From the I.A.D.D., and DieInfo

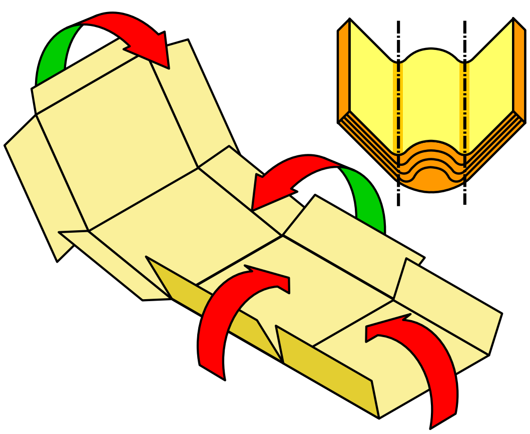
Tech Notes

For Diemaking and Diecutting

DIE.06.07
January, 2007

"The ABC's of Specifying & Designing Optimal Reduced Bead Creasing."

This training guide is a pictorial, step-by-step training program, which is designed to teach the specification and design of Reduced Bead Creasing. The goal is to simplify the converting process; to improve diecutting, gluing and cartoning efficiency; and to optimize carton and container folding quality, consistency and repeatability.



As with any information introduced into the converting process these technical recommendations should be greeted with positive skepticism. The goal of the guide is to augment current knowledge, and it is not intended to immediately replace current methods and practices. However, these techniques are designed to be integrated and blended with current methods, into a systematic and a more effective approach to creasing. This should be achieved through teamwork, through discussion and brainstorming, through education, and through careful testing. The objective is knowledge, skill, and experience parity, and procedural uniformity. In other words, to get everyone to know what everyone knows, and then to work as a cohesive team, to find and apply the best consensus methods and practices.

To get the best performance, to generate the best creasing and folding, and to produce the best quality cartons and containers, it is essential to have an open mind, to think outside of the "box," and to continuously share all of our knowledge, our skill, and our experience.

The best source for the knowledge, for the experience, for the resources, and for the technical discussion of subjects like this is the International Association of Diemaking and Diecutting.

IADD
INTERNATIONAL ASSOCIATION of DIECUTTING and DIEMAKING

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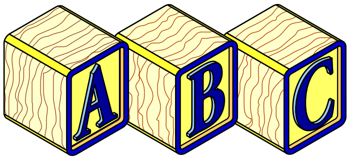
“The ABC’s of Specifying & Designing Optimal Reduced Bead Creasing.”



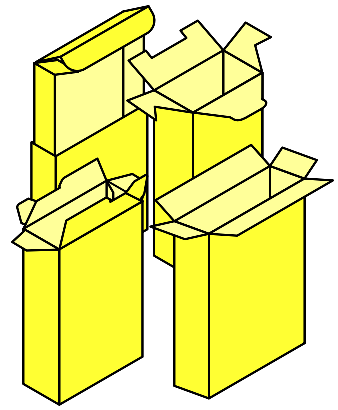
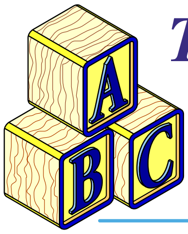


Table of Contents



The ABC's of Diemaking & Diecutting

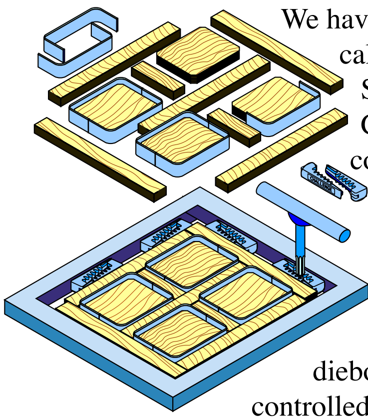
Article Title "The ABC's of Specifying & Designing Optimal Reduced Bead Creasing."

Introduction

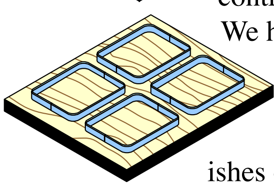
"Insanity: doing the same thing over and over again and expecting different results." *Albert Einstein*

Progressive change is a daily reality of our lives, but in some institutions, we manage to resist change, even when the evidence points to the need for an alternative approach.

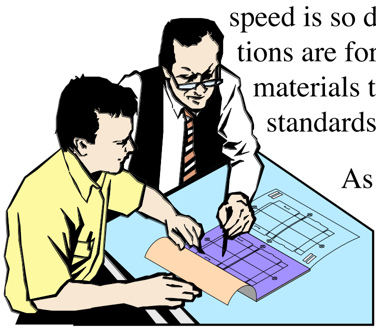
In the converting industry we have experienced continuous change in the manufacturing methods for paperboard, for fluted paperboard, and for laminated paper materials.



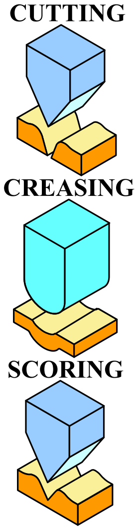
We have seen positive and radical change in the diversity of Structural Design, and in the Cartoning Systems used to complete the packaging cycle. We have enjoyed enormous innovation in toolmaking technology, moving from block dies and hand knife formation, to lasercut dieboards integrating computer controlled rule processing. ***See left***. We have experienced an explosion in our ability to print sophisticated graphics and fine images, in a startling array of colors and finishes onto customized paperboard and fluted material surfaces.

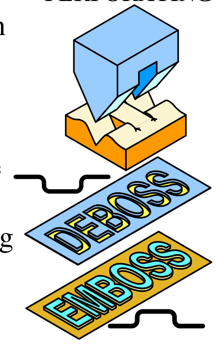


Matching this diversification of materials, products and processes; speed to market, turnaround and industry throughput standards compress time and force everyone to compete against a relentless benchmark. Importantly, this compression of the processing cycle has resulted in the elimination of the trial order, and a more measured evaluation and pretesting of the product to be converted. ***See below***. In fact, speed is so dominant, many organizations are forced to use a mix of different materials to meet competitive delivery standards.



As a result of these and other changes, we compete against the clock every day, and there is little room and little patience for adjustment, for correction, and least of all for failure. Given this dramatic but inevitable competitive race to market, it is important to recognize that our Achilles Heel in the process, is our reliance on a method of crease and folding design, which was developed in the 1920's!





It is obvious we need an upgraded method of crease formation, which will generate a more reliable system of folding, to successfully accommodate a far greater range and diversity of paperboard materials. We need a more realistic, a more robust, and a more practical approach to ensure predictable, consistent and repeatable folding performance.

Fortunately, the development of the Reduced Bead approach to crease design and the selection of toolmaking parameters, is providing a more effective match between the design, the material, the process, and the end user folding converted product.

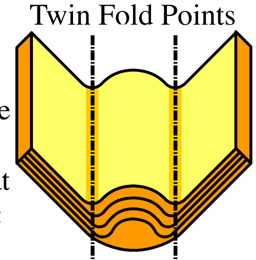
However, before we discuss the differences, it is important to understand what creasing is and how it works.

What is Creasing?

"There is a great difference between knowing and understanding: you can know a lot about something and not really understand it." *Charles F. Kettering*

Creasing is one of six Converting Disciplines, ***see above,*** however, the reason it has taken so long to adopt change, is there is a poor understanding of how a crease is formed and how it works.

A crease is effectively a paperboard hinge, however, the ability to create an effective fold point in paperboard requires generating a controlled failure in the material. The most important factor in creasing, is to understand that ***a crease is not a single fold but it is a double fold! See right***.



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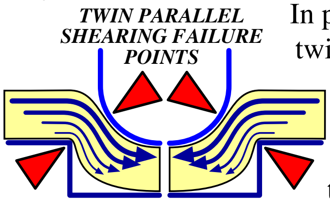
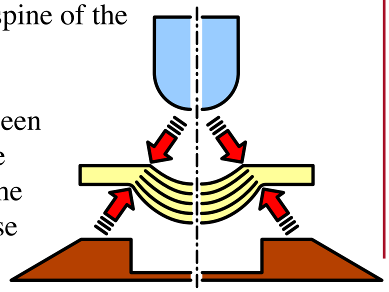
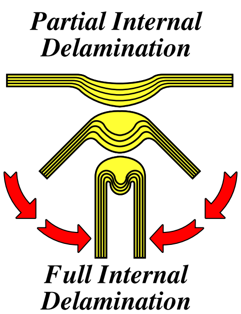


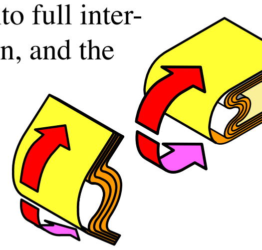
In practice, a crease is formed by twin, parallel shearing failures, ***see left***, which are distanced to create a central deformation or bead, around which the two attached panels rotate. The greater the distance between the parallel failure lines, the greater the stress on the spine of the crease.



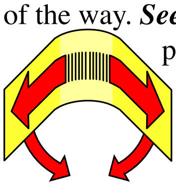
The material is sheared between matched lower corners of the female crease channel, and the upper faces of the male crease rule, which form the matching twin, shear points. ***See right***.



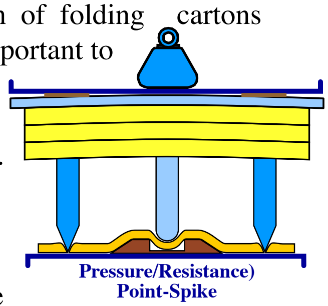
This combination of shearing and pinching causes the material to partially delaminate internally, however, it is when the panels are folded from zero to 90 degrees that the increase stress generated by the action of each lever, transforms the partial internal delamination into full internal delamination, and the crease/hinge is fully formed. ***See left***.

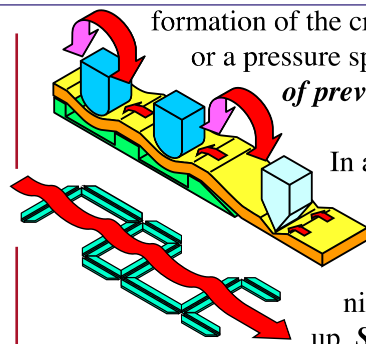


As the crease folds from 90 through 180 degrees, the inner surfaces of the panels move closer together, and the flexible bead, now consisting of layers of delaminated material, compresses laterally out of the way. ***See right***. At the same time, the thin layer of paperboard forming the spine of the crease has sufficient elasticity to stretch and to accommodate the tensile stress generated by the folding action. ***See left***.



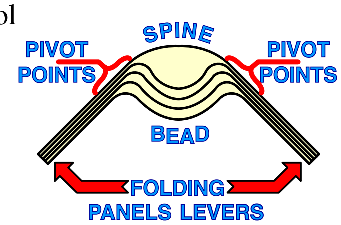
A crease/fold is a structural design feature, which is the key attribute enabling the formation of folding cartons and containers. However, it is important to recognize the generation of the crease imposes some key restraints on the diecutting process. To pinch and shear a material, pressure or compressive force must be generated between two opposing surfaces. Therefore, the formation of the crease creates a resistance point or a pressure spike in diecutting. ***See bottom of previous column***.





In addition, creasing is the primary source of tensile stress or draw in diecutting, and is the key force causing flaking, nick/tag failure and sheet break-up. ***See left***.

