Design and carton construction

How is paperboard used and how can you get the most out of it as a material? Whether you are using the paperboard for a book or brochure cover or for a packaging it is important to have a detailed knowledge of how it should be handled and what demands will be made on it from the various players involved in the chain between manufacturer and consumer or sender and recipient. Matching the requirements for an appealing design with the requirements for cost-effective production, simple logistics and good functioning in a retail environment is not an easy task. In the following chapters we have chosen to focus on functional requirements, mainly in the packaging chain, before we go on to describe paperboard properties that affect your choice of the most appropriate material.

The appearance of a package or graphical product is decided during the design process. Paperboard is a versatile material which provides an almost endless number of possibilities. This means that when designing shapes the only limitation is your own imagination. The design comprises both the surface appearance and the shape or structural design, and these two aspects of design are discussed separately.

Brand owners and designers need to have a good understanding of the different stakeholders and their respective needs in order to make the most of the packaging and its potential.

Examples of influencing factors
- the brand itself
- the core product
- printer/converter
- packer/filler
- distributor
- retailer
- consumer
- legislation
- non-governmental organisations such as environmental organisations.

Surface design
The surface design of a packaging or graphical product based on paperboard comprises the effect of its print presentation with the possible additional use of varnishing, embossing, hot foil stamping, extrusion coating or lamination.

The end user must define and describe the surface design needs of the packaging or graphical product. This usually relates to the promotional and information needs concerning the product and its use.

The designer has to prepare suggestions to meet the surface design needs described by the end user. This may have consequences concerning the choice of conversion process, which in turn affects the choice of paperboard.

The converter has to reproduce the ordered quality in such a way that it conforms with the agreed surface design using the specified paperboard.

The best basis for achieving the desired visual impact is by using paperboard based on primary fibres with uniformly white-coated surfaces with a high smoothness and a good print reproduction.

When discussing surface design we usually mean the exterior or print side of the product. Aspects of surface design, depending on the product and its use, may also apply to the reverse side or inside surface. The inside surface may be printed, as with chocolate and cosmetics cartons, or it may be important to convey a hygienic image, as with food and pharmaceutical packaging.

Examples of surface design
Features which can be used in surface design are described below. Often a combination of techniques is used.

Text and pictures bring the product’s message to the customer. The shape and colour create an image for the product. High whiteness together with smoothness give good print reproduction.

Key paperboard properties
The decisive paperboard properties for achieving good design are:
- printability
- whiteness
- surface smoothness
- ink absorption and drying
- rub resistance
- lightfastness
- strength and elasticity.
<table>
<thead>
<tr>
<th>Text, colour and images</th>
<th>Description</th>
<th>Achieved by</th>
</tr>
</thead>
</table>
| Printing                | Text and pictures bring the product’s message to the customer. The shape and colour create an image for the product. High whiteness together with smoothness gives good print reproduction. | • choice of paperboard  
• print method  
• post print finishing |
| Metallic appearance     | A metallic appearance is effective in giving the product a luxury image. | • choice of paperboard  
• aluminium foil lamination  
• metallised polyester film lamination  
• metallic ink printing  
• hot foil stamping  
• cold foil transfer  
• effect varnishes |
| Glossy or matt appearance | A way to attract attention is to create a contrast between glossy and matt areas of the design. | • choice of paperboard  
• varnishing  
• gloss PE extrusion coating  
• film lamination |
| Relief                  | An overall effect such as a linen finish or high relief of specific parts of the design will give the product an exclusive image. | • choice of paperboard  
• embossing & debossing  
• effect varnishes |
**Structural design**

Paperboard is widely used for graphics and packaging applications where its versatile cutting, creasing, folding, locking and gluing properties, together with its strength, make it suitable for a wide range of functional and creative structural designs.

Both creative shape and functional shape are important aspects of the structural design. Packaging applications have to meet functional needs, such as protection during distribution and storage, and ease of handling and display at the point of sale, as well as fulfilling the consumer’s demands. Creative design is used for promotional purposes. The graphics designer has the freedom to use a wide range of shapes.

Critical aspects of structural design differ depending on both the conversion and packing processes and also the ultimate end use. To a converter these are the qualities of stiffness, creasability and flexibility and the ease with which paperboard can pass through the conversion process.

An end user only sees the final carton shape. The critical aspects are good presentation, effective protection and durability, when prolonged or extended use is required. From a sales or promotional point of view the visual appeal is vital. Structural design provides creative ideas for promoting new products but perhaps the main responsibility is to provide a functional shape which in the majority of cases is based on accepted or specified carton shapes.

**Popular carton shapes**

The potential of paperboard to provide an almost endless range of carton shapes is considerable. Some of the more popular shapes are described in the following table together with the specific requirements these place on conversion and end use.

