellent dead-fold characteristics (i.e., the ability to be flattened or rolled up). Decoration can take advantage of their metallic character. They have a wide range of internal lining options because of the metal's ability to withstand high curing temperatures.

10. Metric practice quotes metal grammage: the mass per square meter. System International Tinplate Association (SITA) quotes tinplate in kilograms per 100 square meters. The used steel is 1,794 grams per square meter.

11. Lithography is used when the can blank is decorated in the flat.

12. A vital can-end component is the compound applied around the perimeter curl. This compound acts as a caulk or sealant when the end is mated and double-seamed to the can body.

13. Impact-extruded tubes and cans.

14. D&I and other round containers have no natural register point and must be printed by offset letterpress, also called dry offset. All of the inks are printed onto a rubber blanket and transferred in one action onto the can surface.

15. Sanitary food cans that may be thermally processed in a retort have bead patterns embossed into the can sidewalls; the patterns improve resistance to collapse because of external pressure. This prevents paneling during pressure differentials encountered during retorting and enables the can to withstand an internal vacuum.

16. For a can that was drawn, the thickness of the finished can sidewall and bottom remain essentially the same as in the original blank. The bottom of a D&I can has the same thickness as the starting disk; however, the sidewalls are considerably reduced in thickness, and the metal area of the final can is greater than that of the initial disk.

17. Necking operations reduce the diameter of the D&I can top, thereby reducing the end-piece diameter. This results in significant metal savings, since the end piece is much thicker than the sidewalls. The thin walls of a D&I can restrict its use to applications where it will not be thermally processed and that will lend support to the walls.

18. Nominal can dimensions are given as the overall diameter by the overall height. Each dimension is given in three digits. The first digit is in whole inches, and the second two digits represent 16ths of an inch. A 202 × 406 can is 2-2/16 in. diameter and 4-6/16 in. height.

19. The Rockwell gauge measures the penetration of a hardened steel ball into the sheet surface at a given force.

20. Oblong, steel three-piece F-style cans are used mostly to contain aggressive solvents.

21. Draw, draw and redraw (DRD), draw and iron (D&I) and impact extrusion.

22. Because of their significantly lower cost, most aerosol propellants have been based on hydrocarbons, or hydrocarbon blends.

23. The ideal propellant is a gas that can be easily compressed and liquefied at the desired operating pressures of an aerosol system.

24. In the simplest two-phase system, such as glass cleaners and room air fresheners, the propellant dissolves in the product. Three-phase systems are those where propellant and product are not mutually soluble and remain separate in the can.

25. Most valves come fitted to an industry standard 25.4 mm (1 in.) mounting cup that allows it to be seamed onto a can body.

26. An aerosol container is a pressurized vessel, and therefore, has a potential explosion hazard associated with it. In Canada and the United States, aerosol containers are governed by each country's hazardous product codes—in Canada by Transport Canada (TC) and in the U.S. by the Department of Transportation (DOT). The construction and minimum container performance level are specified according to the contained pressure. The specifications are similar for both countries.

Chapter 9—Glass Containers

1. Soda, lime, silica.

2. Cullet is broken glass from rejected production and/or post-consumer recycled bottles. It is added to help improve melt rate and reduce energy cost.

3. Amber glass is used to filter out light to protect UV-sensitive products.

4. Blow-blow is used for narrow-neck containers. Press-blow is used for wide-mouth containers.

5. These three glass types are used in the pharmaceutical industry for vials and ampules. Type 1—a borosilicate glass that has the most stringent extractable standard. Type 2—a soda-lime glass that has been treated in the annealing oven with sulfur to reduce alkalai solubility. Type 3—a conventional soda-lime glass that has been tested and shown to have a specified extractives level.

6. Glass Packaging Institute.

7. Annealing raises the temperature of a newly blown bottle and slowly cools it to room temperature. The process reduces the stresses in the container wall caused by inside to outside temperature variation.

8. Chrome oxides for emerald. Iron and sulfur for amber.

9. To reduce the coefficient of friction and to help preserve the inherent strength of the glass by protecting the surface.

10. Pros: Inert to most chemicals, no flavor leaching, clarity allows product visibility, strong, great for hot-fill products. Cons: breakable, high density, energy intensive.

11. The high center of gravity will cause the bottle to be unstable. Conveying is problematic because the shoulders touch first, but the bottom has room to continue moving forward, causing the bottles to tip backward. A larger shoulder is a vulnerable spot for abusive contact. An oval bottle will be heavier, will label at a slower rate, may have limited decoration options and could "shingle" on a conveyor.

12. 1%.

13. Gob—a sheared unit of molten glass. Blank mold—a mold set used to create the container parison. Finish—an opening of the bottle that accepts the closure. Heel tap—an excess wall thickness at the base. Choke neck—an excessive thickness just below the finish. Push-up—a concave area at the bottom of the bottle.

14. Higher center of gravity, more visible fill-level variation.

15. Indented label panels help protect the label from abrasion. An orientation lug is used to register the label with a bottle feature.

16. Efficient use of material, strength, easy to handle, no orientation, label options and speed of labeling.

17. Bird swing is a glass thread that joins the two walls of a bottle. Flat bottles are where Bird Swing defects are most prominently found.

18. Flint—clear; amber—brown; emerald—green.

19. To enhance the whiteness of a product.

20. Glass has no distinct melting point. It depends on the type of glass being manufactured. The raw materials for commercial glass fuse into glass at about 1500°C.

21. The stipples reduce the surface contact area and accept the inevitable scratches that occur during handling and use that would weaken the bottle.

22. By acid etching or sand blasting.

23. It is essential to transfer the hot glass parison from the blank mold to the blow mold.

24. They are made from preformed tubing stock rather than the blowing methods used for glass bottles. The container is cut and formed into shape without the use of a mold, so there are no visible parting lines.

25. Window glass, and other specialty glasses, have much different melt points than common soda-lime packaging glass. Their inclusion in the cullet mix will adversely affect manufacturing.

Chapter 10—Polymer Chemistry for the Nonchemist

1. Thermoplastics and thermosets are the two types of polymer classes. Thermoplastics are most commonly used in packaging. Thermoplastic polymer chains are free to pass over one another when heated. Thermoset polymer chains are cross-linked and interconnected so they can never come free of one another without destroying the material.

2. **a.** increases. **b.** decreases. **c.** dimer. **d.** crystalline. **e.** amorphous. **f.** higher.