It is important to recognize that although the material in a crease is still one piece, the formation of the crease has created four distinct and important folding components. These are the Flexible Bead, Elastic Spine, Twin Crease Fold or Pivot Points, and the two attached Folding Panels of Levers. ***See right***. By manipulating the proportion and the interaction of these components, through a more effective selection of male and female tool parameters, the performance of the crease/fold can be precisely adjusted and controlled.



Now that we know more about the formation of the crease and the basic components of the paperboard hinge, why is the Traditional Crease formulation and selection of tool parameters frequently so ineffective?

Why is the Traditional Creasing Formula Ineffective?

BENCHMARKING - "The continuous search for the best practices leading to superior performance."

It is somewhat unfair to label a system of creasing ineffective, when in many instances it works perfectly fine. However, to reiterate an earlier point, the materials, the processes, the technology, and the products have changed and continues to change, and it is time to implement a more effective and a more consistent alternative.

There are a number of technical reasons and formation issues which cause Traditional Creasing parameters to fail to meet our current needs. These would include:

- ***Over Penetration of the tools generating excess Tensile Stress***
- ***Rapid, inconsistent and uneven Crease Channel Wear***

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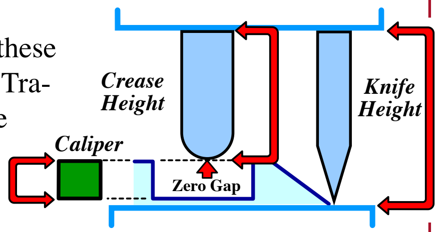
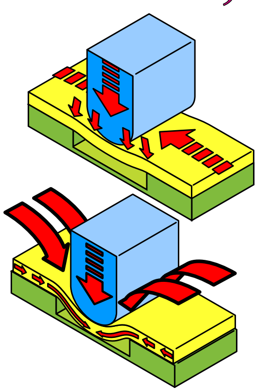
- ***High levels of "Draw" causing Flaking and Nick Failure***
- ***Inconsistent crease formation and folding performance***
- ***Poor adjustment and control of Folding & Opening Force***
- ***Parallel Crease Competition***
- ***Bead Binding***
- ***Spine Failure and Crease End Splitting***
- ***Surface "Bursting & Buckling"***
- ***Marking generated by a "Protruding Counter"***
- ***A "Pressure Spike" destabilizing cutting performance***
- ***Poor male/female tool alignment***

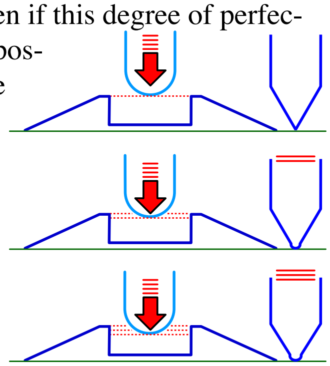
Let us examine some of these problems and failures of Traditional Creasing in more detail.



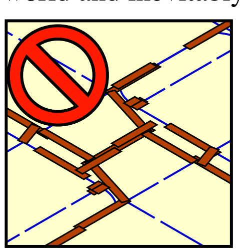
Over-Penetration, Channel Wear, & Tensile Stress

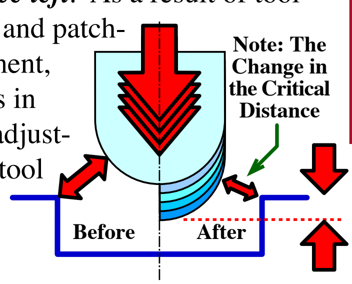


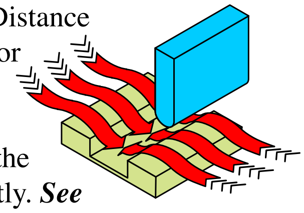
The design of traditional tooling specifies a perfect alignment of the steel rule die and the female crease tool channel. When the press is fully closed, the tip of the crease rule in the die will be level with the surface formed by the female crease tool. ***See above***. Even if this degree of perfection were possible, these parameters cause the resulting crease to be formed with excessively high levels of tensile stress and damaging lateral draw force. ***See above***.



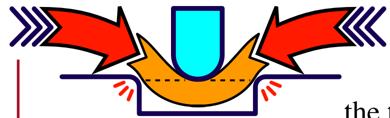
Unfortunately, it is not a perfect world and inevitably some of the knives suffer compressive cutting edge damage, ***see above***, and the tools must be shimmed or patched to compensate. ***See left***. As a result of tool shimming and patch-up adjustment, the creases in close proximity to this Z-Axis adjustment are driven into the crease tool channel, which changes the Critical Distance. ***See right***.



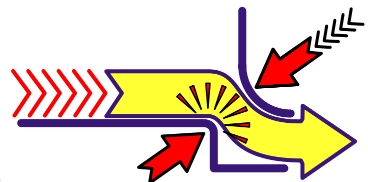




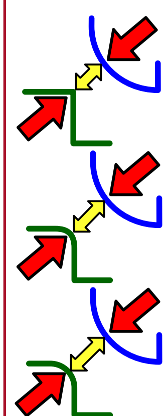
Prematurely reducing the Critical Distance increases the amount of resistance or pressure to diecut at this point in the layout, and the degree of lateral stress pulling toward and into the crease channel increases significantly. ***See above right***.



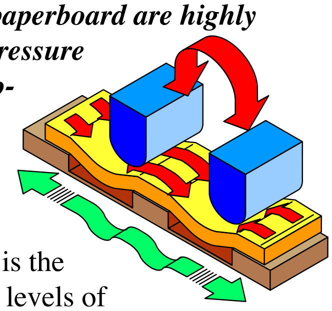
This increased penetration of the tip of the crease rule into the channel results in a number of disastrous impacts on creasing, folding and converting diecutting, and finishing and cartoning performance, which are rarely accurately tracked to the source of the problem.



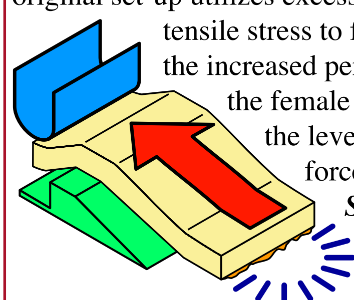
The first, and most serious is, the accelerated wear of the lower crease channel shearing points, ***see above left***, as the combination of increased pressure and abrasive lateral slippage, ***see above right***, rapidly erode the upper corner of each channel. ***See left***.



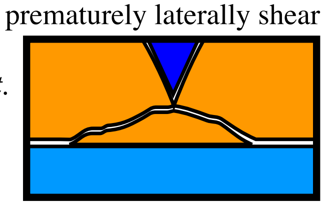
(Certain types of paperboard are highly abrasive, and as pressure is increased disproportionately, the abrasive wear is accelerated!)



The second major disadvantage, is the original set-up utilizes excessive levels of tensile stress to form and shear each crease, and the increased penetration of the crease rule into the female channel, significantly raises the level of damaging lateral draw force on the surrounding material. ***See above right***.



This often results in diecut edge chipping or Flaking, ***see above***, as the increased lateral ***"pull"*** from the creasing rule combined with the increased displacement ***"push"*** of the knife bevel, cause the material to prematurely laterally shear apart, before the knife has fully penetrated the material. ***See right***. Flaking is most common when there is a parallel crease very close to the cutting knife.



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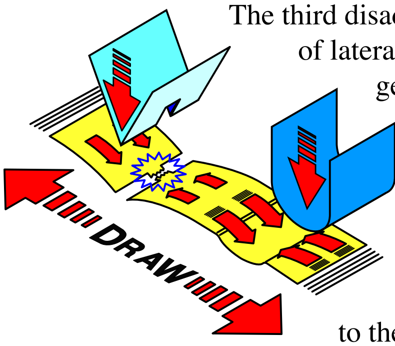
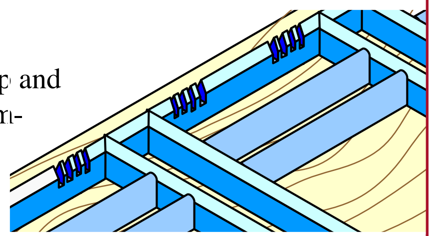
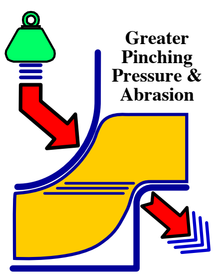


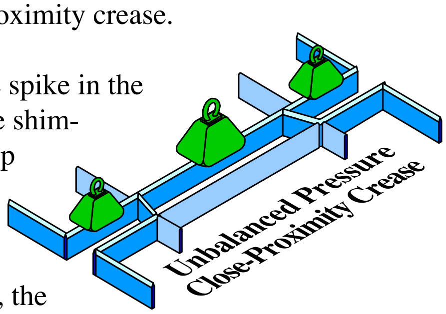
The third disadvantage, is the high levels of lateral draw or tensile stress generated by the excess penetration of the crease rule into the protruding channel, which will-cause any nick/tags in the die, and particularly those in close proximity to the crease, to fracture and to fail. ***See left***.



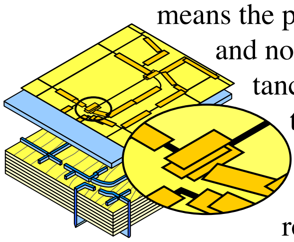
To prevent sheet break-up and slow press speed, the number and the size of the original nicks must be increased, ***see right***, and this time wasting necessity occurs on-press!



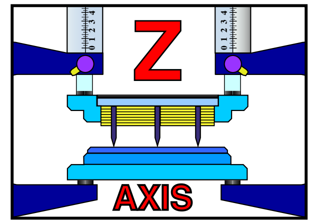
The fourth disadvantage of excess crease rule penetration into the female crease channel, is the sudden increase in resistance/pressure caused by the greater pinching force at the critical distance, ***see left***, adds to the pressure/resistance in the ability of close proximity knives to cleanly cut. ***See below***. This knife in a layout often rapidly loses its edge, as it is over pressurized because of the close proximity crease.



The pressure resistance spike in the layout, is fixed by more shimming and more patch-up adjustment. This will get the knives to overcome the resistance and cut, however, the additional shimming also drives the crease rule even further into the crease channel, accelerating already damaging critical distance wear. Even worse, the over penetration of the crease rule into the channel puts pressure on the upper corners of each channel, which causes them to gradually abrade to relieve the unbalanced pressure. However, this means the pressure spike was only temporary, and now the resistance of the critical distance pinching force has been reduced, the knives are over-pressurized, further knife-edge damage ensues, and another round of patch-up is required. ***See left***.

