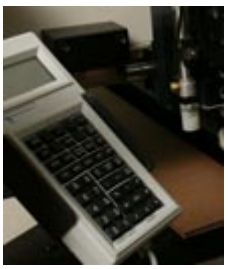
Box Performance



MULLEN

Box strength is measured in two different ways. The **mullen** test measures resistance to rupture in pounds per square inch (psi). Linerboard constitutes the bulk of the bursting strength of a corrugated sheet. The basis weight of the paper as measured in lbs/1000 sq. ft. directly impacts paper strength. Some of the standard basis weights of mullen grades include:

LINERS	MEDIUM
26#/msf	23#/msf
33#	26#
42#	33#
69#	40#
90#	

When the corrugated box industry was new, most shipments were made by rail. Classification committees had control over all conditions related to shipping, including packaging. Rules regarding packaging in corrugated were incorporated in Rule 41 of the Uniform Freight Classification. When motor carriers evolved, similar rules were established in the National Motor Freight Classification Item 222 patterned after the rail classification. Rule 41 and Item 222 state minimum mullen requirements for packages based on size and weight. Although there are other rules in the Classifications that relate to corrugated boxes most shipments are made in single wall corrugated boxes and the below table illustrates the minimum requirements for single wall.

MAX.WT. (BOX & CONTENTS)	MAX. OUTSIDE DIM. (1L,1W, &1D ADDED TOGETHER)	MIN. BURSTING TEST	MIN. COMBINED WT. OF FACINGS
20	40	125	52
35	50	150	66
50	60	175	75
65	75	200	84
80	85	250	111
95	95	275	138

120	105	350	180

As far as Classification rules go, Rule 41/Item 222 is fairly easy to understand and easy to administer. However, the mullen test is thought to correlate poorly with another important box characteristic, stacking strength. In 1990 the trade associations for the corrugated industry sponsored proposals to revise Rule 41/Item 222 thus paving the way for an alternative rule for measuring box strength, **ECT** .

ECT

The **Edge Crush Test (ECT)** measures the ability of combined board to sustain a top-to-bottom load. The strength is directly related to the compression strength of both the liners and medium. There are two gages of strength. *Box compression strength (BCT)* is the maximum load a given box can stand for a moment. *Stacking strength* is the maximum load a box can stand throughout the distribution cycle. This means that the bottom box must support the top load over a period of time in which it may be exposed to fluctuations in temperature and humidity as well as other factors that impact performance such as handling, pallet patterns, pallet deck board spacing, and overhang. All these factors weaken the stacking strength of the box. Therefore the stacking strength of a box is almost always much lower than its compression strength. The most commonly used box style is the *Regular Slotted Container (RSC)* . The *McKee* formula is a formula that can estimate the compression strength of a given box. This is useful information when designing a package. By knowing the compression strength and carefully considering all the potential detractors encountered throughout the distribution cycle the designer may better determine the ECT test required to achieve the desired stacking strength. The table below illustrates the minimum carrier requirements for single wall ECT grades.

MAX. WT. (BOX & CONTENTS)	**MAX. OUTSIDE DIM** .(1L,1W, &1D ADDED TOGETHER)	**MIN. BURSTING** TEST FACINGS	**MIN. COMBINED** WT. OF FACINGS
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It is important to understand that whichever measurement you prefer to use to measure box strength, basis weight and flute caliper are the 2 most important performance indicators of raw material quality. Below is a table of target basis weights p/msf and flute calipers for various grades of single wall and double wall grades prior to converting operations.

SINGLE WALL

			Flute Caliper		
MULLEN	**COMBINATION**	**WT/MSF**	**B**	**C**	**E**
125	26/26/26	92	0.112	0.152	0.065
150	33/26/33	106	0.116	0.156	0.069
175	42/26/33	115	0.118	0.158	0.071
200	42/26/42	124	0.12	0.16	0.073
250	69/26/42	151	0.127	0.167	0.08
275	69/26/69	178	0.134	0.174	0.087
350	90/26/90	220	0.146	0.186	0.099

			Flute Caliper	
ECT	**COMBINATION**	**WT/MSF**	**B**	**C**
32 ECT	35/26/35	110	0.114	0.159
40 ECT	35/26/55	130	0.117	0.162
44 ECT	55/26/55	150	0.124	0.168

DOUBLE WALL

			Flute Caliper

MULLEN	COMBINATION	WT/MSF	BC
200	33/26/26/26/33	172	0.26
275	42/26/26/26/42	190	0.264
350	42/26/42/26/42	206	0.268
400	69/26/42/26/69	260	0.282
500	90/26/42/26/90	302	0.294
600	90/26/90/26/90	350	0.307

		Flute Caliper	
ECT	COMBINATION	WT/MSF	BC
42 ECT	33/26/33/26/33	179	0.261
48 ECT	42/26/33/26/33	188	0.263
51 ECT	42/26/35/26/35	192	0.265
61 ECT	55/26/35/26/55	225	0.273

There is a take up factor for medium. For C flute the take up is 1.44 and for B flute it is 1.35. The Wt/msf contains 2.5 lbs/msf of starch adhesive for single wall and 5 lbs/msf for double wall.

There is a certain amount of caliper degradation throughout the converting process. This affects ECT values, box compression strength, and stacking strength. The best converters using the best raw materials have the least amount of degradation. The crush allowance ranges from .001-.006 on single wall flutes. Heavier grades are more resistant to crush. Newer machinery also helps protect against crush.

The above table illustrates basis weights and calipers for combinations that all use 26# medium. However, the days of 26# medium are fading fast and most corrugators have switched to 23# medium. This affects the basis weights by approximately 4 lbs/msf for single wall and 8 lbs/msf for double wall.

When designing a packaging solution, the best designers begin with the end in mind. Every packaged product has its own unique set of problems to solve. These include physical characteristics of the product, the mode in which the package will be shipped or stored, and the functions the package will be asked to perform.

Burst strength is more relevant when product containment or puncture resistance is the main concern. ECT is more relevant when stacking strength is the main concern.