

Corrugated Substrate Fundamentals

To be successful on a consistent basis, you must understand the characteristics of the substrate you convert. As you travel through Europe, the Americas or Far East, you will find considerable difference in corrugated paper. It is due to the resources that are available to the country that is creating it. The most noticeable difference may be something as simple as the color. The browner you see, the more you would think about virgin fibers being used to make up the paper. As the paper color turns more towards a grayish tint, the more recycle content is attributed to the paper. Another difference may be in the measurement systems.

Let's look at the individual pieces of paper that make up corrugated. If we look at one piece of paper, the properties that are most important to us as tool makers, is the weight, the thickness, the recycle content and the moisture content. Weights may be measured in gram weight or pound weight. This would mean the actual grams that a square meter or pounds that 1000 square feet of this paper would weigh if placed on a set of scales. The thickness of the paper is measured in millimeters or inches. A typical piece of paper could be .23 mm (.009") or another piece may be .28 mm (.011"). In most all cases as the paper becomes thicker, the weight is increased. The recycle content has a drastic effect on the cutting and creasing. The moisture content is higher when the corrugated is made and as time allow begins to dry out. The die cutting process is one of many challenges faced when the paper does not have time to properly cure due to high speed production and increasing turn around time for the corrugated converter.

A piece of corrugated is made from a minimum of two pieces of paper. The outside piece of paper is referred to as the liner and the fluted piece of paper is referred to as the medium as shown in Figure 1. These pieces of paper are adhered together during the corrugating process. The paper used for the liner is generally made from a softer wood than the medium. With longer fibers, the liners have more elasticity and give the paper the ability to stretch easier. The medium which is made from a more dense wood has shorter fibers. The medium will give the corrugated strength for stacking purposes.

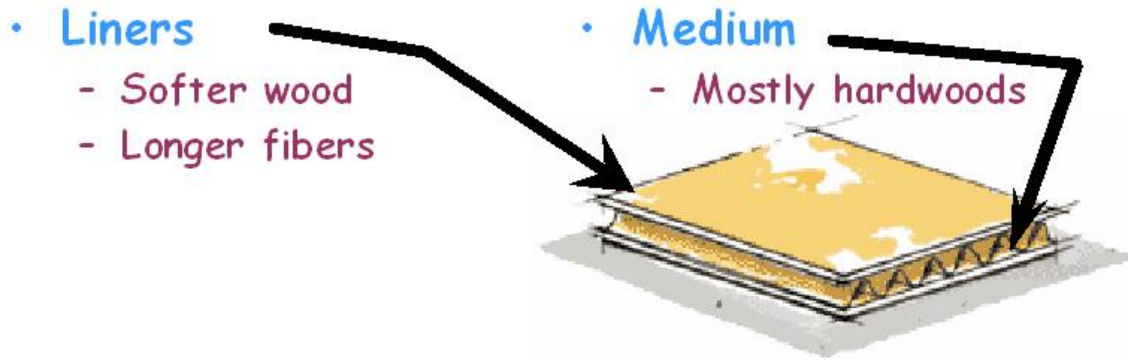


Figure 1

As I said earlier, a minimum of two pieces of paper is required to make a corrugated substrate. When using only two pieces of paper it is referred to as open face or single face. Combining a liner on each side of a medium is called singlewall and is the most commonly used corrugated. Adding an additional medium and liner for a total of 5 pieces of paper is referred to as doublewall. Triplewall is 3 mediums and 4 liners. Triplewall is used primarily for heavy duty use and die cutting this product requires not only special die cutting techniques, it may require special machinery. Figure 2 illustrates these differences.