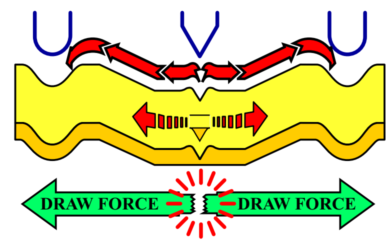


Crease Formation, Parallel Crease Competition, and Controlling Opening Force

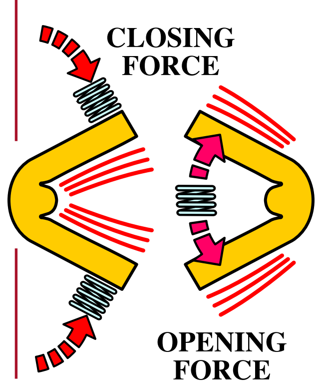


When male and female tool parameters are set as though variation in the Z-Axis Positioning of the tools was impossible, ***see right***, these settings are immediately compromised when variation in the distance between the steel rule die and the cutting plate or anvil inevitably happens. If everything was perfect, and setting the Platen Gap or the Z-Axis was simple and easy, and patch-up or shimming were not necessary,

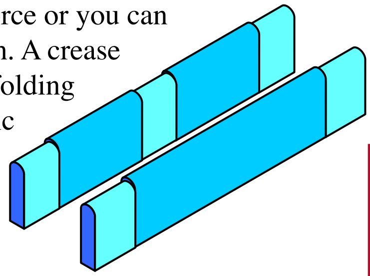
this approach may work, however, poorly calibrated presses and steel rule dies, wear in parts and press components, press temperature variation and ineffective pressure, results in considerable variation in the distance between the tools from one crease to the next. ***See above***.



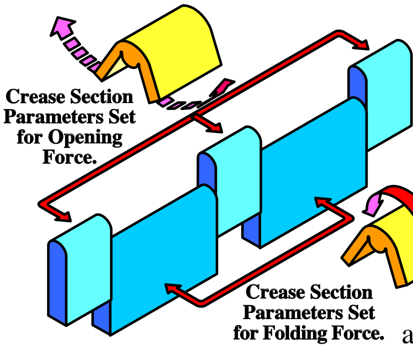
This uneven distribution of the platen gap results in uneven crease shearing pressure, uneven tool wear, uneven crease formation, uneven tensile stress and draw, and uneven cutting performance, in terms of flaking and edge chipping, and uneven speed performance, because of nick/tag instability. ***See above***. This is the complete opposite to what was sold to the customer, and the absence in consistency and repeatability from die-station to die-station, and from the first impression to the last, undermines gluing and finishing and the customer packaging process. Ignoring the impact of uneven crease formation pressure or a pressure spike in attempting to set a fast, stable kiss cut impression, is one of the key reasons press make-ready and creasing performance are so variable.



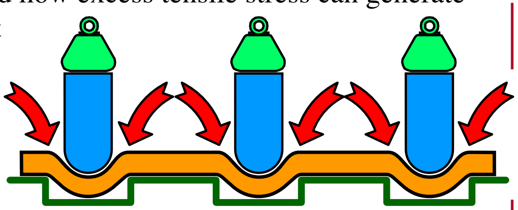
Naturally, this degree of instability at the start of the production process makes accurately setting folding and opening force virtually impossible. ***See left***. When using a single crease/fold, with a single set of parameters, you will be able to either set folding force or you can set opening force, but not both. A crease has by default a single set of folding parameters, and it is unrealistic to expect the crease to perform with control of two sets of parameters, folding and opening force.

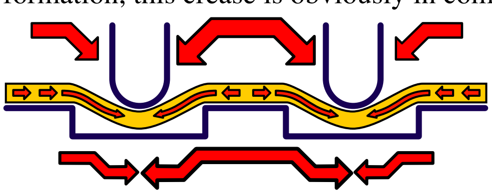


The solution is to divide the crease fold into 3 or 5 components, ***see above right***, and set 2 or 3 of the individual components for folding force and the rest for opening force. ***See left***. Unfortunately, because of the inherent instability of the traditional crease-tooling set-up, attempts to control both folding and opening force are doomed from the start.

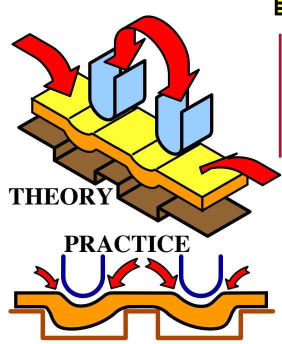


We have discussed how excess tensile stress can generate flaking and diecut edge chipping, nick/tag failure, and the generation of a temporary pressure spike in the cutting make-ready. In addition, as the traditional crease set-up relies upon tensile stress of lateral draw for formation, this crease is obviously in competition with other close proximity parallel creases. ***See above***.

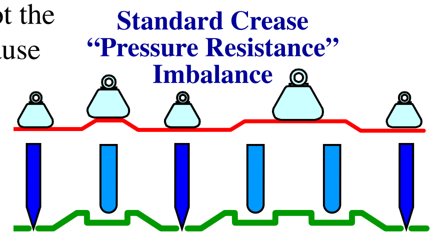




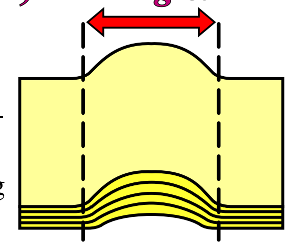
As the simultaneous formation of both creases is trying to draw material toward and into each crease channel, ***see above***, there is a limit to how much each material can stretch and distort to make the accommodation. As a result each crease is poorly formed, with an asymmetrical bead and internal delamination. ***See right***. This type of failure is often referred to as a ***"One-Sided Crease."***



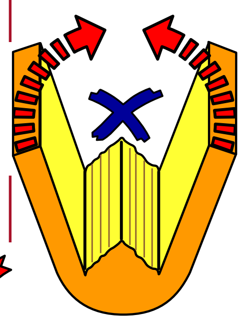
Unfortunately, this is not the only disadvantage, because as parallel creases are moved closer together, the resistance to crease formation, the shearing/pinching force required, ***see right***, at the critical distance grows disproportionately, which results in another unbalanced, uneven pressure/resistance spike, thereby destabilizing both cutting and creasing.



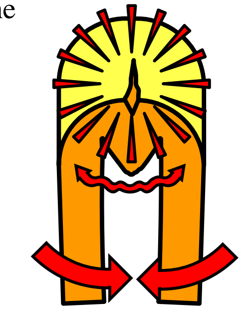
Bead Binding, Spine Failure, Bursting & Buckling

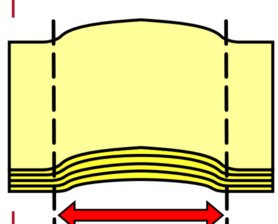


A critical failure in traditional creasing is the bead formed is often proportionately too large for the folding application, in other words the distance between the twin parallel shear lines is too wide. ***See above***. This crease typically is generally poorly defined, with a bead profile, in which it is difficult to see where the crease and uncreased portion of the bead begin and end.



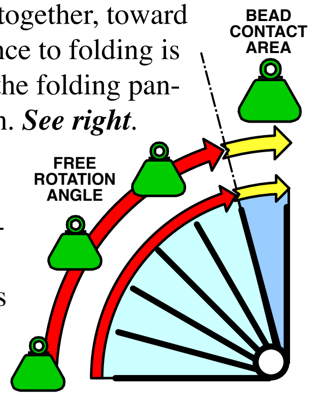
As a result, the bead has insufficient internal delamination force to generate the necessary flexibility, and folding the attached panels causes the bead to be crushed, ***see above***, which inevitably transfers great stress to the crease spine, ***see right***, resulting in spine fracturing or crease-end-splitting.



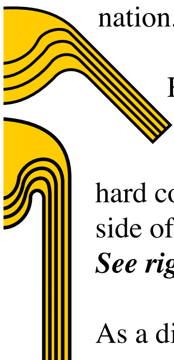


In addition, when there is insufficient or balanced shearing pressure, the resulting bead is flat and lacks definition, ***see above***, which is again caused by a lack of even shearing force and balanced internal delamination. Both of these formation profiles result in a serious folding problem called "***Bead Binding"***. ***See right***.

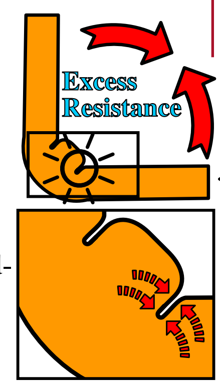
As the attached panels are folded together, toward 90 degrees of rotation, the resistance to folding is minimal and fairly constant until the folding panels reach 70-80 degrees of rotation. ***See right***.



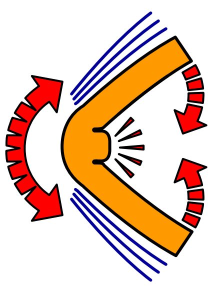
At this point of rotation the force required to fold increases dramatically, which you would expect at this point as the stress generated is converting the partial internal delamination to full internal delamination. ***See left***.



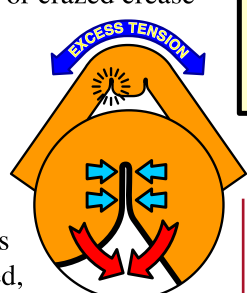
However, when the bead is too large or is not properly delaminated, the inflexible bead and the inner surface of each fold panel, make hard contact and bind at the intersection between the side of the bead and the inside of each folding panel. ***See right***.



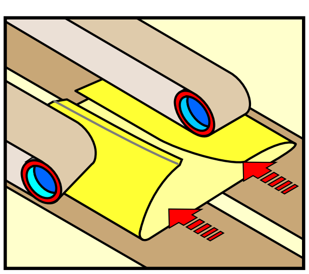
As a direct result of binding the pressure to fold dramatically increases, the stress on the spine increases significantly, and the resistance to folding climbs as the panels bow and flex out of shape because of the high resistance to folding. ***See below***.



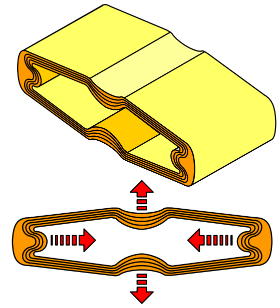
At this point the bead is forced to compress, the inner wall of each folding panel at the fold intersection is forced to crush and collapse, or the stress will be transferred to the spine of the crease, in terms of excess tension. ***See below***. This will generally result in a split or crazed crease spine.



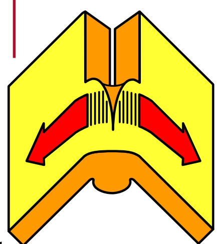
Naturally, the force of machine gluing, ***see below left***, has the power to overcome this resistance and fold the panels through 180 degrees, however, the resistance slows machine speed, it requires greater control, variation increases, the bead is permanently crushed, and cartoning-packaging performance is severely compromised.

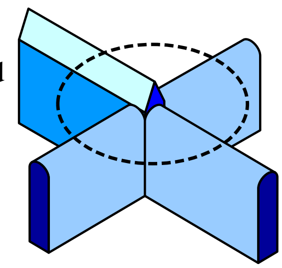


Even if the spine of the crease does not fracture the ability for the folded panels to open with any degree of resiliency is compromised. ***See right***.

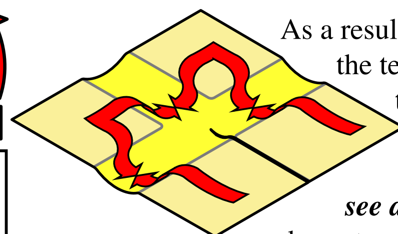


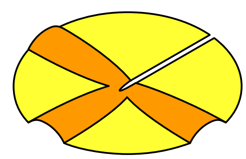
The key issue with the critical crease set-up is spine failure and crease end splitting. ***See left***. (A split at the end of the crease spine, where it intersects with a cutting knife.) The combination of uneven shearing/pinching pressure, rapid and often unbalanced critical distance wear, incorrect bead proportions, crease-to-crease competition and bead binding, ensure spine failure is a constant probability in creasing and folding.