3. HDPE structures are linear chains, LDPE are highly branched chains and LLDPE have short, branched chains.

4. Orientation of polymer molecules can be carried out in one or two directions. Orientation straightens out and aligns the molecules in the direction of the stress.

5. LLDPE = Linear low-density polyethylene, PVC = polyvinyl chloride, PET = polyethylene terephthalate, PVAC = polyvinyl acetate, PP = polypropylene, EVOH = ethylene-vinyl alcohol, PVDC = polyvinylidene chloride, PS = polystyrene, PA = polyamide, OPP = oriented polypropylene.

6. A polymer with lower crystallinity will have better clarity than the same polymer with higher levels of crystallinity.
7. Thermosets will have higher potential use temperatures and be resistant to solvents.
8. Polarity affects properties such as melting point, solubility, barrier properties and coefficient of friction.
9. A combination of thermal and mechanical history is used to produce shrink film.
10. Deformation of plastics under load is referred to as “creep” and “cold flow.” Plastics with lower cold flow should be selected if the part is required to hold a significant load.
11. All plastics are clear or amorphous in the melt state due to rapid molecular movement that prevents the ordering of molecules.
12. Polyethylene and polypropylene are predominantly nonpolar.
13. Most packaging plastics are made from petrochemicals.
14. Flame or corona treatment is used to impart polarity to the surface of low-polarity plastics.
15. The higher-molecular-weight polysulfone has the higher melting point.
16. Copolymers bring together the favorable properties of distinctly different polymers.
17. Addition polymerization involves monomers adding onto themselves like links in a chain. Condensation polymerization occurs when two reactive monomers join together with the release of a molecule of water.
18. The filling temperature or application temperature will determine if PET is amorphous or crystalline.
19. Each plastic being molded has a unique expansion of coefficient and temperature at which the molding takes place. Using the same mold for different plastics would produce parts with slightly different dimensions.
20. Polyamide, polyacrylonitrile, polycarbonate, polyvinyl chloride, polyethylene terephthalate, poly vinylidene chloride and fluorocarbon would sink in water.
21. Tamper-evident neck bands and shrinkable label stock are monoaxially oriented so that shrink occurs in only one direction.
22. T_g is the glass transition temperature at which a polymeric material changes from a rigid solid state to a soft, rubbery or elastic state. T_m is the melt transition point where the plastic enters a melt phase. Amorphous polymers tend to have a more prominent transition at T_g while crystalline polymers have a more prominent transition at T_m.

Chapter 11—Shaping Plastics

1. Extrusion blow molding, injection molding, profile extrusion and thermoforming.
2. The shrinkage rate is different between types of plastics. The part varies in size when

different plastics are used. Molds are built with shrink tolerance incorporated into the mold.

3. Co-extrusion occurs when more than one extruder feeds material to a sheet to make layers into one sheet. This method is used to combine the performance advantages of different materials.
4. A plasticating extruder—a barrel with rotating screw.
5. Personal care products.
6. Sprue—the main channel through which molten plastic enters to the mold. Runner—a channel that distributes molten plastic to various cavities in a multicavity mold. Flash—when a machine's clamping force is insufficient to keep the mold halves together, plastic flows to the parting line; it is called flash. Gate—a small opening through which the molten plastic enters the mold cavity. Parison—a hollow plastic tube used in bottle making.
7. Cast film and blown film.
8. Blown film, cut to size and sealed on one end.
9. Plug assist vacuum forming—heated plastic sheet is forced into a cavity mold by a plug above the mold and then vacuum is pulled to conform the plastic to the mold cavity. Billow forming uses air to push the film upward and then a plug pushes the stretched film into the cavity, and a vacuum pulls the intruded material to conform to the cavity.
10. A programmed parison controls the wall thickness in a narrow-waisted container. The extruder has a moving mandrel on a set program to help control wall thickness along the length of the bottle.
11. High-oxygen multilayer bottles would be made from PP, EVOH, and PP, with bonding layers on each side of the EVOH to the PP layers.
12. Rotational molding.
13. Numbers are used in multi-cavity molds to identify which cavity a certain container/bottle came from, which can be used for troubleshooting issues and/or to investigate complaints.
14. Injection stretch blow molding because the bottles can be filled with hot heat. Hot-filled bottles will shrink. They are round to withstand internal pressures.
15. Extrusion blowing molding makes oil, detergent and household chemical bottles. They can include handles, pumps and hardware.
16. Injection molds are very expensive. Certain provisions must be made to remove threaded containers from the mold. Injection blow molding is used to make narrow-mouthed bottles.
17. An injection mold extruder must have a provision for ejecting a certain amount of melted material while an extrusion profile extruder has a continuous flow of melted material.
18. Injection molds can make complex designs. They are completely controlled by metal mold surfaces, giving the most dimensionally accurate part. Extrusion blow mold-

ing makes bottles. Thermoforming uses vacuum and has high draft angles to remove parts. Thermoformed parts cannot have undercuts or holes without an extra step after forming.

19. Cast film is biaxially oriented by “grasping” the film along the sides and stretching it wider, as it is already stretched in the machine direction.

20. An undercut is a part feature that prevents a mold from opening in a normal back-and-forth motion unless the other pieces of mold metal are first removed. This increases mold costs significantly.

21. Advantages of injection blow molding are: 1) no generated regrind, 2) no secondary operations, 3) high-precision neck and finish, 4) more cavities for small bottles, 5) better material distribution, and 6) wide-mouth jars are easy to make. Injection blow molding is used in bottle making.

22. The main difference between injection molding and thermoformed tubs is tooling cost. Neither can have an undercut without major tooling cost improvements. Thermoformed tubs cannot hold the tolerance required for a special interference snap-on lid. Thermoforming can run multilayer sheets if the tub requires certain properties. It is difficult for injection molding to run multiple layers into a tub mold. You can tell which method created the tub because a) an injection mold has a small, obvious gate point and mold parting lines, and b) thermoforming has no obvious parting lines, and vacuum holes sometimes are seen.

23. An extrusion blown molded bottle has a pinch-offline across the bottom where the parison was cut and sealed, as well as faint parting lines up the sides where the mold halves came together. An injection blow molded bottle has no pinch-off marks, but it does have a gate point “bull’s-eye” where the material was first injected. Faint parting lines are evident on the sides.

24. Plug molds have poor material distribution and limited draw. Cavity molds have better material distribution with the use of plug assist.

25. A sink mark is the point where there is a substantial wall thickness change. This is caused by plastics' high expansion coefficients. This occurs only in injection molding.

