Corrugated Box Specification and Optimization

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Corrugated box specifications are often written for ease of purchasing comparison or simple validation rather than for end-use performance. This practice may not be ideal for optimization of either costs or sustainability. Given the functional needs of the packaging, the purchaser is better served by collaborating with their packaging provider to create a technical spec that provides flexibility for true optimization. That process must recognize existing variability in materials and distribution environments. It requires understanding acceptable failure rates, clear distinctions between critical and non-critical damage, and collaboration to identify root causes. No single metric can capture all box requirements; achieving further light-weighting and performance gains depends on multi-metric, trust-based producer–purchaser partnerships.

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Functional Specifications

There are many ways that one can set up the specification for a corrugated box so that key parameters are verifiable. Some are more related to actual end use parameters than others, and many are driven not by what is expected of the package but by what is easiest for the purchasing department to compare or to understand. As we move towards systems optimization, driven both by cost and sustainability goals, it is worth reconsidering how we specify corrugated packaging.

A functional spec states in plain English what we need from the product. Specification for a desktop computer might emphasize capabilities such as memory, processing speed, and the ability to run required software, rather than internal hardware design choices, reinforcing the idea of specifying what the product must *do*. For a package or packaging system, the functional spec goes well beyond "I want my box to work" by defining what "work" means, across manufacturing, distribution, and end use. A functional specification, the foundation on which practical specifications can be developed, must be provided by or developed in conjunction with the customer, as every customer will prioritize the jobs of their packaging in different ways.

From the functional spec, the purchaser and vendor can co-develop a technical spec. Producers can translate needs into measurable attributes and agree on what to specify. From an optimization perspective, specifications for non-critical attributes potentially add cost without adding value, and the customer should specify only what is essential for the package to function, resisting the urge to set specifications on ancillary properties.

Common Specifications

This approach is not typically how corrugated packaging is specified today. Packaging purchasers often seek to specify the basis weight of the components (e.g. 42KLB-23SCM-42KLB) under the assumption that assuring the mass of the material will provide consistent performance. This allows the purchaser to quickly verify that a package meets their materials requirement and also easily compare prices across suppliers. But the range in strength and other performance parameters across paper mills for a given nominal grade of paper can be significant (*e.g.* 15 to 20%, Frank and Jackson 2016), and any specification of this type can only be sure of the lowest strength. Relying on a material spec is unlikely to achieve either optimal cost or performance.

Many purchasers have switched to incorporating edge crush test (ECT) values into their requests for pricing, recognizing that this strength parameter correlates with box compression strength. They often use the common Box Maker's Certificate (BMC) values (NMFTA, FBA), and the shift from Mullen BMCs to ECT was the industry's first big effort to try to make the box specification correlate better with a functional spec. The BMC rules have precise definitions that make them seem scientific, but the architecture of the "levels" used is very coarse, so that a minor paper change often doesn't change the BMC certification one obtains, and a major upgrade does not require a change.

Both recipes and BMCs are challenged by a structure that limits optimization. If one producer's paper is 10% stronger than the other, the advantage cannot be leveraged if a specific paper grade is required. We might improve the distribution process to require somewhat less strength, but the large steps in the freight rules often give us no way to adjust the specified requirement. And neither of these specification methods guide how a package will form on an automatic case erector (where porosity and panel stiffness may both be important) or how it will effectively protect its contents in singulated parcel distribution. While convenient and effective in a broad sense, and while they may seem like reasonable technical specifications, they are too far removed from our functional specification to enable anything beyond coarse optimization.

Optimization

Corrugated boxes encounter many environmental impacts during distribution, including from time, moisture, handling, unitization, and transport (see for example Coffin 2005; Dunno *et al.* 2021; FBA 2025; Garbowski 2026). Hazard assessment tends to be conservative by design. Incorporating a series of conservative estimates to assure that *each* box will exceed what is needed in the most challenging distribution scenario leads to a situation where *most* boxes tend to be well over-designed relative to what they will experience. While extra caution may be justified for a small number of high-value products, minimum-value specifications (such as ECT) are usually overly conservative for most applications. Very few products require—or can afford—a zero-defect packaging system.

Optimization inherently acknowledges variation—not only in how materials are produced, but in how packages interact with real distribution systems and how performance is ultimately assessed. Every relevant property exhibits a distribution, as do our models for performance optimization (Frank and Kruger 2021). As designs move closer to true performance boundaries, some level of damage or failure becomes statistically inevitable. Meaningful optimization therefore requires explicitly defining acceptable failure rates, clearly distinguishing critical from non-critical damage, and collaborating across all stakeholders to understand and address the root causes of performance challenges and product damage.

A good technical spec is quantifiable, and it should be agreed to by both the producer and purchaser with respect to both the measurement method and metrics. Once we identify critical functional performance metrics (*e.g.* receiving boxes as ordered that can be erected using my equipment and can stack in my warehouse for 90 days without collapsing and then drop ship individually to my customers) we can start to establish the associated technical metrics (*e.g.* on-time delivery; porosity; box compression strength; *etc*.). We need to agree on how these are evaluated: specified as a minimum for each box or a population average; examined per lot or as a system over time; under what environmental conditions; *etc.* The specifications may well evolve as the producer and purchaser work together to identify and quantify the right properties underlying both the process and performance needs.

Given the many demands on a box, there is unlikely to be a single parameter that can capture box requirements to be used alone for optimization. That approach may work for simple commodity products, but as evidenced by over a hundred years of ongoing research from puncture resistance to box compression and creep to finite element modeling, corrugated packaging is neither simple nor a commodity. Box specifications have evolved, from pure material specs (basis weight) to performance-adjacent specs (ECT), enabling significant light-weighting of packaging. Further optimization requires strong collaborative relationships between producers and purchasers, built on trust and defined by a range of agreed upon metrics, to deliver packaging that best satisfies the expectations of all stakeholders and protects its contents though an ever-evolving distribution landscape.

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NMFTA National Motor Freight Classification Item 222, Packaging - NMFTA - National Motor Freight Traffic Association