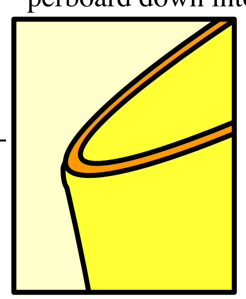




As a result of the tensile stress used to form traditional creases, any concentration of creases, at an intersection for example, ***see above right***, puts tremendous stress on the surface of the paperboard, as each crease competes with the other creases as they all combined to drive, to stretch and to stress the paperboard down into the close proximity crease channels. ***See above left***.

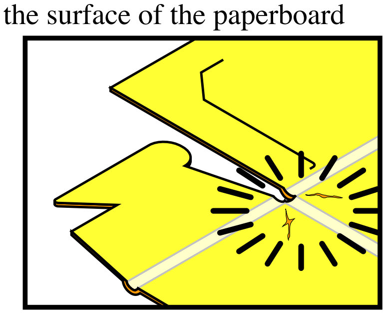






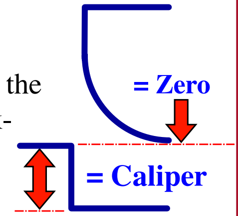
This is physically impossible, particularly as the density or the caliper of the paperboard increases, and it results in poor bead formation at the ends of the intersecting creases. ***See above right***.

As a result of this pressure imbalance and the resulting incomplete bead formation, the surface of the paperboard will buckle as the panels are folded, ***see above***, and it will often result in bursting or ***"checking"*** of the paperboard surfaces at each intersection point. ***See right***.

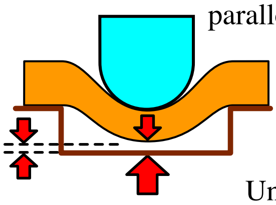


Article Reference Number: DIE.06.07 *Publisher-Editor: Kevin B Carey* ***kevin@dieinfo.com***

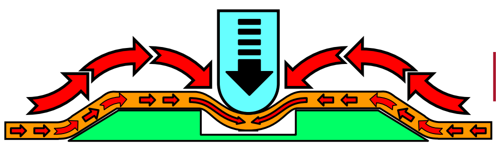
Protruding Counter, Pressure Spike, and Tool-to-Tool Alignment



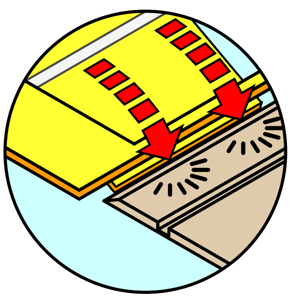
A key inhibition in traditional creasing is the use of a counter, which matches the thickness of the paperboard being creased. ***See right***. The thickness or this depth of channel is largely unnecessary because when the crease is formed, the material between the twin parallel shear points is so stretched, the thickness of the material is less than the original caliper of the material. ***See left***.



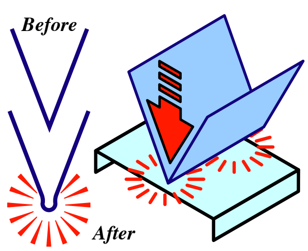
Unfortunately, when using fiberglass counters and individual matrix strips, the crease tool protrudes above the surface of the cutting plate, and the material must be wrapped and stretched around this profile. ***See right***.



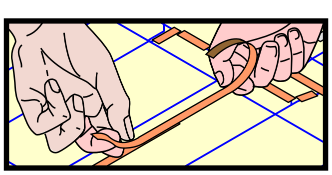
This adds to an already excessive amount of tensile stress and draw, it requires greater pressure in the cutting make-ready, and because it severely stresses the nick/tags it causes sheet break-up.



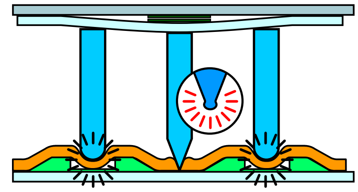
Although lateral stress and stretching is a primary source of nick/tag failure, the protruding counter will result in many incidents of snagging; ***see left***, which causes the diecut sheet to break apart. Because there is no provision or compensation in traditional crease rule parameters for inevitable variation in the platen gap or the Z-Axis, the degree of resistance to crease formation will often compromise and destabilize cutting performance. ***See right.***

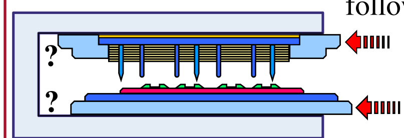


However, as cutting performance is critical to production, the temporary pressure spike caused by the over-penetration of the crease rule into the female channel, is overcome by adding more and more pressure in the form of layer upon layer of patch-up tape. ***See left***.

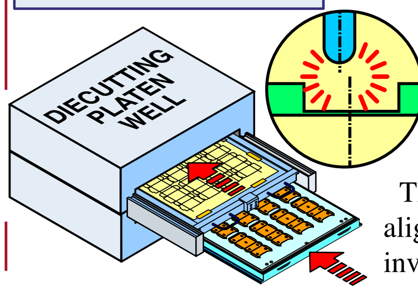


Because the pressure spike is temporary; the added pressure will cause the upper corner of each channel to abrade, thereby lowering the amount of force required. The force added to the cutting knives to overcome the spike is no longer required and the knives strike the cutting plate with increasing force. ***See above***. This will of course restart the cycle of compressive edge damage, patch-up adjustment, followed by more compressive edge damage, etc.

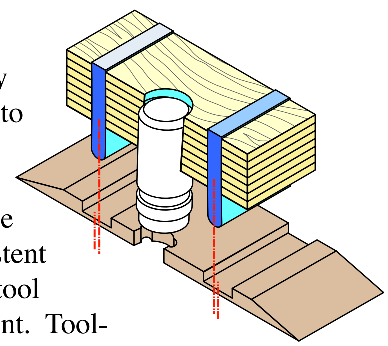




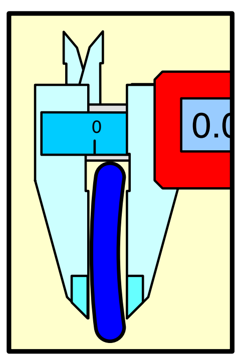
The final strike against traditional creasing, is this method of tool design is highly sensitive to male/female tool misalignment. ***See left***.



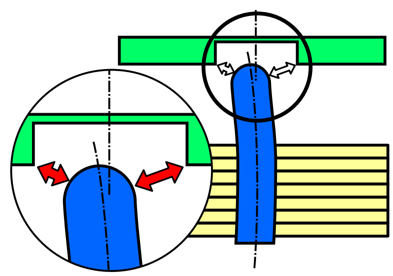
This problem describes the alignment between the upper inverted chase, holding the steel rule die, and the lower sliding platen, upon which is mounted the female creasing tools.

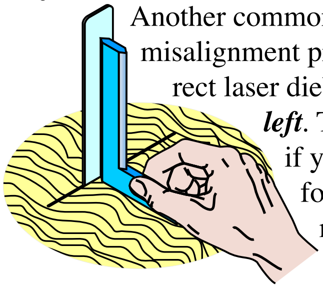


As these tools are frequently withdrawn and reinserted into the press platen well during each production cycle, it is not uncommon to experience inconsistent tool-to-tool alignment. Tool-to-tool misalignment can also be caused by plywood/dieboard shrinkage, during lasercutting; and it could be simply a mismatch between the machined tolerances of the steel rule die and the machined tolerances of the individual fiberglass counter. ***See above***.

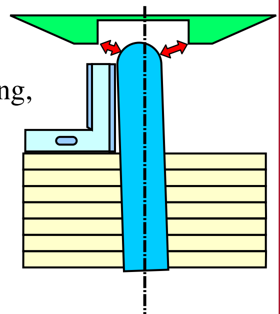


Additional factors such as crease rule dish, ***see above***, are common sources of male/female, crease rule/ female fiberglass counter channel misalignment. ***See right***.

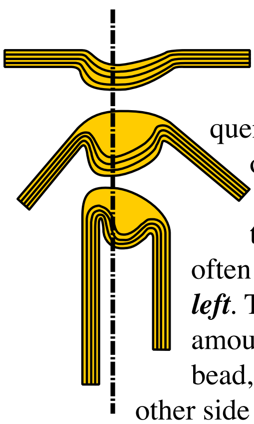




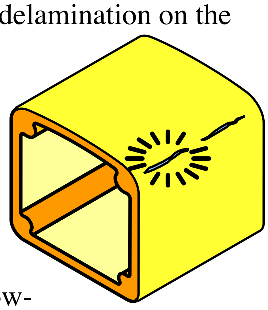
Another common, but well hidden tool-to-tool misalignment problem can be the result of incorrect laser dieboard cutting verticality. ***See left***. This is very difficult to detect if you are not specifically looking for the problem, as it is a common misconception that a laser dieboard has perfectly consistent and vertical kerf channels.



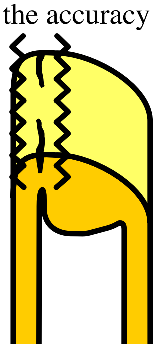
The perception is that a slight amount of variation from the vertical is not a problem in steel rule diemaking, however, even though this is not true, it is obviously vital to have perfect crease tool alignment. Unfortunately, even a slight deviation in crease rule verticality will impact and may compromise the performance of the male and female tools. ***See right***.



These factors in tool-to-tool registration and synchronization are frequently overlooked as a potential source of creasing and folding variation. The consequences of this type of deviation are asymmetric bead formation, often referred to as ***"one-sided crease." See left***. This simply means there is an excess amount of delamination on one side of the bead, and insufficient delamination on the other side of the bead.

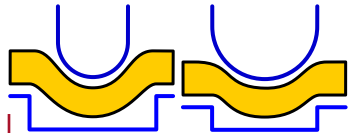


Depending upon the degree of misalignment, this can lead to off-center folding, which may compromise the accuracy and consistency of the erected carton or container. ***See right***. However, the most frequent problem generated by tool-to-tool misalignment is the potential for producing excess tensile stress in a narrow area of the folded crease spine, which inevitably leads to fracturing and folding failure. ***See left***.



AREA OF MAXIMUM SPINE STRESS

In many instances Traditional Creasing can still work, but you are operating on the edge of failure. Reduced Bead Creasing generates predictable, consistent, and more bullet proof folding performance.



STANDARD **REDUCED BEAD**

What are the important differences?

What is Reduced Bead Creasing?

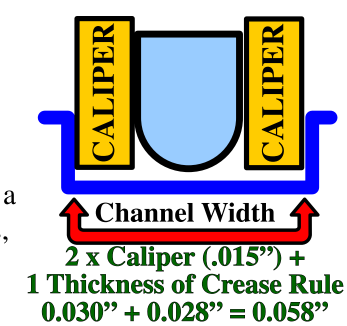
"The farther backward you can look, the farther forward you are likely to see." *Winston Churchill*

As the name Reduced Bead Creasing suggests, this method of creasing uses a smaller, more precisely defined bead than a traditional crease. ***See above***. In making the transition to Reduced Bead Creasing, there are ***Seven*** key toolmaking and tool parameter changes from the traditional approach to tool design. These require a:

1: Proportionate-Smaller Bead
2: Higher Pointage Crease Rule
3: Wider Surface Delamination
4: Balanced Bead Delamination
5: Thinner Counter
6: Compression Gap
7: Compressive Formation

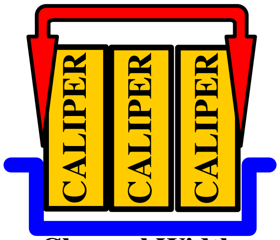
1: Proportionate-Smaller Bead

In reduced bead creasing the size of the bead is directly proportionate to the caliper of the paperboard being creased, and by comparison, in traditional creasing the caliper is only a part of the formula. We will illustrate the difference using a simple example.