<table>
<thead>
<tr>
<th>Type of carton shape</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Simple rectangular or square carton shape</td>
<td>The rectangular or square cross-section with a large or main display panel is the most widely used carton shape. It is based on a simply cut and creased square or rectangular sheet, or blank, of paperboard. The carton is side seamed, leaving ends which are closed after the product is loaded. The product, method of filling and the way the pack will be stored and displayed will have a major influence on the dimensions. The ratio of the sides of the main panel is usually between 5:3 and 5:4 as these dimensions display well. This may not be possible if the product is an object or objects with differing dimensions. The rectangular shape also makes efficient use of space in storage, distribution and merchandising. Shelf stability of the pack will also be taken into account in defining panel dimensions as well as the facings expected to be made available for display with products sold through supermarkets. The dimensions of the unit package also influence the dimensions of the transit outer (secondary packaging) and the pallet plan. It is worth considering the latter at an early stage as a difference of a few millimetres in one or two dimensions can significantly affect distribution costs. This style of carton is widely used for cigarettes. It includes a U-card inner frame, which assists the packing of the product, is part of the unique flip-top closure and increases the compression strength. Security and additional pack protection is achieved by the use of an overwrapped heat-sealed clear film.</td>
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<tr>
<td>Hinge lid carton</td>
<td></td>
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## Type of carton shape

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<tr>
<td>These designs give added strength and rigidity. A popular use is for assortments of chocolate confectionery. They may have double-walled hinged lids or separate lids and bases.</td>
<td>Flanged and double-walled carton</td>
</tr>
<tr>
<td>Two popular applications are available: 1. Thermo-formed trays made from extrusion-coated paperboard enabling lids to be applied by heat sealing. These trays may be slightly tapered. With a heat-resistant plastic extrusion coating, e.g. PET, these trays are used for heating chilled and frozen foods in microwave and conventional ovens. These trays can also be used to cook bakery products. 2. Shallow trays (25–38 mm deep) with glued or locked corners to hold groups of cartons or other types of packages for stretch and shrink wrapping.</td>
<td>Trays</td>
</tr>
<tr>
<td>These cartons comprise a tray erected carton (glued or locked corners) with a hinged top flap. The product is loaded from above, i.e. top load. There are two main types of closure: 1. The top flap has an extended tuck in flap feature which tucks in and can lock into the front panel of the tray. This type of pack is usually film overwrapped for product protection and security. 2. The top flap is extended on three edges which fold down over the outside of three of the sides of the tray and are sealed by hot melt adhesive. Alternatively, if the paperboard is PE coated on one or two sides the closure can be made by heat sealing.</td>
<td>Top load tray erected cartons</td>
</tr>
<tr>
<td>These cartons can be used to show the product inside the carton. The windows can simply replace cut-outs of the paperboard in one panel or form part of patented, more sophisticated systems in which the clear plastic incorporates creases and replaces paperboard on two or more sides of the carton.</td>
<td>Cartons with windows and plastic panels</td>
</tr>
<tr>
<td>These cartons may have crash lock or lock end bases and specially designed top flaps. The cartons hold a number of unit packages which are sold individually from the outer in a point of sale display. The top flap and, optionally, additional portions of the side panels are creased and perforated so that they can be opened and partly tucked down behind the product and the back panel, thereby attracting attention to and promoting sale of the product.</td>
<td>Display outers</td>
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## Design and carton construction