26. Melt flow rate helps determine a plastic's melt temperature and fluidity intended for the appropriate forming method. It works by placing a charge of the material in a heated chamber. A specified load is placed on a piston that drives the plastic through a small orifice. The weight of the polymer extruded after 10 minutes is reported as the melt flow rate.

Chapter 12—Plastic Applications

1. **a.** PVC. **b.** PVC. **c.** PVDC. **d.** PC. **e.** LDPE/LLDPE. **f.** PC. **g.** PP. **h.** HDPE. **i.** PP. **j.** PA (unoriented nylon 6). **k.** PE. **l.** PET. **m.** PVAL. **n.** PVDC. **o.** PP. **p.** LDPE.

2. The force producing or tending to produce deformation in a (package) body, divided by the area over which the force is acting. If the stress is tensile or compressive, the area is perpendicular to the stress; in sear, it is parallel to the stress.

3. When measured up to the point of permanent material deformation, stress is reported as "yield strength" or "yield point." The significance of yield point is that the package needs to be strong enough to hold the items you are planning on packaging, such as in a suspended retail bag for heavy groceries, hardware, etc.
4. A material's "elongation" is the difference between the length of an unstretched tensile-strength sample and its length at the break point or the yield point. Ultimate tensile strength defines the maximum stress a material can withstand before breaking.
5. "Static slip" or "static COF" defines the force required to start the film moving (slipping) over another surface. "Kinetic" or "dynamic COF" defines the film's friction as it is moving over other surfaces.
6. Dimensional stability, which is the capacity to retain original size/shape when exposed to environmental changes. Materials that shrink even slightly with the application of heat during processing, hot filling or heat sealing will produce distorted packages of unreliable volume and with puckered heat-seal areas.
7. PS.
8. Surlyn—used to seal through fatty contaminants. Metallocene—where a stronger heat seal may be required. LDPE and LLDPE—as a heat-seal layer in a laminated film or extrusion-coated as a tie layer in multilayer laminates.
9. Because they can be steam sterilized.
10. PET, PA.
11. Best = PCTFE (Aclar) and PVDC (Saran). Worst = PA (Nylon) and Acrylonitrile copolymer (Barex).
12. Chemical compatibility implies that no significant chemical activity will take place between the product and the chosen polymer. ESC is a surface-initiated physical phenomenon resulting from the operation of biaxial stresses (loads) in the presence of an external agent that produces no other discernible effect on the plastic. Chemical degradation is not involved.
13. It is formed by incorporating a "blowing agent" with the PS that will expand the plastic into a low-density cellular foam.
14. PE or a copolymer. PP is subject to cold fracture when frozen and therefore is unacceptable for ice cream tubs.
15. Bioplastics are developed from renewable resources, thus far including materials such as cellulose, starches and other biopolymers. Some resins that fall within the bioplastics spectrum may not be biodegradable, but they may be recyclable.
16. Bio-based polyethylene is sourced from sugarcane-based ethanol/ethylene.
17. PLA is derived from starch (it could be sugar, corn, casava, or sugarcane as well. It just needs to be starch-based) rather than petrochemical feedstocks, and it is industrial compostable.
18. PC bottles and linings for metal cans. It has been found to cause cancer, obesity and endocrine disruptions.
19. Plasticizers impart flexibility or softness and assist in processing.

20. "Hot tack" is the ability of a heat seal to withstand stress while the seal is still hot.

Chapter 13—Closures

1. Product compatibility, container compatibility, ease of handling, contain and protect functions, hermetic seal, recloseability, user friendliness, economics, convenience, safety, demographic considerations, decorative appeal, product viscosity.
2. The International Society of Beverage Technologists (ISBT).
3. I = diameter at smallest opening inside finish; T = thread diameter measured across the threads; E = thread root diameter; H = top of finish to top of bead or to intersection with bottle shoulder on beadless designs; S = the vertical distance from the top of the finish to the start of the thread. Corresponding dimensions are S, H, T and E.
4. M, or modified buttress thread. However, L-style still can be used for plastic as well.
5. By diameter and thread design; inside diameter in millimeters followed by a number that designates style. The designation numbers have been arbitrarily assigned and there is not dimensional significance to the digits.
6. The seal is accomplished with fewer degrees of rotation, allowing for a faster and more positive application.
7. They are not suitable for food because they would leave a small amount of product at the dispenser tip, exposing the contents to the atmosphere.
8. The plastisol gasket softens and conforms to the glass container's threads when heated during steam-vapor vacuum sealing, creating a vacuum seal.
9. To make a hermetic seal; this is achieved through the use of resilient liners inside the closure that conform to the minute irregularities of the container finish. The backing material in a lined closure is combined with appropriate other materials to create the actual barrier and seal.
10. Induction heat-sealing heads have sealing coils powered by generators running at 50 to 500 kilohertz; they produce energy that couples with the aluminum foil that is part of the innerseal. The foil's temperature rises and transfers heat to the heat-seal coating, which then bonds with the container's land area. 10b) Glass containers and metal closures.
11. A compression molding, vacuum metallizing, close dimensional tolerances, high use temperatures, solvent resistance, viscoelastic deformation problems. The pharmaceutical, chemical and cosmetics industries use thermosets frequently.
12. Most plastic closures are made from polypropylene. Thermoplastic closures can be either injection molded or compression molded.
13. Polyethylene might be specified for closures that require elongation or some deformation (snap-on tub lids). Polyethylene also might be the choice when better cold resistance is needed. Polystyrene might be specified for closures that require press-fit bases that snap over an interference ridge on a container or that require a hard, glossy surface or complex designs; also, when a fast capping process is desired. Polystyrene often is used for cosmetic closures for its hard, glossy surface and exceptional clarity.

14. Flip top, push-pull, plug orifice dispenser.

15. Application torque is a measure of the tightness to which the capping machine turns the closure. Removal torque is the force necessary to loosen and remove the closure. Stripping torque is the torque level that will cause the closure or bottle finish to distort to the point where the closure threads will override the matching closure or finish threads, resulting in component damage, loose caps or no seal.

16. If a bottle's S dimension is too short, the closure could wind down past the bottle thread, resulting in partially unengaged threads. If the bottle's S dimension is too long, not all of the closure threads may completely engage the finish threads.

17. If the bottle's H dimension is too small, the cap will bottom out in the bottle neck bead or shoulder before a tight seal can be achieved at the closure land.