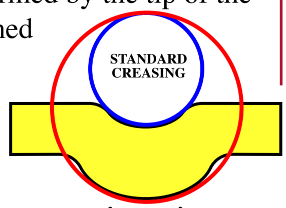
In standard creasing, to calculate the channel width for a paperboard of 0.015" thickness, it would require doubling the caliper of the paperboard and adding one thickness of the crease rule in use to the total. For this thickness of material or paperboard the crease rule would almost certainly be 2 Point or 0.028" thick. ***See above.***

Although it varies from company to company and from technician to technician, 0.004" is generally added to the total to adjust crease formation to reflect this as a cross grain crease.

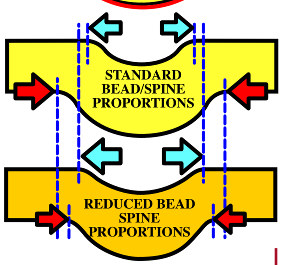


Channel Width
3 x Caliper = 0.045”

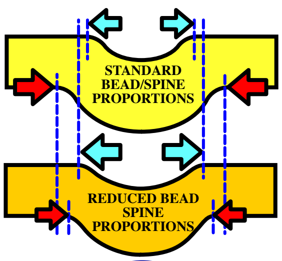
As the example shows, this would result in an initial bead width of 2 x 0.015”, plus 0.028”, to give a channel/bead width of 0.058”. In reduced bead creasing the calculation requires simply multiplying the caliper by 3, to give a channel width or crease bead width of 0.045”. ***See left.*** Therefore, in this specification of a reduced bead calculation, the thickness or the pointage of the crease is not a key factor in the calculation of the channel width. However, the proportion of the arc formed by the tip of the crease and the arc formed by the formed bead **are** critical factors.



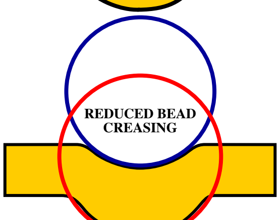
The relationship between the inner and outer profile, or the arc of the crease and the arc of the bead, formed between the crease rule and the caliper of the material in standard creasing are shown ***right***.



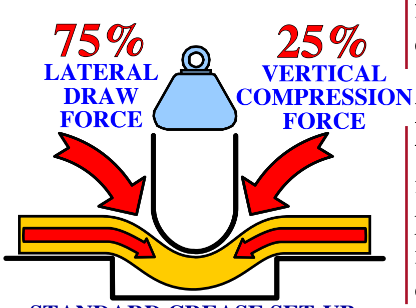
As this diagram shows, in the standard crease formulation the diameter of the inner segment of the Crease Arc is much smaller than the diameter of the outer segment of the Crease Arc.



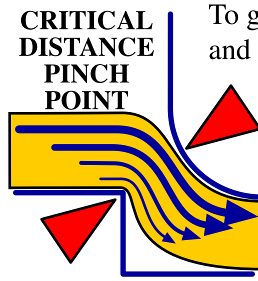
By comparison the proportions of the reduced bead creasing formulation are shown ***left.*** In this diagram it shows the proportion of the arc formed by the crease rule and the shaped of the formed bead are almost identical.



A traditional crease is formed through a combination of initial compressive force and lateral shearing draw. In the standard crease set-up this force is approximately 75% lateral draw or tensile stress, and 25% compressive force or pressure. ***See right.***



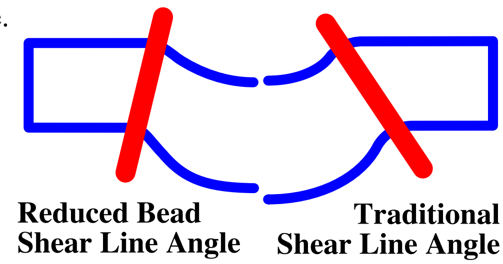
STANDARD CREASE SET-UP



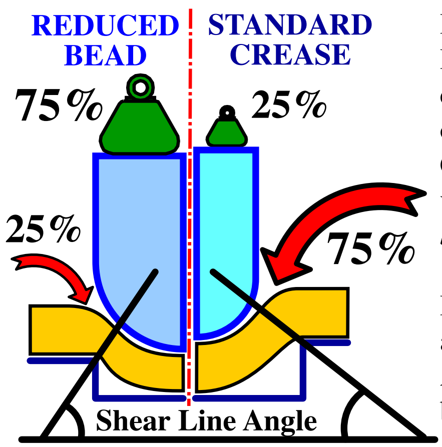
To generate the shear line failure point and sufficient internal delamination of the bead, it is necessary to pinch the paperboard between the face of the crease rule and the upper corner of the crease female channel. ***See left.***

However, if the Shear Line Angle is too shallow, as it is in a traditional crease set-up, ***see below right***, the degree of lateral draw force is excessive.

In creating the shear line fold point in this manner, the resulting bead is inconsistently internally delaminated, and the degree of variation in performance is excessive.



Finally, using a shallow Shear Line Angle, the definition of the bead or the crispness of bead formation is poor, and as a result, folding is inconsistent and it will generate excess spine stress.



By adopting a Reduced Bead approach to crease set-up the roles of Tensile Draw and Compressive force are virtually reversed. ***See below right.***

In addition, the more acute Shear Line Angle in reduced bead creasing, ***see left***, a more precise delamination of the bead is generated, for essential bead folding flexibility, and it creates a more well defined, and consistent crease folding failure point.

It is also obvious that as we recommend a smaller bead, the accomplishment of the more effective shear line angle is made easier using a proportionately thicker or higher pointage male creasing tool. This brings a more direct and more concentrated shearing pressure at the critical distance of the crease.

2: Higher Pointage Crease Rule

What is the role of the male crease rule? The male creasing rule mounted in the steel rule die performs four key functions in the formation of the crease. These are:

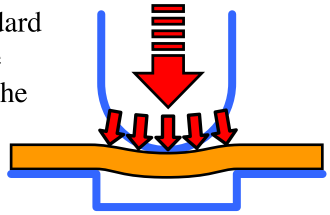
1: To punch/shear the paperboard into the crease channel

2: To form twin pinching surfaces to match the twin upper corners, of the female crease channel

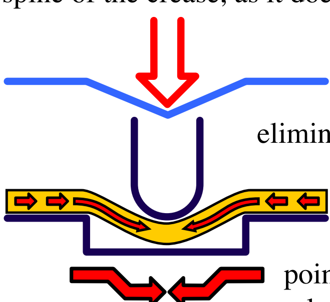
3: To define an effective shear line angle, to generate internal stress in the bead of the crease

4: To apply even pressure to the surface of the crease, to ensure balanced internal bead delamination, and an effective, elastic crease spine

Why is a higher pointage than standard more effective?

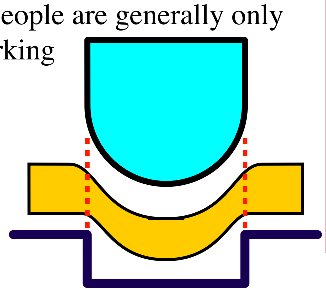


To a greater extent than the standard set-up the higher pointage crease applies a more even pressure to the surface. ***See right***. And while the act of shearing is on either side of the crease rule, it is important not to concentrate high tensile stress in a narrow section of what will become the spine of the crease, as it does in a traditional crease set-up. ***See below left.***

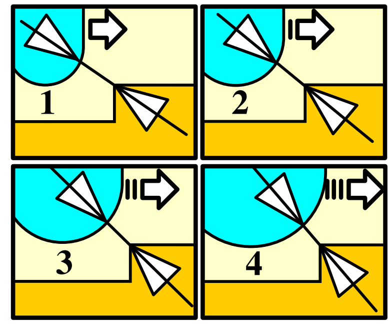


The most difficult practice to eliminate when moving to reduced bead creasing, is to overcome the habit of assuming the width of the channel and the pointage of the crease have a linked relationship, or that the channel has to be wider than the crease rule.

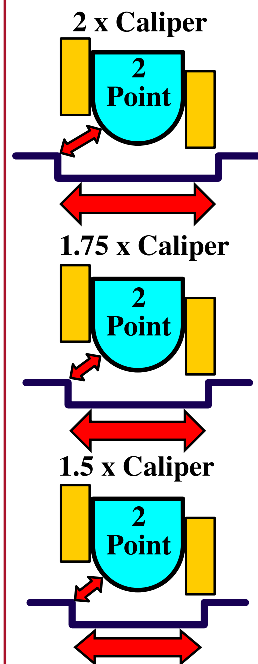
Particularly in thinner paperboard and paper materials, there are many situations where the pointage of the crease is the same or larger than the crease channel. ***See below***. This is an important technique designed to solve specific creasing and folding problems, however, people are generally only convinced when they see this working for the first time!



The combination of making the channel narrower both increases the punching force between the face of the crease and the upper corner of the crease channel, and it gradually increases the angle of the “***Shear Failure Line***.” ***See right***.



As the illustration clearly shows, as the pointage increases and/or the channel width is narrowed, the pinching distance between the face of the crease and the upper corner of each channel is gradually reduced, and the Shear Failure Angle moves from approximately 45 degrees, to an angle of approximately 60 degrees.



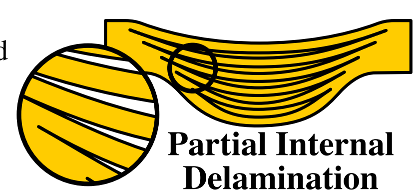
This could be achieved by keeping the original 2-Point Crease and simply narrowing the channel. In other parts of the world industry, the standard formula for calculating the crease channel is to multiply the caliper by 1.75, or 1.5, and add the thickness of the 2-Point Crease. ***See left***. These options will be discussed in the section on crease specification, however, the reduction in the channel width has the same effect as reducing the Critical Distance, the pinching distance, and to change the Shear Failure Angle.

However, one of the important benefits of using a higher pointage crease than standard, is the impact on the area of surface or spine delamination.

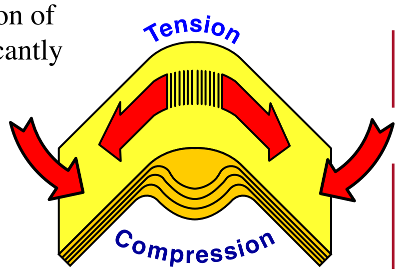
3: Wider Surface Delamination

One of the key roles or the crease rule mounted in the steel rule die, is to generate internal delamination of the paperboard by compressing the material against the upper corners of each channel to form partially separated layers of material in the resulting crease bead. ***See below***.