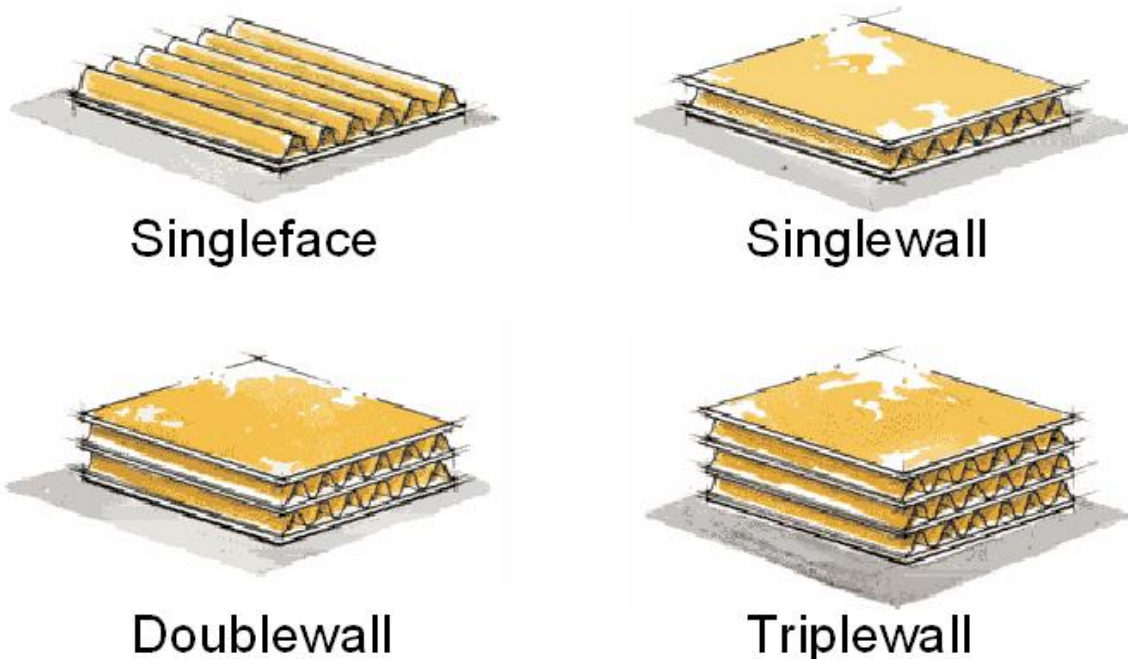


Figure 2

Not only do we have different combinations of paper we also have different flute configurations. The height and spacing of these flutes make up their

characteristics as shown in *Figure 3*. While there are many fluted options available today, the most common flute configurations are B, C and E flute. You will also want to note that there is no correlation to thickness to the order of the letter denoting its name. C flute is thicker than B flute but E flute is thinner than C flute. Originally, the lettered name came in sequence that they were invented. Today that is not the case. The person that named G-flute wanted the name because they wanted G to stand for graphics-flute. They felt their product was ideal for printing.

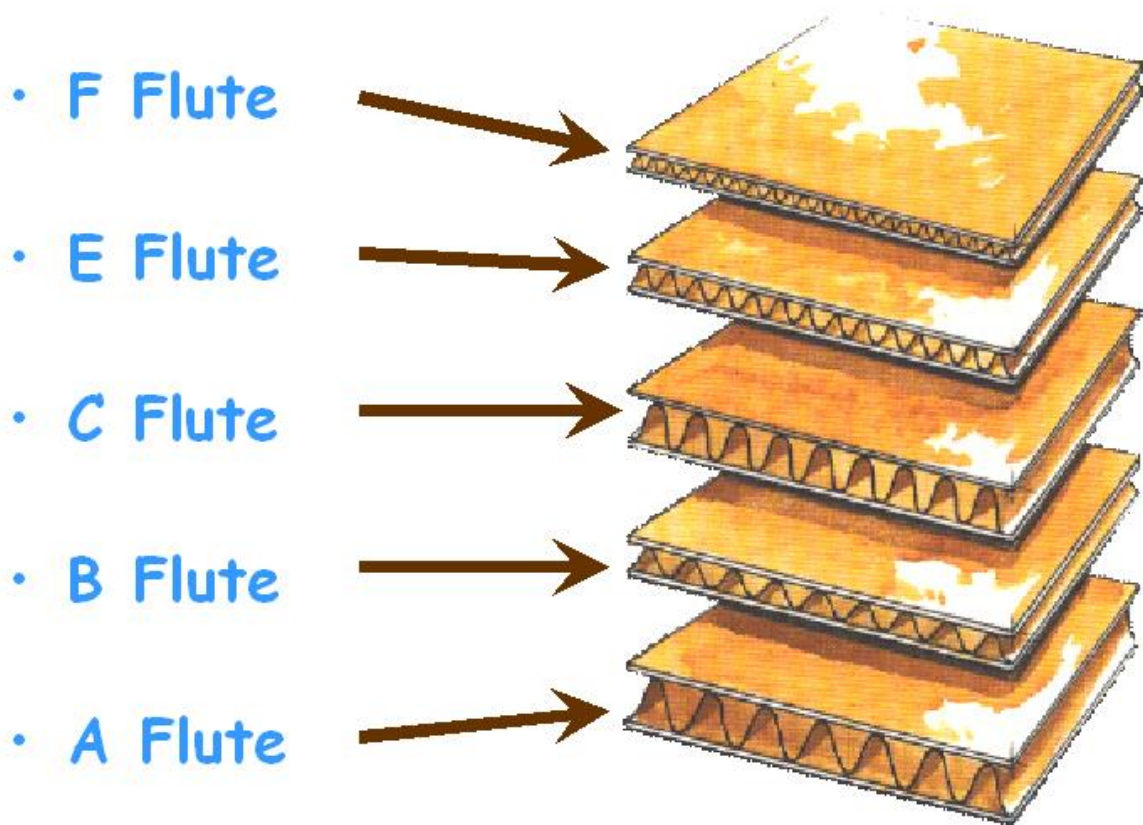


Figure 3

Chart 1 is a typical flute chart. It is also important to note that these are average flute heights and spacing. Each manufacturer has their own set of standards they adhere to. It is also important to note that these average flute heights do not include the thickness of the liners.