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<td>Lined cartons</td>
<td>In this style a flexible material (paper/PE, paper/foil/PE, etc.) is either positioned inside a side seam glued carton blank by the cartonmaker, or is applied on the packaging line. The base of the barrier material is then sealed or folded on the packaging line, the base of the carton sealed, product filled, pouch sealed or folded and finally the top carton flaps sealed or tuck-in closed. Associated with this type of design are cartons incorporating plastic ends, tamper-proof, and product protecting diaphragms. These cartons can be used to protect sensitive products, they can be gas flushed or vacuumised, e.g. for coffee, and they can be liquid tight or provide protection against the ingress of moisture vapour.</td>
</tr>
<tr>
<td>Cartons with internal display fitments</td>
<td>These have paperboard fitments inside the carton which support and display the contents. The carton may have a top opening hinged or separate lid or it may be a windowed carton of the types already described. The fitments may be integral parts of the carton blank or separate structures added during the packaging operation. Another type of fitment is a divider. These can also be either an integral part of the carton blank or a separate fitment.</td>
</tr>
<tr>
<td>Sleeves</td>
<td>Paperboard sleeves can be wrapped tightly around other items, e.g. a ready prepared meal in a lidded tray, “six pack” for plastic pots or other containers, or pre-wrapped products such as cheese. The sleeves are sealed by either locking tabs or adhesive.</td>
</tr>
</tbody>
</table>
| Sleeves with inner sliding components         | Typical examples are:  
1. matchbox  
2. hull and slide cigarette carton. |
| Other shapes of paperboard packaging          | Typical examples are:  
1. triangular shape, e.g. chocolate confectionery  
2. hexagonal shape, e.g. chocolate confectionery  
3. wallet style, e.g. hosiery  
4. tubes, e.g. tubes with paperboard or plastic ends for products such as confectionery and cosmetics.  
Other packages with a high degree of ingenuity in design. They display the product and often use additional paperboard fitments to support the product. Other additional confectionery products are often incorporated in the packages. These are usually, but not exclusively, associated with confectionery and toy packaging where they have a play value after use. In other product areas they are associated with gift packing. |
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<td>Cartons for hanging</td>
<td>This feature can be incorporated by extending the back panel of a rectangular fitment display shaped carton, folding the panel over and tucking it inside the carton. A hole may be punched through two thicknesses of paperboard which may be reinforced with a plastic clip for merchandising.</td>
</tr>
<tr>
<td>Cartons with curved panels</td>
<td>Interesting shapes can be created with curved creases or straight creases meeting other creases at other angles than 90°. Typical examples are: 1. curved panels 2. round corners.</td>
</tr>
<tr>
<td>Blister and skin packaging</td>
<td>A printed card, often printed on both sides, is used to support the product by either enclosing the product in a plastic tray, the flanges of which are then heat sealed to the card or, alternatively, by folding extended panels of the plastic over the edges of the card or by draping clear plastic over the product and sealing to the whole area of the card.</td>
</tr>
<tr>
<td>Tubs</td>
<td>For example ice cream tubs. Tubs of this type may also have circular paperboard lids.</td>
</tr>
<tr>
<td>Composite packages</td>
<td>Granular powder products e.g. retortable packages. Plastic and foil containing laminates with paperboard.</td>
</tr>
<tr>
<td>Plastic-coated barrier cartons</td>
<td>1. For example milk, fruit juice. Two-side PE coated paperboard and other plastic foil laminations on paperboard. 2. Cartons with PE on both sides can have heat-sealed side and end seals which are liquid tight and can give moisture vapour protection to the contents. These cartons can also have PE on the reverse only, in which case they may be sealed with a flexible diaphragm material having PE on one side to seal across the end closure.</td>
</tr>
<tr>
<td>Media</td>
<td>There are different solutions for covers entirely out of paperboard. They can have sliding components, a perforated or die-cut slit or folds that hold the discs.</td>
</tr>
</tbody>
</table>
**Closure**

The type of closure, opening feature and, where required, reclosure feature can be chosen from a number of design options. These features provide security and protection of the contents during storage, distribution and at the point of sale and, subsequently, convenience for the consumer.

### Types of closure

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<tr>
<td>Glued or sealed end</td>
<td>The style shown has full-depth overlapping outer flaps with the inner flaps meeting. This gives a leak-proof style for powdered or granular products in direct contact with the paperboard. The inner flaps never exceed the depth of the outer flaps as this would lead to an uneconomical use of paperboard. The outer flaps may be shorter than the depth of the carton, in which case they are known as economy flaps. The most common type of adhesive used is hot melt, although emulsion adhesives are also used. The position and pattern of the adhesive applied can be varied to suit the needs of security, opening and reclosure. Alternatively, if the paperboard is extrusion coated with PE (or other thermoplastic material) on one or both sides, secure closures can be achieved by heat sealing, usually with hot air or direct gas flame.</td>
</tr>
<tr>
<td>Tuck end</td>
<td>The top flap has an extended crease-hinged section which is folded through 90° and simply tucked down into the carton. With tuck-in flaps at each end there is a choice of whether they tuck in on the same side or on the opposite side. Small cuts at each end of the hinged tuck flap crease give greater security against accidental opening. For greater security and product protection a heat-sealed transparent overwrapping film can be used. An alternative is to overlap a self-adhesive label across the 90° angle between the end and main panel, i.e. over the tuck-in entry position. It is also possible to position adhesive between the underside of the tuck-in panel and the inner flaps. The tuck-in cannot then be opened without rupturing this glued area.</td>
</tr>
<tr>
<td>Lock end</td>
<td>1. Used as the base of a carton with a simple tuck-in flap at the top. 2. The carton has extra cuts in each side panel flap for extra security. For greater security and product protection a heat sealed transparent overwrapping film can be used.</td>
</tr>
<tr>
<td>Crash lock</td>
<td>The cartonmaker pre-glues this style, which is quickly hand erected by the packer. It is usually used as the base of a carton and can support a considerable weight.</td>
</tr>
</tbody>
</table>
Opening and reclosing features
The tuck-end carton clearly has an efficient method of opening and reclosure once the overwrapping film or other method of security is broken. There are several opening designs for glued-end cartons – some of which incorporate reclosure features.