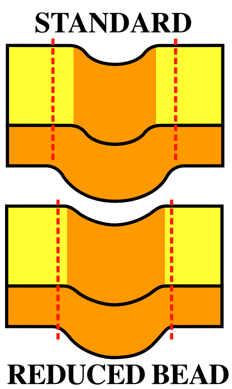
However, the proportion of the degree of delamination at the surface of the material, where the crease punched into the material, and the width of the delaminated lower layers of the bead,



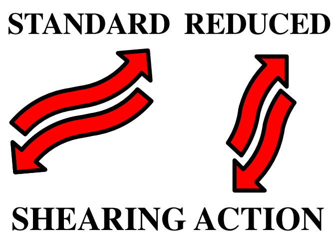
formed by the shearing action of the pinch points, are significantly different.



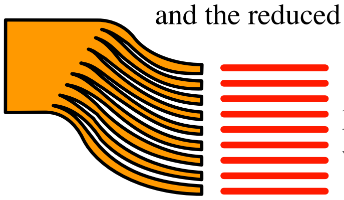
This is critical to crease performance, because as the crease folds, the surface indented by the crease rule becomes the spine of the crease, and it is essential it is as flexible and as elastic as possible, to absorb and to compensate for the tensile stress the spine is subjected to. ***See above***.



The advantage of the Reduced Bead crease over a Standard crease is first, the width of the surface delaminated area is larger, and secondly, the area of surface/spine delamination is more in proportion to the delamination area of the crease bead. ***See left.***



In addition, because of the larger crease rule in proportion to the width of the crease channel, the shearing is more vertical than horizontal, ***see right***, with the result, the delamination is even and consistent from the surface of the bead, to the surface of the crease spine. ***See below***. (It should also be noted that the difference in the shearing action between the standard and the reduced bead crease is a key reason the reduced bead crease female upper channel corners are far less susceptible to abrasive wear!)

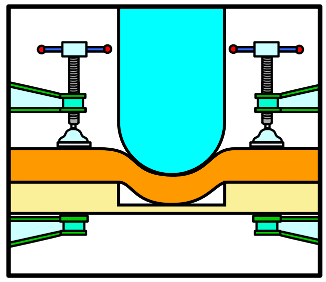


These factors translate to greater folding flexibility and the elimination of excess spine stress and spine fracturing and splitting.

Finally, because with Reduced Bead Creasing there is far less tensile draw generated by this and other surrounding creases, and because the counter/matrix tool is much thinner, the formation of the crease bead, and particularly the spine is somewhat isolated from competitive tensile forces, further reducing the stress on the surface of the paperboard, which will become the spine of the crease.

4: Balanced Bead Delamination

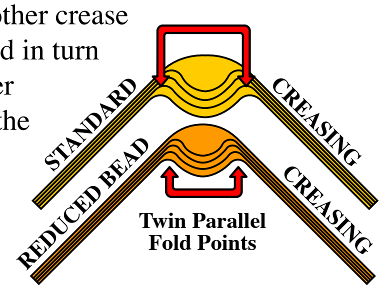
It is important to remember the goal is to create an effective paperboard hinge, and the engine room of the hinge is the crease bead. It is not just that the size of the bead has been reduced in this approach to creasing, but in how that reduction in size has impacted the structure and the performance attributes of the bead.



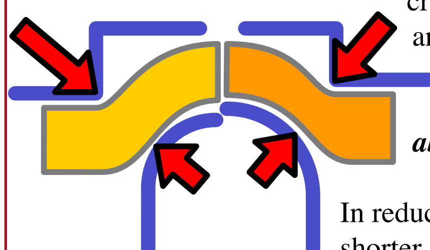
Some of the advantages of the smaller bead include:

The concentrated application of compressive force in a narrower band, more efficiently uses pressure in diecutting, and it generates more even layering and flexibility in the bead.

Because this crease method employs a higher proportion of compressive force rather than lateral draw to form the crease, the action of each individual crease formation is isolated. This means the formation of the bead is not influenced by the action of other crease formation and diecutting, and in turn it is not interfering with other converting activities across the steel rule die. ***See above***



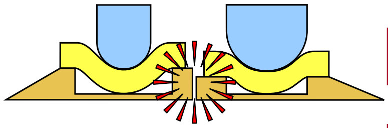
The relationship between the pinching faces of the crease and the pinching upper corners of each crease channel is critical to effective bead formation. Both Standard creasing and Reduced Bead creasing are double folds, and rely upon twin, parallel shear failure line/points to fold. ***See above right***.



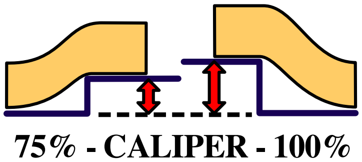
In reduced bead creasing, the shorter and more compressive action of shearing separation is more effective than the longer more lateral shearing action of the standard crease. ***See above left***.

In summation, the reduced crease bead is smaller, it is more evenly delaminated, it requires less overall force to form than a standard crease, and the flexibility of the bead in folding is a significant advantage.

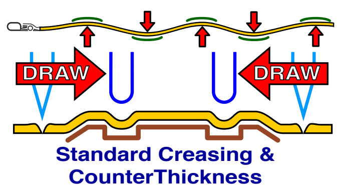
5: Thinner Counter



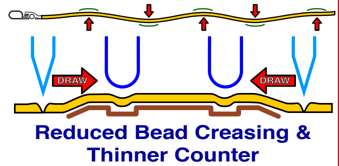
A key feature, and a significant benefit of reduced bead creasing, is this approach to male and female tool design uses a much thinner female counter/matrix than the standard crease. ***See above***.



In reduced bead creasing the thickness of the female tool, or the depth of the crease channel is only 75% of the caliper of the material being creased, rather than 100% of the caliper used in standard creasing. ***See left***.



This modification to the standard creasing profile, also means the difference in height between the knife and the crease is reduced, which lowers the distortion and wrap effect of traditional creasing. ***See right***.

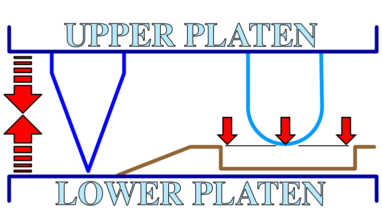


The thinner counter/matrix tool obviously limits competitive tensile draw forces to help to isolate the unencumbered formation of individual creases, and to prevent crease formation effecting surrounding creases and cutting knives.

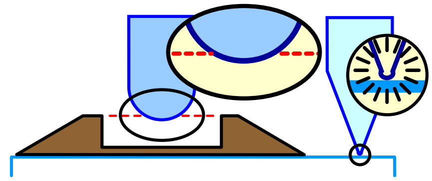
Because limiting the wrap effect of paperboard being stretched and deformed around a thinner counter, the stiffness of the material is reduced and each crease and each cut can convert more efficiently.

6: Compression Gap

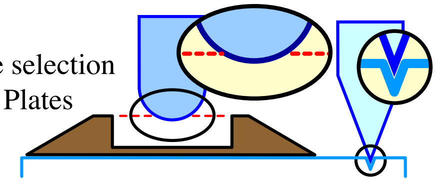
One of the more complex challenges of platen diecutting, is to achieve a perfect kiss-cut impression across the entire steel rule die layout. In standard creasing tool set up, if the knife is making perfect kiss cut contact with the surface of the cutting plate, the tip of crease rule in the die would be level with the surface of the counter or matrix tool. ***See right***

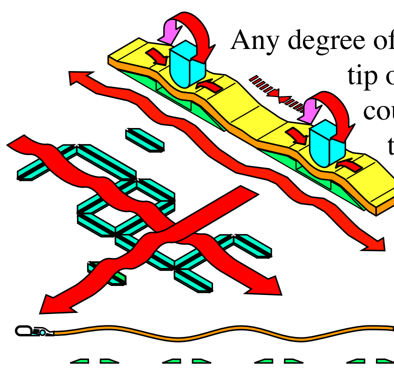


Unfortunately, variation causes some knives to strike the surface of the cutting plate with excessive force, and they suffer compressive failure of the tip of the blade. This also means now, the tip of the crease rule is protruding below the surface of the counter or matrix channel. ***See above***.



In a similar fashion, the selection of Thin or Soft Cutting Plates anticipates the degree of diecutting variation. This allows the tip of the knife to penetrate the surface of the cutting plate, to eliminate damage to the sharpness of the edge. However, the tip of the crease rule is now pushing down into the counter/matrix channel, and it is below the plane formed by the surface of the tool. ***See above***.

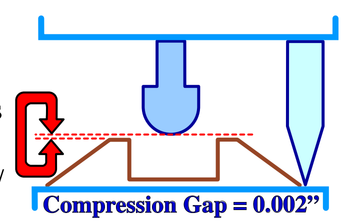




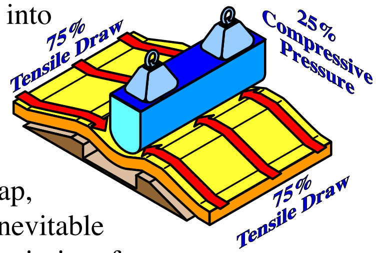
Any degree of over penetration of the tip of the crease into the counter channel and below the surface of the female tool, accelerates upper channel corner wear, and it increases the level of damaging tensile stress or lateral draw across the entire layout. ***See left***.

In addition, over penetration of the tip of the crease, particularly at the beginning of the press make-ready, creates a temporary high resistance point in the layout. This resistance is gradually eliminated as the upper corners of the counter channel wear down, however, during this period, the resistance prevents adjoining knives from cleanly cutting through the material. The operator responds by patching the knives, however, as the wear of the counter eliminates the crease resistance point, the knives suffer further compressive damage, and the cycle of patching continues.

The integration of a Compression Gap in the Reduced Bead crease tool formula is an important setting adjustment, which is simply there to recognize the normal dynamic of press make-ready. ***See right***.



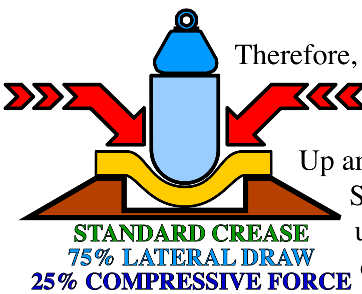
The advantage of the Compression Gap, is it enables the cutting make-ready to proceed without false pressure/ resistance readings from over penetration of the crease rule into and below the surface of the counter/matrix channel.



However, the primary reason for the compression gap, is this allowance for almost inevitable variation will mean that the majority of crease rules and the counter channel, will be set-to zero penetration after press make-ready, and the cutting will be more stable and crease performance will start at optimal levels, and will change and degrade at a consistent rate.

7: Compressive Formation

Using a thin narrow crease rule, a thicker counter, and a wider female tool channel, crease formation and shearing rely primarily upon, and generate excessive levels of tensile draw and stress. ***See above***.



Therefore, one of the primary differences between the Standard Crease Tool Set-Up and Reduced Bead Crease Tool Set-Up, is the standard crease uses more than 75% lateral draw as the crease formation force. ***See left***.

By comparison, the Reduced Bead Crease Set-Up is approximately 75% Compression Pressure, and less than 25% Lateral Draw. ***See below***.

The importance of this difference in tool set-up and crease formation forces cannot be underestimated. By using a majority of compressive force, reduced bead set-up minimizes damaging lateral tensile draw, it minimizes rapid and uneven tool wear, and the more vertical shearing action generates better delamination and folding flexibility.