Flute	Avg. Flute Height (US)	Avg. Flute Height (Metric)	Flutes Per Foot (US)	Flutes Per Meter (Metric)
N Flute	.018"	.45 mm	170 +/-4	558 +/- 15
G Flute	.023"	.60 mm	179 +/-4	587 +/- 15
F Flute	.030"	.75 mm	128 +/-4	422 +/- 15
E Flute	.045"	1.15 mm	90 +/-6	297 +/- 15
B Flute	.097"	2.45 mm	47 +/-3	155 +/- 10
C Flute	.142"	3.60 mm	39 +/-3	130 +/- 10
A Flute	.184"	4.65 mm	33 +/-3	110 +/- 10
K Flute	.260"	6.60 mm	25 +/-2	82 +/- 7

Chart 1

One of the things you must understand is that just because it is B Flute does not mean all B Flute is the same height. Depending on the thickness of each individual paper will change the overall thickness of the completed substrate. Chart 2 shows the differences in the thickness of the corrugated sheet when different paper combinations are used. It is not important that you memorize these charts, but it is important that you understand the principles that are associated with them.

Non-Compressed Thickness of Singlewall			
Flute	127/127/127 26/26/26	205/127/205 42/26/42	336/127/336
F Flute	1.15 mm	1.45 mm	1.65 mm
E Flute	1.55 mm	1.85 mm	2.05 mm
B Flute	2.85 mm	3.15 mm	3.35 mm
C Flute	4.00 mm	4.30 mm	4.50 mm

Non-Compressed Thickness of Doublewall			
Flute	205/127/127/127/127	205/127/205/127/205	336/127/336/127/336
BC Flute	6.80 mm	6.95 mm	7.40 mm
EB Flute	5.35 mm	5.50 mm	5.95 mm

Chart 2

By now, you can see there can be an endless combination of paper weights, flute configurations and board make-ups. I'm sure you know the reasons. They are always trying to get the most from the least. With all these different options to choose from, what terminology do they use to simply distinguish these combinations? If you put 3 pieces of paper together with a 205 gram (42 lb) weight inner and outer liner and a 127 gram (26 lb) weight medium, do you refer to this as a 537 gram (110 lb) weight? The answer is no, you refer to it as 1,378 kPa (200 lb). This number and terminology is derived from one of the more common testing systems. This system measures the amount of pressure needed to burst through the corrugated board as shown in Figure 4. This is a standard testing used throughout Europe.

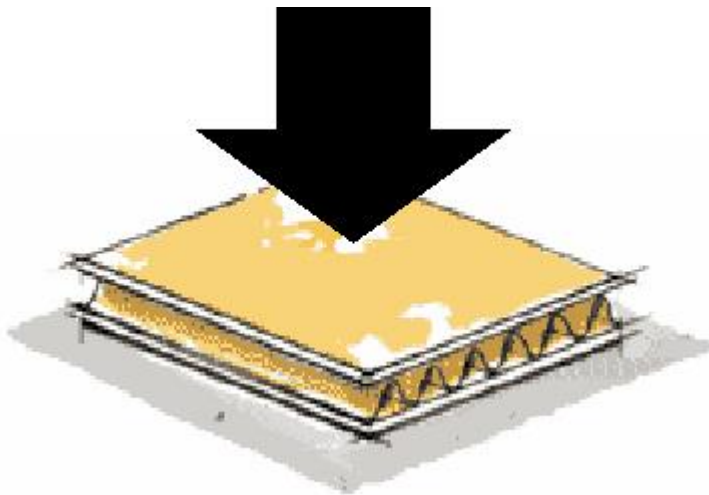


Figure 4

This type of testing is referred to most commonly as the bursting test or mullen test. The test is conducted using a burst tester and in essence, consist of forcing a rubber diaphragm through a 25 mm (.98") diameter hole with hydraulic

pressure. The resultant upward bulge of the diaphragm causes it to puncture the corrugated specimen. The hydraulic force required to burst the specimen is recorded on a dial or electronic digital readout device. In this type of testing, it is most important that the liners be strong and resilient. The medium plays a smaller role in achieving a high bursting strength reading. You will see in a few minutes how this directly affects the cutting and creasing.

Another test that is more popular in the US, is the ECT test or Edgewise Compression Test. ECT testing, determines the amount of force needed to crush a small section of combined board held on its edge with the flutes in the vertical direction as shown in Figure 5. ECT is a primary factor in predicting the compression strength of the finished box and used primarily when stacking boxes on top of each other is the most important aspect.

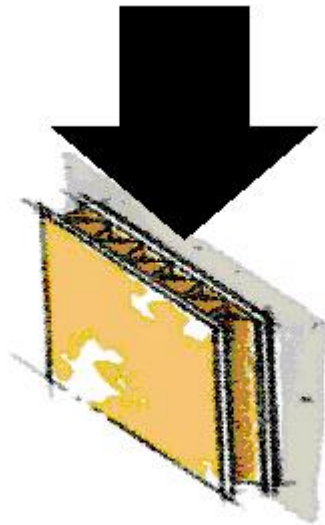


Figure 5

In this type of test, the medium becomes the most important part of the structure. When standing corrugated edgewise, the fluted material gives the strength. As I stated earlier, the converter will want to give the most for the least. That means the emphasis will be placed on the medium. Better stronger paper inside with lesser, weaker paper on the outside. As this testing becomes more popular, your die cutting challenges will change as we will discuss next.