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<tr>
<td>Tear strip</td>
<td>If the overlapping flap is full or nearly full depth, a tear strip with a lead-in tab comprising two intermittent lines of cuts can be incorporated across the full width of the panel between the glue line and the flap crease. This design is not normally used for reclosure, though it can be to meet special needs.</td>
</tr>
<tr>
<td>Perforation</td>
<td>Both overlapping flaps can be perforated in the same positions in two parallel lines so that by means of a lead-in tab both thicknesses of paperboard can be removed. This method of opening is not suitable for reclosure.</td>
</tr>
<tr>
<td>Pull tab</td>
<td>The edge of the outer overlapping flap incorporates a tab to facilitate pulling and tearing – not suitable for reclosure.</td>
</tr>
<tr>
<td>Perforated press opening</td>
<td>A push-in area is perforated in the top of the face panel, with the perforations extending and widening into the end panels, so that a clean tear-open is achieved, providing a partial reclosure.</td>
</tr>
<tr>
<td>Glue lines</td>
<td>Normally, the glue line is continuous across the full width of the end flap. If, however, the glue line is not applied in the middle area, a finger can be carefully slid under the flap so that by breaking the glued area to the right and left it is possible to open the carton. Reclosure is achieved by inserting a tab in the outer flap into a cut in the under flap. A variation of this form of opening is to replace the line of adhesive with a row of dots of adhesive which more readily break open. Another alternative allows the use of a continuous line of adhesive. In this case the underlapping flap is printed and varnished, leaving small areas without print and varnish such that good adhesion is only achieved over these areas. The perimeter of these areas can be scored so that tearing is limited to the areas of good adhesion.</td>
</tr>
<tr>
<td>Perforated panel</td>
<td>A perforated area in one of the main panels of the carton can be removed allowing access to the product, e.g. facial tissues.</td>
</tr>
<tr>
<td>Concora</td>
<td>Through a scoring (half-cut) on both sides (printed side + reverse side) of the carton, tear tabs can be worked out, guaranteeing a fail-safe opening of the packaging without the assistance of a plastic strip. The appearance of the sales packaging on the shelf will not be negatively affected by this scoring.</td>
</tr>
</tbody>
</table>
Design and carton construction

Conversion, packaging, and graphics finishing
The following operations are used by converters, packers, and graphic finishers to make creative and functional shapes.

**Creasing** makes the paperboard fold accurately along well-defined lines.

**Die-cutting** produces a blank for further conversion. It is usually performed at the same time as creasing. Perforations can be used to facilitate opening. Tabs and slits can be cut in separate panels. When tabs are inserted into the slits a self-locking permanent structure is created.

**Folding** is usually performed to 90° or 180° angles.

**Gluing** means applying glue on a side flap, pressing it to a carton panel and maintaining the pressure until the glue seam has set. The paperboard is converted to a permanent shape.

**Heat sealing**, heat and pressure can be used to seal plastic coated surfaces or surfaces to which a pattern of hot melt adhesive has been applied in an earlier operation.

Key paperboard characteristics
Stiffness is probably the most important property related to packaging structural design. As we have seen, this property is closely related to other strength related features, such as fibre composition, particularly in the outer layers, and thickness.

Important considerations for carton panels are stiffness, panel dimensions, paperboard grade and fibre orientation. Paperboard stiffness is anisotropic with respect to the machine direction (MD) and cross direction (CD).

Box compression strength is closely related to structural design requirements.

When packed cartons are stored or transported they are often stacked in such a way that the boxes are subjected to compression loading. In practice the strength requirement of the filled carton is dependent upon:

- Package design, i.e. shape and general strength due to the structure.
- Whether the contents support the package or not.
- Design and strength of transit package (the outer, etc.)
- Storage and distribution method – palletisation, stacking and climatic conditions.
- Conversion route – presence of barrier materials may be relevant in some methods of distribution.

Carton design must take into account the stresses that are likely to be exerted on creases during the packing process and also during end use. To this end, creases must be well formed to avoid premature failure under compression, and must also provide a crease stiffness that is suitable for the packaging operation. Folded creases and adjacent panel size must not exert unnecessary stresses during the gluing operation and subsequent handling and storage.

Key paperboard properties
The following paperboard properties are important for achieving good structural design:

- stiffness
- tensile strength
- compression strength
- box compression strength
- tear strength
- creasability and foldability
- elasticity
- density
- plybond
- lamination strength (for plastic coatings and laminates).