18. Because no practical package can thwart a determined tamperer.

19. Film wrappers, blister or strip packs, bubble packs, shrink seals and bands, foil, paper or plastic pouches, bottle inner seals, tape seals, breakaway or drop-band closures, sealed collapsible tubes, sealed cartons, aerosol containers.

20. True child-resistant packages depend on the limited manual dexterity of a child. Typically, this involves two dissimilar simultaneous motions or actions.

21. Thermoplastic closures on thermoplastic containers can suffer from considerable torque loss after closure application because of the viscoelastic flow (cold flow or creep) properties associated with the materials.

22. On a paint can or when solvent vapors or product oxidation or drying is a concern.

23. Polypropylene is less subject to viscoelastic deformation than polyethylene.

24. Application torque, closure and container materials, geometries, tolerances, handling of the package's (transit vibration and drops/impacts) environmental conditions and time.

25. Ease of application, secure seal, small rotation of closure.

Chapter 14—Adhesives

1. The Mechanical Adhesion Theory proposes that fluid adhesives mechanically interlock into the surface cavities of the substrate and they cannot be pulled away without destroying the surface of the substrate. The Specific Adhesion Theory is based on the bonding that takes place when regions of positive and negative charges are brought into intimate contact to mutually attract each other. The surface charges are expressed as polarity and occur at molecular distances.

2. Hot melt has the highest percentage of solids (100%) and starch has the lowest percentage of solids (20%–30%).

3. High-speed packaging, when there is a need to bridge gaps and when substrates are difficult to bond.

4. In thermal processing operations (before or after the adhesive application, i.e., retort, boil-in-bag, microwave), or in packaging applications for heat-sensitive food products (i.e., chocolate).

5. Starch adhesive for corrugated, for their low cost. Casein adhesive for refillable beverage bottles, because of their cold-water resistance. Cold-seal adhesive for chocolate bar wrapping, for no-heat, high-speed applications.

6. The adhesive has low cohesive strength, and its excess amount has reduced the tensile strength of the bond.

7. **a.** The surface energy of the plastic was low. **b.** The adhesive has low cohesive strength. **c.** The surface strength of the carton board was too low (clay coating broke away from the board). **d.** Poor fiber cohesion.

8. Cohesive failure indicates low internal strength in the adhesive. Adhesive failure indicates a high internal strength of the adhesive that exceeds the interfacial bond of the adhesive to the substrate.

9. a) Loss of water. b) Loss of solvent. c) Loss of heat. d) Polymerization (via a reaction process).

10. Wettability refers to the surface energy of a substrate and indicates a high polarity that promotes bonding of the adhesive to the substrate. The formation of a chemical union is enabled in “clean” surfaces, free of contaminants, with intimate contact of the adhesive with as many high-polarity sites as possible.

11. a) The nature of the surfaces to be bonded (polarity, porosity). b) Application method (speed, tooling). c) Open time (tack and range). d) Temperatures of application and end-use. e) Chemical resistance (product volatiles).

12. In PVA emulsions, the suspension of the colloids will break as soon as the water is reduced beyond a critical point and the individual polymer units coagulate to create an adhesive film with adequate bond strength. This series of events enables faster application speeds than with dextrin adhesives, which require more time for water evaporation to set.

13. **a.** False. **b.** False. **c.** True.

14. In thixotropic fluids, the resistance to movement changes with the shear rate of the fluid, i.e., stirring a viscous thixotropic fluid will result in a decreased viscosity.

15. The adhesives exhibit various degrees of thixotropy. Because the method applying them (pumping, rolling, etc.) affects the shear, it is necessary to know their viscosity at the application shear rates.

16. Corona discharge generates ionized air in contact with the plastic via a high-voltage discharge that increases surface polarity on the treated film.

17. Labels and tape.

18. Solvent-borne, waterborne, 100% solids (solventless) and UV light/electron beam curable.

Chapter 15—Flexible Packaging Laminates

1. To combine the best of all material properties into a single package structure.

2. Co-extrusion combines the outputs of two or more extruders so that a curtain of ma-

terial exiting the extruder is actually multiple materials fused together. It is solventless, so there is no release of objectionable solvents.

3. Laminates for aseptic juice packages usually consist of seven material layers. Paper provides body, while aluminum foil provides a barrier. The ionomer provides a superior bond to the aluminum metal.

4. EVOH and OPP. EVOH is used as a high-oxygen barrier. However, EVOH absorbs water and must be sandwiched between materials that will keep moisture away from it. Oriented polypropylene's (OPP) combination of excellent base properties at an economical cost makes it one of the most popular materials for wraps and laminates having sparkling clarity. Foil and metallized film are other non-transparent options.

5. Wet bonding requires that at least one substrate be porous enough to allow adhesive solvent or water to escape. (See Figure 15.13) Almost invariably, this substrate is paper. Adhesive is applied to one substrate, the two substrates are nipped together and the whole is sent through an oven to set the adhesive. In dry bonding, adhesive is applied to the substrate and then dried of solvents. (See Figure 15.14) The resinous adhesive is either tacky or can be activated and set by heat. The second substrate is joined by a heated nip against the first to create the bond.

6. Pouches made on a VF/F/S machine feature a seal across the pouch top and bottom and a vertical seal across the center of the back. Pouches made on HF/F/S machines are characterized by a three-sided edge seal.

7. It will increase to 1680 mg/100 sq in/24 hrs.

8. **a.** PET and polycarbonate have the highest use temperature. **b.** Paper or polyethylene for bulk. **c.** Meat or cheese packs that have one part of the web drawn to a product-conforming tray require easy formability of the web stock. The web stock also needs to have clarity to show off the product, and it must have good oxygen-barrier properties. This combination of properties is best found in nylon-based laminates or nylon extrusion-coated structures. **d.** Ionomers are used when high melt strength is needed. Ionomers tolerate contaminants and create adequate heat seals across greasy contaminants and have superior adhesion capability on metal surfaces.

9. Material plies are properly listed from the outside of the package to the inside.

10. .0015" = 1.5 mils.

11. Barrier is a nonspecific word that describes a material's ability to prevent gases from permeating through the volume of the material. As can be seen in Table 15.5, the barrier qualities of a given material vary, depending on the gas being permeated. It is not enough to say, "We need a high-barrier material." The gas to which a barrier is required must be specified and quantified.

12. Time/temperature/pressure data should be developed for all heat-sealing systems. (See Figure 15.9) Excessive combinations of time, temperature and pressure tend to force melt from the seal area and create a weaker seal.