To summarize, the seven tool set-up features which make Reduced Bead Creasing unique are:

1: Proportionate-Smaller Bead
2: Higher Pointage Crease Rule
3: Wider Surface Delamination
4: Balanced Bead Delamination
5: Thinner Counter
6: Compression Gap
7: Compression Formation

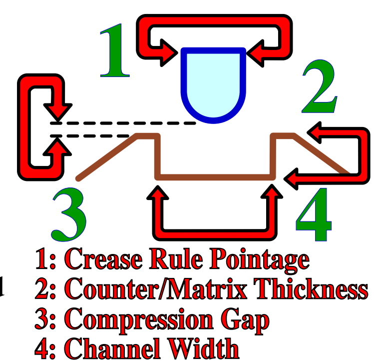
How to Design Reduced Bead Creasing?

"Creativity --It's like driving a car at night. You never see further than your headlights, but you can make the whole trip that way." *E. L. Doctorow*

In practice, the specification and design of Reduced Bead Creasing is simple to understand and easy to execute. It is also important to recognize, that while some of the differences between traditional creasing and reduced bead creasing are small, they are all significant in terms of improving the performance of crease formation and effective folding.

There are four key elements of Reduced Bead Creasing tool specification and design. ***See below***. These elements are:

- ***The Pointage of the Crease Rule***
- ***The Thickness of the Counter/Matrix***
- ***The Compression Gap***
- ***The Channel Width***



Each change to the standard procedure provide measurable improvement in crease formation and in folding performance, in process productivity, and in the quality and the consistency of the carton and the container. It is important to remember that the design process should be a open minded discipline, in which personal knowledge and experience, should play a key part.

The Pointage of the Crease

There are 7 reasons to increase the pointage of the crease in proportion to the thickness of the paperboard and the width of the channel. These are as follows:

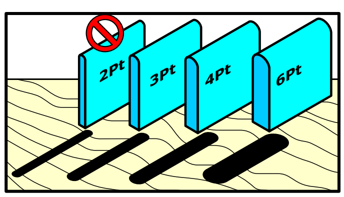
1: To change the Angle of Attack.
2: To evenly distribute Compressive Force.
3: To reduce dependence on Lateral Draw.
4: To delaminate a wider area of the Material Surface.
5: To use vertical force to minimize Female Tool Wear.
6: To minimize the impact of tool-to-tool Misalignment.
7: To provide a stiffer and a Stronger Tool.

So how do we accomplish this?

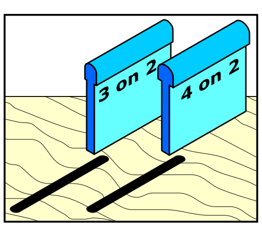
In Reduced Bead Creasing we eliminate 2-point creasing from the process, except for the thinnest material, between 0.001" and 0.010", and even then a 2-point wide male former has limited usefulness. The charts provided cover the standard range of paperboard between 0.006" and 0.040."

CALIPER	Against Grain	With Grain
0.011 - 0.014	3-Point	3-Point
0.015 - 0.019	3-Point	3-Point
0.020 - 0.024	4-Point	3-Point
0.025 - 0.029	4-Point	4-Point
0.030 - 0.035	6-Point	4-Point

Starting at the lowest caliper, 0.006", we use 3-point creasing rule, however, as it is important in this approach to delaminate as large an area of the channel/bead as possible, it is necessary to increase the pointage of the crease rule at selected points, as the caliper of the material being converted gets thicker. ***See above***.



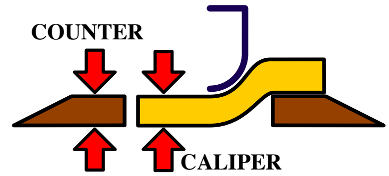
When evaluating the information and recommendations, it is important to remember that they are simply that, recommendations. For example, many choose to use 3-point creasing rule for the entire range of caliper. This is because of the cost, complexity, and time involved in lasercutting a 3, 4 & 6-point kerf, ***See above***. And as a result they often choose to use 3-on-2-point, or even 4-on-2-point creasing rule, inserted into a 2-Point lasercut slot. ***See left***.



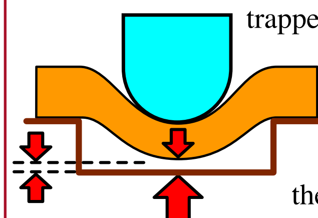
The bottom line? The higher the pointage of crease rule you can successfully use, the better the formation of the bead, and folding performance will be more reliable, and more consistent.

The Thickness of the Counter-Matrix

As the entire focus of Reduced Bead Creasing is on a proportionately smaller bead than the standard formula, there is no need for the thickness of the counter or matrix tool, to match the thickness of the caliper. ***See right***. In practice, the thickness of the female tool, and/or the depth of the female channel can be reduced as a percentage of the caliper of the paperboard.



The original concept of the caliper and the female tool thickness matching, was based upon the misconception that the paperboard would make contact with the base of the female tool channel. However, in reality the paperboard trapped between the upper corners of the channel is stretched as it is sheared, so the total thickness of the material at the centerpoint of crease formation, is less than the caliper of the material. ***See left***. This provides a number of important advantages in crease formation.



There are 6 reasons to reduce the thickness of the female crease tool. These are as follows:

1: The Knife-to-Crease Vertical Shearing Distance.
2: The Reduced Competitive Draw and Lateral Tension.
3: The ability to keep the diecut sheet Flatter and Aligned.
4: The positive impact on Nicking & Flaking.
5: The reduction in Product Marking.
6: The reduction in Material & Processing Cost.

So how do we accomplish this?

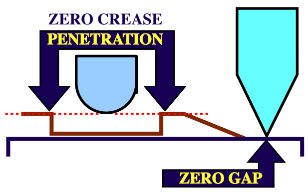
The recommendations, ***see below***, specify the thickness of the counter or matrix strip should be set as a percentage of the caliper. However, this has to be mitigated by what crease tool materials are available. The recommendation is to use the closest material available, and round up to the next size.

Female Crease Tool Thickness
0.010" - 0.014" = 90% - Caliper
0.015" - 0.020" = 85% - Caliper
0.021" - 0.025" = 80% - Caliper
0.026" - 0.030" = 75% - Caliper
0.031" - 0.035" = 70% - Caliper
0.036" - 0.040" = 65% - Caliper

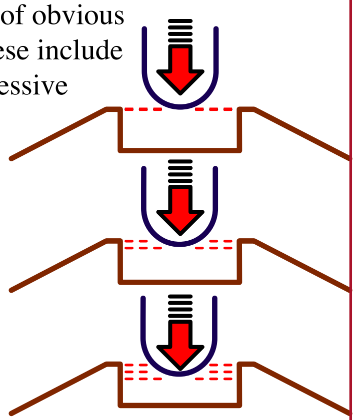
The closer to the

recommended thicknesses the better, however, plus or minus 0.001" is fine, and frankly by using the ***"wrong"*** thickness of counter material, you may discover an even more effective crease formulation!

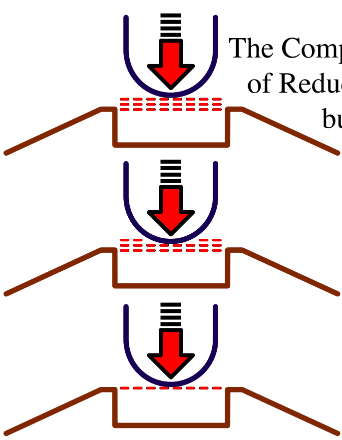
The Compression Gap



Setting the tip of the crease rule level with the surface of the female tool, ***see left***, in designing creasing tools, is a recipe for quality and productive disaster. The practical reality of platen diecutting press make-ready, is that after the cutting impression has been set, the male crease rule is now protruding below the surface of the female channel. ***See right***. This leads to a multitude of obvious and some hidden problems. These include uneven crease formation, progressive product variation, and an unstable diecutting press cutting make-ready, to name only a few?



The Reduced Bead Creasing method integrates a gap between the tip of the crease rule and the surface of the counter or matrix strip, as a buffer to compensate for inevitable compression of the steel rule die. ***See below***.



The Compression Gap is a key element of Reduced Bead Creasing, as it is a buffer designed to compensate for over-pressurization and the progressive deterioration of the standard press make-ready.

So what are the benefits of setting the male and female tools so that when the press is at the optimal Shut Height, there is a gap between the tip of the crease and the surface of the counter/matrix?

There are 6 reasons to set the male and female tool to include a gap between the tools. These are as follows:

1: Eliminate over-penetration of the crease rule.

2: Minimize the Press Make-Ready "Resistance" Point.

3: Reduce rapid wear of key female tool features.

4: Design for the "After" press make-ready process.

5: Improve Press Speed & Yield.

6: Improve Folding Performance & Consistency.

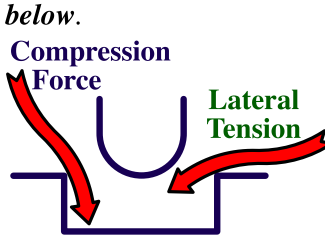
The Reduced Bead Calculation of the Compression Gap increases as the caliper increases, ***see below***, however, the compression gap allowance is slightly different for recycled materials. The gap is smaller because recycled paperboards are generally more malleable and less stiff than a virgin fiber paperboard.

Compression Gap Calculation		
Caliper	**Virgin**	**Recycle**
0.010" - 0.014"	**0.001"**	**0.000"**
0.015" - 0.020"	**0.002"**	**0.001"**
0.021" - 0.025"	**0.003"**	**0.002"**
0.026" - 0.030"	**0.004"**	**0.003"**
0.031" - 0.035"	**0.005"**	**0.004"**
0.036" - 0.040"	**0.006"**	**0.005"**

The consensus is a Compression Gap in creasing provides multiple benefits, and it is and essential feature of Reduced Bead Creasing.

The Channel Width

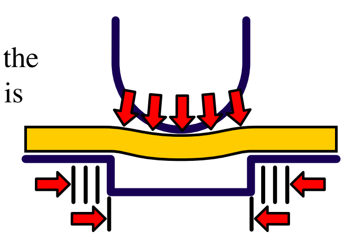
The goal of Reduced Bead Creasing is to produce a smaller, more evenly delaminated bead, which is flexible and elastic as the panels are folded. This requires concentrating the delamination force in a narrower band, and utilizing a ***Vertical Compressive Force*** for shearing, rather than the standard ***Lateral Draw Stress*** method of shearing. ***See below***.



This requires a narrower channel, proportionate to the caliper of the paperboard, and it requires a thicker male tool to more evenly distribute the delamination force. ***See below***.

What is different from the standard approach, is the relationship between the width of the female tool channel and the thickness of the male tool.

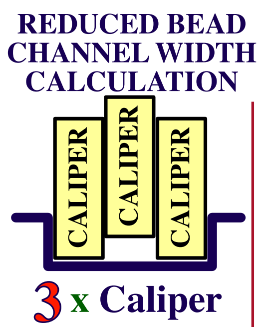
What are the benefits of setting the male and female tools so that it is proportionate to the caliper of the paperboard, and narrower than the traditional calculation?



There are 6 reasons to reduce the width of the female crease tool channel. These are as follows:

1: Generate a smaller, more evenly delaminated crease bead.
2: Base the bead parameters on the caliper of the paperboard.
3: Change from predominantly Lateral Draw to Compressive Force for crease formation.
4: Increase crease formation consistency by reducing tool wear.
5: Generate a more effective folding bead.
6: Improve control and consistency of folding performance.

So how do we accomplish this?