13. Coefficient of friction, yield point and sealability.

14. HF/F/S machines can have many operating stations grouped along the horizontal travel path of the pouch. This allows for multiple filling heads, steam purges and other activities.

15. A poor hot-tack seal might not be able to resist peeling apart, even though it is still hot.
16. Ensure that the EVAL film selected is a barrier to the organics in the soup, and also assure that a very good moisture barrier is used in the structure.
17. A fin-style vertical seal is easier to make because it brings together two inside heat-seal-coated surfaces.
18. Pouches made on HF/F/S machines are characterized by a three-sided edge seal. An advantage for graphics is that both front and back panels are free of seals. HF/F/S pouches can be accommodated easily to produce gusseted stand-up pouches and provide an attractive billboard for a product.
19. Appearance –packaged mints; barrier properties–raisin pouch; dead-fold –margarine wrapper; friability—single-dose tablet package; hygienic—tamper seal on sterilized a pharmaceutical bottle; conductivity–susceptor film in a microwave package.
20. Foil coating may render the foil surface heat-sealable, increase the foil's scratch or scuff resistance, increase tensile or burst strength, produce a specific surface (e.g., slip, nonslip, release, decorative), improve adhesion of other coatings or printing inks, enhance the water-vapor/gas-barrier properties of light-gauge foils, increase foil's resistance to corrosive agents or products, impart high gloss and three-dimensional depth to foil decoration or printing and lubricate during converting or processing operations.
21. In the thinner gauges used for most packaging (as low as 7 micrometers/0.000285 in.), foils suffer from pinholing—minute holes through the foil. Pinholing increases as foil gauge decreases and is a major pathway for gas penetration.
22. It is not uncommon for a prospective barrier laminate to have no measurable permeability in the flat but to have significant permeability when formed, folded and creased into a package.
23. Transparent lacquers and varnishes allow the brilliant reflective metallic sheen to show through. A transparent yellow lacquer gives the appearance of gold.
24. Vacuum-metallized paper gains the aesthetic appeal of a reflective aluminum surface.
25. The high vacuum within the chamber will boil away most of the moisture, but a small amount of moisture content—less than 5%—is still evident within the paper.
26. Oriented polypropylene (OPP), PET and nylon (PA).
27. Plastic film being metallized does not need to be sealed, smoothed or dried as a paper substrate does. In addition to adding decorative appeal, metallizing a plastic film significantly improves barrier properties to all gases.
28. Metallizing is used in "susceptor" packaging where the metallized component serves to create a local microwave energy "hot spot" (the aluminum converts microwave energy to radiant heat).

Chapter 16—Corrugated Fiberboard

1. Paper for boxes is made from any plant, including trees that contain woody cellulose fibers.

2. Differences in fiber source, manufacturing processes and even geographic location influence the quality; also, the intended end use of the paper is taken into consideration in making the paper.
3. Basis weight describes how paper grades are listed. It is the weight of 1,000 square feet of paper (U.S.) or the "grams per square meter" for Europe and other foreign markets.
4. There are similarities, but no direct correlation. Each type has a different end-use purpose and properties.
5. Performance versus cost and other economic factors drive the variety of different paper weights and finishes for containerboard.
6. Flute is the term that describes the wavy medium between the two faces of linerboard that make up corrugated. Flutes range from A, the thickest/tallest to E, the thinnest or even F or Micro, which have hardly any "wave" to them.
7. B and C flutes and BC doublewall comprise the majority of singlewall board in the U.S.
8. A, E, F and micro flutes are used in niche markets and for special-purpose packaging where volume justifies the different board type.
9. Flutes provide cushioning in the direction perpendicular to the liners and load-bearing capacity along the plane of the board. Smaller flute structures can be combined into doublewall and triplewall board, which use more paper than singlewall but may enable the use of lighter papers to meet box strength in some applications, and improved visual quality in others.
10. Because the main ingredient in corrugated adhesive is food-grade corn starch. Corn starch plus water makes the glue that adheres the medium to the linerboard.
11. Boxes, through adhesives, can be made moisture-resistant and water-resistant, but not fully waterproof.
12. Chemicals can be added to the starch to increase moisture or water resistance. Also, boxes can be wax-coated or plastic-coated inside and outside to help hold them together. Some box styles add to the ability to hold ice or wet product without the box coming apart.
13. A die-cutter uses a die to cut and score the combined board into shapes. Die-cutters make die-cut boxes and combined board pieces with unique designs. Die-cutters also can make perforated lines, ventilation holes or access holes in boxes.
14. Box board comes from the corrugator as a flat sheet, perhaps containing some scores. "Converting equipment," such as printer-slotters, flexo folder-gluers, tapers, gluers, stitchers, die-cutters (flat bed and-or rotary) transform the flat sheet of corrugated board into a box.
15. A printer-slotter can print onto the box board, add scores (creases) and other minor operations. A flexo folder-gluer can print, slot, fold, glue and stack completed boxes for delivery. Some flexo machines even have rotary die-cutting sections.
16. The predominant boxmaker's joint today is adhesive. It is quick and can be automated into the flexo folder-gluer, and tests have shown that with the proper dimen-

sions, adhesive joints are stronger than either stitches (staples) or tape, both of which are slower and have less desirable characteristics.

17. They are a good example of sustainable packaging. Whether the boxes are brown or white, made from newly harvested fiber, 100% recycled fiber—or something in between—the fibers that make up the box were once in a growing plant. In the papermaking process, the fibers are separated but still retain their cellulosic structure and other attributes of the original plant.

18. Decades ago, the answer was no, but with preprinted linerboard, spot labels and halftone flexographic plates, some surprisingly sharp graphics are being printed on corrugated board. Board quality is the biggest factor in achieving an acceptable image.

19. Complex prints can be beyond the capabilities of some box plants. In these cases, a designer may suggest using a preprinted liner, a liner that is printed prior to the corrugating process. Preprinted linerboard, preprint liner or preprint adds to the cost of the packaging or display since the printing of the liners often isn't done at the same facility where the box is produced, which increases transportation costs. But preprint offers a much higher quality of graphics and will not contribute to a loss in compression in the process.

20. To be covered under the general liability provisions of the rules, an Item 222/Rule 41 box must carry a circular box manufacturer's certificate (BMC) on an outside panel. Without the BMC, carriers are not obligated to honor damage claims or established freight rates. Boxes can be made to either the burst (Table A) or ECT (Table B) provisions of these rules.

21. The Mullen Test determines the burst strength of a box, ECT determines the stacking strength. The Pin Adhesion Test measures the force required to separate the flue tips of corrugated medium from the linerboard facings of corrugated combined board.

22. Preconditioning followed by conditioning at standard conditions is required to ensure that the equilibrium moisture content of a sample is reached. This process is required by all standard test methods to minimize the hysteresis effect inherent in paper.

Chapter 17—Distribution Packaging

1. At the inception of a product's design.

2. Such a product, designed only with its end use in mind, is likely to increase the manufacturer's costs for protective materials. Additional costs are likely if the product doesn't fit efficiently into a standard distribution system.

3. "Fragility" describes a product's susceptibility to damage and addresses the following questions: What is the safe working load? What are the critical drop and "G" levels? What are the resonant frequencies and their response to random vibration? What are the critical temperatures? What is the critical humidity? What is the projected shelf life? What is the critical discharge voltage?

4. How will the product be handled? How will it be stored? How will it be transported? How high will it be stacked? What will the temperature and humidity range be? How many times will it be transferred and handled? What kind of pallets will be used? Will it be unitized or containerized?

5. 13 % free space exists within the pallet envelope.
6. Product design (fragility), the distribution environment, the primary container as a shipping container, complementary primary and shipping containers, dimensions for maximum efficiency, ease of (package) assembly and disassembly, multiple use and reuse, compliance with legal and/or carrier requirements, disposal of packaging waste material, efficient materials handling.
7. Static compression, dynamic compression, piercing and puncturing, racking and deformation, elevated temperature, reduced temperature, low pressure, light, moisture/water, biological hazards, time, contamination.
8. The damage and loss is mostly attributable to higher humidity.
9. Compare packaging and damage costs and balance them with a desired acceptable damage rate coupled with preshipment testing.
10. 48 in. × 40 in.
11. A household toaster may be packed in a primary paperboard carton; six toasters may be packed in a corrugated box. However, the sturdy corrugated box may go only as far as the local distribution warehouse. From that point, the actual distribution container may become the carton that houses each toaster.
12. To find the minimum system costs, the total distribution costs—including packaging cost and damage cost—must be established.
13. Odd shapes do not pack well in a mixed-product pallet load.
14. Slip sheets are economical, take up little space and are light. However, the equipment is not universally available and is more expensive and slower to operate. Pallets are universally adaptable to a variety of handling situations and locations. However, they are costly and consume space, and disposal can be difficult. Clamp trucks use no added materials, but the geometry and character of the load must be such that it can be squeezed between the truck's clamps.
15. The Food Marketing Institute holds pallet issues responsible for about half of all observed damage and cites poor pallet footprint as the single largest cause of shipping damage. Of this damage, 50% is attributed to poor pallet stability and 35% is attributed to poor pallet overhang.
16. More pallets are needed, more stretch-wrapping is needed, more storage pieces are needed in the warehouse, more tractor-trailer loads are needed to transport product and forklift trucks operate longer.
17. Strapping, stretch-wrapping, high-friction inks/coatings and high-tack packing adhesives.
18. 30 days at 32°C (90°F) and 80% R.H., stacked two loads high.
19. Pre-shipment testing reveals inadequate product design or packaging long before it starts costing money.
20. The product, package and distribution environment.
21. ASTM D999, ASTM D5276 and ASTM D3332.
22. Code of Federal Regulations CFR Title 49 Part 178.

23. Both NMFC and UFC require container materials to meet minimum specifications detailed in Item 222 and Rule 41 of their respective carrier rules.

Chapter 18—Shock, Vibration and Compression

1. Shock is an impact characterized by a short-duration, relatively high-intensity dynamic event with a sudden change in velocity. Resonance describes the condition in which a vibration input is amplified.
2. 8.4 kilometers per hour, or 5.2 miles per hour.
3. Heavier products probably have a lower probable drop height, there is little control over drop orientation with small packages, handholds reduce the probable drop height, address labels will orient the drop to a label-up position, unitized loads will experience fewer drops than individual packages and cautionary labels have only a minor effect on either drop height or the number of drops.
4. Shock can frequently damage the contents during a flat drop onto one of the faces, without damaging the container. Shock can damage the contents due to insufficient cushioning protection without adversely affecting the package.
5. Frequencies below 30 Hz.
6. Vibration damage from relative motion and vibration resonance.
7. Stack resonance occurs when the bottom container goes into resonance and passes that input to the container above it. This happens in succession for all containers in the stack until the top container bounces off the top of the load.
8. The greatest damage to the container is from edge or corner drops and greatest to damage to the contents is a flat drop on one of the faces. Re-evaluate the amount of cushioning protection for the product.
9. The label tends to orient the drop to a label-up position.
10. Direct coupling, where output equals the input; resonance, where output is greater than the input; and isolation, where output is less than the input.
11. Hertz and frequency.
12. Compression strength is a dynamic value measured over a short time, stacking strength is measured as a static value over time.

Chapter 19—Packaging Law

1. Packaging law involves regulations at the national and state level. These can be politically driven by a hierarchy of U.S. constitutional and congressional laws that assign regulatory agency powers and instructions for those agencies to make or “promulgate” regulations intended to implement provisions of the law.
2. News about federal rules and regulations are published in the Code of Federal Regulations (CFR).
3. The Food and Drug Administration (FDA).

4. California Proposition 65 regulation requires warnings be provided to consumers regarding chemical substances deemed by the state of California to be carcinogens or reproductive toxins.
5. The Toxics in Packaging model legislation addresses restrictions for heavy metals, phthalates and PFAS substances potentially contained in packaging.
6. Child-resistant packaging gives authority to the Consumer Product Safety Commissions (CPSC) and is published in Title 16 CFR Part 1700 (of the Code of Federal Regulations).
7. The Federal Trade Commission (FTC) issues guidelines for environmentally-friendly products that make claims related to recyclability, biodegradability or compostability.
8. The FDA enforces the FPLA for labeling of food, drugs, devices and cosmetics. The FTC regulates all other consumer products subject to the statute.
9. It is best to first determine which government agency has authority over a particular product category to understand the labeling requirements.
10. Three areas of intellectual property laws are patents, copyrights and trademarks.

Chapter 20—Packaging Machinery

1. Reduce station inefficiencies and increased production line output.
2. Free-flowing liquids, viscous and pastes. Controlling them prevents spillage if the container is not present in the filling position.
3. When an accurate product volume is required. They are used for high-cost products and pharmaceuticals or chemicals requiring accurate dosage rates or non-free flowing viscous and paste products.
4. Discrete items filled by counting systems, free-flowing products filled by cup or flask filling, non-free-flowing products filled by auger fillers and low-density products filled by vacuum-volumetric fillers.
5. For customer satisfaction that demands that all containers be filled to the same level, i.e., low- or moderate-cost products such as soft drinks and beer, when accurate volume is not as important as keeping a visually constant-fill level.
6. Buy state-of- the-art equipment when significant capacity increase is needed. Retrofitting, refurbishing, re-building existing equipment when only a small increase in capacity is needed. Buying refurbished equipment when time constrains are the limiting factor. Hiring a contract packager either for slow initial growth or for temporary product-demand surges.
7. Since products and packages come in different forms and materials, machine manufacturers have to accommodate different customer needs. Packaging machines must be designed according to customer specifications.
8. Straight-line machines (intermittent motion) have limited speed, compared with rotary machines. The versatility of a straight-line machine for container size and style is greater than for a rotary machine. The cost per unit for changeover in straight-line is lower for rotary.

9. The angle of repose defines the flowing behavior of the powders or granules, as the flatter angle indicates a consistent density, forming a fairly flat cone upon pouring. Selecting a filler for the non-free flowing powders should not be based on gravity alone, and provisions must be made for physically assisting the product through the filler.

10. The theoretical throughput of this production line is 259.2 cpm as a result of the lowest theoretical capacity station (TE applicator $260 \times 99.7 = 259.2$). The other two stations have higher theoretical capacity ($275 \times 97.5 = 268$ and $290 \times 91.60 = 265$).

11. The auger filler operates on the principle of centrifugal forces throwing product off a bottom disk of a tube. The volumetric cup filler operates on gravity, where the product feeds open bottom cups passing under a product hopper. The vibratory-feed filler operates on the net-weighing principle that employs weigh cells receiving product via a vibratory advancing station.

12. The computer-combining techniques operate on feeding approximate quantities of product on several weighing stations in fractional amounts of the target weight, discharging it into holding buckets. Load cells determine the weight in each bucket and enter the data into a microprocessor that calculates the optimum combination of buckets closest and above the target weight for discharging the product to the container. The major advantage of the combination scales is their accuracy while minimizing product giveaway.

13. Bottom-up fillers are important for semi-solids and foaming products, because they eliminate air pockets, frothing and aeration, while preserving volatile products by preventing evaporation.

14. Gravity-type fillers have applications limited to free-flowing products with consistent density. They cannot accommodate granular and fragile products and those with the potential to trap air, bridge and agglomerate.

15. Vacuum-volumetric fillers are used for low-density and fluffy powders, which entrap large quantities of air, such as talcum and cocoa powders.

16. The rigidity of the container affects the choice of filler. A glass container is appropriate for a vacuum filler. However, a plastic container requires a pressure-vacuum combination to dispense viscous foaming product.

17. JIT manufacturing is based on minimum inventory, while the prolonged changeover requires a larger inventory. A rapid changeover enables JIT by reducing the amount of inventory.

18. The plots of production volume against the costs of inventory and changeover present intercepting points of the two costs, called "economic order quantity." EOQ can be used to define the most economic inventory size for a given cost of changeover.

19. New packaging lines may consist of several functional stations for various suppliers located in different countries connected by conveyors and buffers supplied by still another supplier. Therefore, the new lines require a long commissioning time to be brought up to operating speed.

20. Upgrading existing equipment has the following advantages: proven technology for in-house machines, no capital cost for upgrading existing machines and reduced initial training and commissioning problems. Purchasing used equipment usually is 30% less expensive than new machines of equal performance with shorter delivery and start-up times.

21. In a typical production line, the most critical station will define the benchmark speed of the line (usually the filler), with all upstream equipment preceding the filler specified at a higher speed than the filler to ensure the filler is never starved of containers. The downstream machines must also run faster than the filler to pull product from the filler and avoid creating a backup problem. The design speed of each machine past the filler increases as the line gets farther from the filler.

22. The infeed starwheel changes the direction of the container flow and either inserts the containers into the filling turret or moves them back out onto the conveyor as needed. The timing screw on the conveyor feeding containers into the starwheel is necessary to separate the containers to the correct pitch.

23. To minimize changeover time, efforts should be made to eliminate the need for tools, externalize or "off-line" tasks where possible, make all settings to quantified scale, perform changeover from one side of the machine and in one direction and to have a single documented procedure for all operators.

24. Design speed is the theoretical capacity under perfect running conditions (running empty, cycle rate). Capacity is the upper sustainable limit of quality packages passing a point just before warehousing. Run speed is the instantaneous operating rate at a point in time. Line output is the exact quantity of quality product passing a point just before warehousing or shipping at a given time.

25. Diaphragm fillers provide precise volume with no risk of product contamination from seals due to abrasion and wear.

26. Working time is the time the workforce is paid for an uninterrupted period. Available production time is the time the line could operate under fully loaded conditions (working time minus incidental stops such as breaks, setup, start-up, run-out, maintenance and upkeep). Overall running time is the above-described available production time minus non-equipment-related downtime. Actual productive running time is the overall running time minus any equipment-related downtime.

27. The machines before and after the buffer need to be capable of temporary increases in speed to ensure that the buffer can be partly refilled when empty and to partly empty when it is filled to capacity.

28. The installation of too many buffers can slow the production line down by reducing the overall line efficiency due the contribution of the multiplied efficiency factor of each buffer.

29. Population, as it relates to statistics, is the total of all possible objects of the same kind from which a statistical sample is drawn. Sample is a quantity of product, drawn from a specific lot or process, that is reasonably representative of the product for purposes of testing or evaluation. Specimen is an individual unit within a sample.

30. A standard distribution curve has the mean, mode and medium values at the same point, and the slopes on both sides are symmetrical about the mean. The tails of the sloped sides continue to infinity.

31. A standard deviation is a value that quantifies the dispersion of a set of values relative to the mean.

32. A 68.25% of the measurements will be one sigma. A 95.46% of the measurements will be two sigma. A 99.73% of the measurements will be three sigma.

33. The X-bar records datapoints distribution about the mean values in relationship to the upper control and lower control limits. The R chart records correlations between the deviations of data and their ranges.

34. Critical considerations include payload weight, speed, the number of axes, work envelope, footprint, accuracy and repeatability, associated safety requirements, programming and training needs.

Chapter 21—Applied Packaging

1. Blister packaging uses a preformed plastic shape that holds the product and is heat-sealed to a backing card. Skin packaging places the product on a backing card and uses a vacuum to draw a plastic film into close conformity to the object.

2. Polyvinyl chloride (PVC) is the most common material. Other materials used include polyethylene terephthalate copolymer (PETG) and polystyrene (PS).

3. Polyethylene or ionomer. Ionomers are retail materials of choice as they have good clarity, are abrasion-resistant, are exceptionally tough and have rapid cycle times.

4. Clay-coated paperboard rarely is used since the clay seals the board surface, increasing the difficulty of pulling a vacuum.

5. The spiral wound and convolute wound processes.

6. Metal tubes offer high barrier and prevent air ingress after dispensing, due to dead-fold properties.

7. Full-body printing using a variety of print methods to achieve high-quality artwork.

8. Metal tubes, highest; laminate tubes, very good; coextruded tubes, good; extruded tubes, lowest.

9. Hoop strength for side wall integrity, stable base shape/profile and a neck opening allowing for product access.

10. Neck finish should accommodate a closure or sealing system appropriate for product dispensing and protection. Neck ID should be wide enough to allow for efficient filling on manufacturing lines. Neck finish and shoulder should have geometry and thickness adequate to accommodate necessary top-load strength and shock impact during transit.

11. The bottle may have poor top-load strength and thin areas in sidewall.

12. The “quiet zone” is a specified area that must be kept clear of any other printing or features a scanner might mistake for a bar code element. This area identifies the start and end of a bar code to the scanner.

13. The scan determines the ratio of bar width to space width. This enables the scanner to read the bar code from different angles.

14. A five-digit group (manufacturer's identification number) identifies the manufacturer or organization controlling the product label. A second five-digit group (item code) identifies individual items within the company or organization controlling the product label.
15. The scanner would not see a bar code.
16. Black, blue and dark green are recognized as a bar.
17. Bare metal refracts light, so a scanner treats it as a bar. Therefore, a white block should be printed behind dark bars, or the white block can be reversed out to show metal "bars" that the scanner will register.
18. Reduction of both product diversion/counterfeiting and shoplifting.
19. Densities in kilograms/cubic meter.
20. A three-way corner joint eliminates the need for weak end-grain nailing.
21. The rigidity of a structure is most significantly improved by diagonal bracing members.
22. Moisture, ultraviolet light and oxygen exposure.
23. Gang run printing refers to multiple print orders being placed side-by-side on a sheet of paper and printed together. It is typically disallowed, as each created component must be tracked and inventoried or disposed of in pharmaceuticals.
24. Validation is the documented act of demonstrating that a procedure, process or activity will consistently lead to the expected results. In pharmaceuticals, it is a process followed to gain permission to manufacture and distribute and sell drugs.
25. Recycled and reground plastics are not allowed for direct contact because of the potential for contaminate migration into the drug product.
26. Precision molding provides a more exactly dimensioned, smoother and denser surface. However, it is slower and more costly than the standard method.
27. The convention for dimensioning a paper bag is face width and finished bag length for flat constructions and face width, gusset width and finished bag length for gusseted bags. Layers of multi-ply paper bags are listed from left to right and going from internal layer to outside layer.

Chapter 22—The Package Development Process

1. It must be viewed as part of a larger system, with many stakeholders such as purchasing, receiving, warehousing, material handling, production, marketing, shipping, sales, design). Each department has its own requirements, but not all are compatible.
2. To effectively showcase a strong product so it attracts first-time buyers and generates repeat purchases.
3. For a totally new product, there is neither a history of consumer attitude toward the product nor any existing marketplace experience on which to base design direction. Between 30,000 and 40,000 new products are launched annually and the competition for survival on shelf is intense.

4. Packaging responsibilities at different companies vary among departments. The company philosophy and view of packaging's role can be different and change, and in the overall process, departments come into play. Information flows continuously through various departments several times during the course of a project, coordinated through the "package design function."
5. Sales targets, increased sales, environmental needs, customer needs, market conditions, reduced costs, maintaining or improving market share. To revitalize a dormant brand and increase sales or provide new convenience or improved utility to the consumer.
6. A package design brief is a comprehensive document containing information that summarizes what the design should achieve. It provides project details for each stakeholder to ensure all needs are met.
7. Facts to know about the competition include their target markets, the packaging that is used, package unit sizes, sales volumes and colors used on graphics and key call-out benefits on their packaging.
8. The supplier knows its business best. Early contact with the supplier identifies the supplier's strengths and position in the marketplace on which to base package designs. Suppliers can be aware of new technologies on the horizon and are aware of methods that can keep costs in line and quality at its peak.
9. Suppliers and internal staff will opt for the package and quality standards that best suit their needs and are easiest for them to develop.
10. Packaging specifications help to identity and negotiate a supply of packaging materials and components of adequate quality from suitable suppliers that conform to the specified requirements. The specs communicate the exact needs to the supplier, provide the supplier with a basis for judging and accepting packaging and enable suppliers to bid on a fair and identical basis. Also, they serve as a benchmark for improvement and as part of a contract if disputes arise.
11. Overly tight tolerances may limit the supplier pool or make the package difficult to manufacture, thereby increasing cost.
12. A jointly drawn-up specification will help determine whether the supplier is capable of producing the package at the level of quality desired. It will help deliver universal agreement on the critical values, measuring method, classifying defects and the tolerances necessary to achieve satisfactory machinability.
13. A material specification provides material indicators to produce a quality product. It identifies the critical properties of the raw materials and package. A performance specification details the protocol and test methods used to qualify the attributes of the materials specified, as well as the desired end result.
14. Machinability, performance and aesthetics.
15. A consistent specification format, responsibility for and an explanation of how specs are written and issued, where they are kept and who receives a copy, how a spec is revised or withdrawn, and implementation and a course of action when events occur outside of the specs.
16. The three general classifications of defects are: 1–Critical: Defects that prevent the

package from fulfilling its purpose. 2–Major: Defects that likely will reduce package performance under stressed conditions, although the package might perform adequately under most conditions. 3–Minor: Defects that are mostly aesthetic and do not substantially reduce package function.

17. a) Identify essential factors and characteristics for meeting acceptable machinability, performance and aesthetics. b) Identify the ranges in which characteristics can vary and still meet expectations. c) Select evaluation procedures suitable for quantifying or otherwise describing each characteristic or attribute.

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