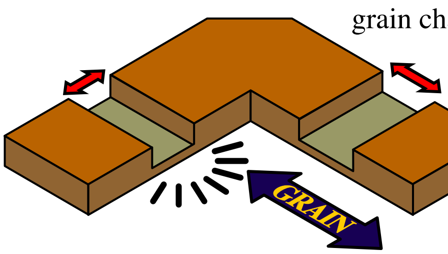
In principle, the basis for Reduced Bead Creasing tool design is to calculate the width of the channel solely on the caliper of the paperboard. This calculation multiplies the caliper of the paperboard times three, to define the width of the female tool crease channel. ***See right***.

Having described the basis for calculating the width of the channels, it is necessary to consider a key characteristic of paperboard, Grain Direction.

All paperboard has a detectable grain direction, and the differences between cross grain folding stiffness and parallel grain folding stiffness, can be relatively small or they can be significant.

Adding to this issue, is the reality of cross web shrinkage as the pulp stream is drained, pressed, and heated, in the paper making process. In practice, paperboard becomes more elastic as it is shrunk, and the increased elasticity is parallel to the grain.

As elasticity is the enemy of delamination, it is necessary to make the parallel grain channels narrower than the cross grain channels. ***See left***.



It is also important to factor in the differences between Virgin Fiber Paperboard

Grain Allowance Calculation		
Caliper	**Virgin**	**Recycle**
0.010" - 0.014"	0.000"	0.002"
0.015" - 0.020"	0.002"	0.004"
0.021" - 0.025"	0.004"	0.006"
0.026" - 0.030"	0.006"	0.008"
0.031" - 0.035"	0.008"	0.010"
0.036" - 0.040"	0.010"	0.012"

parallel grain creases and Recycled Fiber Paperboard parallel grain creases. The differences in cross grain and parallel grain folding stiffness between a Virgin Fiber paperboard and a Recycled paperboard can be quite different, therefore, it is necessary to treat the two materials differently, with regard to the channel grain adjustment. ***See above***. As you can see, we are recommending a graduated adjustment cased upon a caliper range.

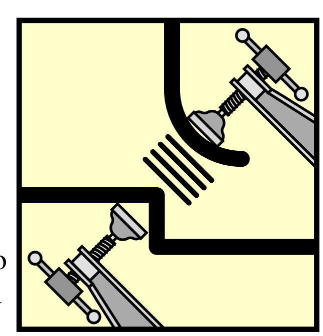
In other words, the adjustment between cross grain and parallel grain channel width is an important factor in tool design, but the difference between the cross grain channel width and the parallel grain channel width must be predicated on the specific characteristics of the paperboard being converted!

So what other factors must be included in the channel width calculation?

The final issue requires categorizing the material to be converted/creased as Virgin Fiber or Reduced Fiber.

To reiterate an obvious warning, it is dangerous to categorize any material by a single attribute, however, for the basis of calculating channel widths, there are key characteristics which can be assumed to be typical of each category of paperboard. In terms of creasing, Virgin Fiber Paperboard is generally a lower density, stiffer material, compared to Recycled Fiber, which is generally a higher density, more malleable material.

In terms of creasing, this means it is necessary to apply greater shearing pressure at the Critical Distance Pinch Point to an identical crease in Recycled Paperboard, than an identical crease in Virgin Paperboard. ***See below***.



How do we handle this variable in the Reduced Bead Creasing tool calculation?

The most common approach to this problem is to make an often inconsistently applied decision to reduce the width of the Recycled

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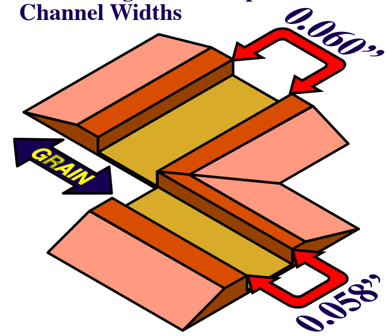
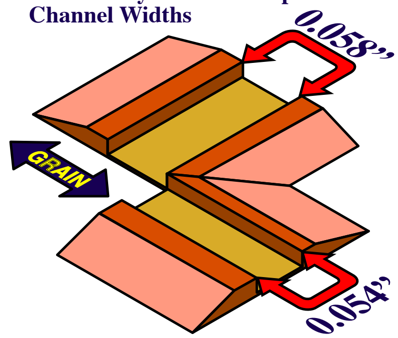
Paperboard channels, in comparison to the channels used for Virgin Fiber of the same caliper. In practice, if this works, then that is fine. However, in Reduced Bead Creasing we use a simple and consistently applied formula.

0.020" Virgin Fiber Paperboard Channel Widths



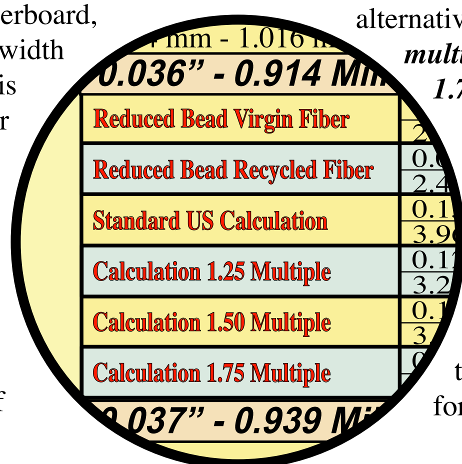
For example, ***see right***, if we were calculating the channel width for a Virgin Fiber paperboard of 0.020" in thickness, the calculation of three times the caliper, would give a cross grain channel width of 0.060". And using the grain allowance chart, the parallel grain channel width would be 0.058".

0.020" Recycled Fiber Paperboard Channel Widths



However, if we were using Recycled Paperboard, we would use the parallel grain channel width from the Virgin Fiber calculation, which is 0.058," for the cross grain Recycled Fiber Channels. And using the grain allowance chart, we would note that in the range of caliper of 0.015" to 0.020" the grain allowance for Recycled Paperboard is 0.004."

Therefore, we would subtract this from 0.058" to give a parallel channel width of 0.054".



This recommendation, as with all others, is a guideline for developing your own approach. However, this recommendation is based upon practical experience, successful problem solving projects, and from feedback from users.

The Crease Charts

The seven charts used to determine key tool parameters at the end of the article cover the caliper range from 0.006" to 0.040." In addition, each individual caliper is broken down into 6 sets of crease tool parameters. These are:

1: Reduced Bead: Virgin Fiber
2: Reduced Bead: Recycled Fiber
3: The Standard US Calculation
4: The 1.25 Multiple Calculation
5: The 1.50 Multiple Calculation
6: The 1.75 Multiple Calculation

The first two are based upon the ***Reduced Bead Creasing*** method and reflect the basic starting point of calculating the width of the channel by multiplying the caliper of the paperboard by 3.

The third, set of parameters is for the generally practiced ***Standard US Calculation***. This is based upon doubling the caliper and adding in the pointage of the creasing rule selected for that specific caliper of paperboard.

The final three calculation formulas reflect a trend in the industry to find a more effective design for tooling, by changing a single variable, the width of the channel. Whereas the Standard US Calculation is to multiply the caliper by 2 and add the thickness of the creasing rule, these alternative methods calculate the channel width by ***multiplying the caliper of the paperboard by 1.75, 1.50, & 1.25 respectively***.

These formulas are often used in Europe and the Pacific Rim, where the materials are both similar and very different. All other factors remain the same. This approach is growing in popularity, and it shows a healthy determination to find more effective methods of crease formation and better folding performance.

Every recommendation is just that a recommendation. It is vital you and your colleagues combine the information contained in the charts with your own hard won knowledge and experience.

Reduced Bead Creasing: Summary?

"Whatever one man is capable of conceiving, other men will be able to achieve" *Jules Verne*

Reduced Bead creasing is an innovative and an effective approach to creasing and folding paperboard. However, it should be initially used to solve difficult problems traditional creasing seems unable to cope with. In this way, the user gains experience with new methods and practices, while overcoming a challenging issue.

The ultimate goal is to create a systematic approach to creasing and folding which integrates all of the knowledge and all of the experience you can collect from every source. As part of this evaluation process, it is useful to consider the proven advantages of reduced bead creasing. These advantages and benefits would include the following:

- ***Critical Distance Stability***
- ***Fold & Opening Force Control***
- ***Improve Bead Flexibility***
- ***Improve Cartoning Performance***
- ***The Elimination of Bead Binding***
- ***Crease Spine Stress & Failure***
- ***Crease End Splitting***
- ***Crease to Crease Competition***
- ***Minimize Draw Induced Flaking***
- ***Minimize Nicking-Draw Stress***
- ***A Stable Cutting Make-Ready***
- ***Improved Overall Quality***
- ***Eliminate Bead Snagging***
- ***Faster Press Speed***
- ***Lower Material/Machining Cost***

As you see from this impressive list of benefits, the Reduced Bead Creasing tool design method, provides the diecutter with a simpler and more bullet proof method of crease formation, and it provides the end user of the carton or container, with the folding consistency and repeatability they demand.

However, it should be noted that cellulose based materials are inherently variable, and their range of properties and converting attributes will vary from batch-to-batch, and from Mill run to Mill run. It is vital to be constantly vigilant and to avoid complacency, as the materials, the structural designs, and the process are constantly changing.

Fortunately, Reduced Bead Creasing is a highly effective solution. It provides a more reliable and a more predictable method of crease formation, and it generates a paperboard hinge, which will fold and unfold with remarkable consistency.

Caliper Range 0.006" - 0.010" 0.152 mm - 0.254 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.006" - 0.152 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.018	0.018	3-Point	3-Point	0.927	0.927	0.010		
	0.457	0.457	3-Point	3-Point	23.546	23.546	0.254		
Reduced Bead Recycled Fiber	0.018	0.018	3-Point	3-Point	0.927	0.927	0.010		
	0.457	0.457	3-Point	3-Point	23.546	23.546	0.254		
Standard US Calculation	0.040	0.040	2-Point	2-Point	0.927	0.927	0.010		
	1.016	1.016	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.25 Multiple	0.036	0.036	2-Point	2-Point	0.927	0.927	0.010		
	0.914	0.914	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.50 Multiple	0.037	0.037	2-Point	2-Point	0.927	0.927	0.010		
	0.940	0.940	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.75 Multiple	0.038	0.038	2-Point	2-Point	0.927	0.927	0.010		
	0.965	0.965	2-Point	2-Point	23.546	23.546	0.254		
0.007" - 0.178 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.021	0.021	3-Point	3-Point	0.927	0.927	0.010		
	0.533	0.533	3-Point	3-Point	23.546	23.546	0.254		
Reduced Bead Recycled Fiber	0.021	0.021	3-Point	3-Point	0.927	0.927	0.010		
	0.533	0.533	3-Point	3-Point	23.546	23.546	0.254		
Standard US Calculation	0.042	0.042	2-Point	2-Point	0.927	0.927	0.010		
	1.067	1.067	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.25 Multiple	0.028	0.028	2-Point	2-Point	0.927	0.927	0.010		
	0.711	0.711	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.50 Multiple	0.039	0.039	2-Point	2-Point	0.927	0.927	0.010		
	0.978	0.978	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.75 Multiple	0.040	0.040	2-Point	2-Point	0.927	0.927	0.010		
	1.016	1.016	2-Point	2-Point	23.546	23.546	0.254		
0.008" - 0.203 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.024	0.024	3-Point	3-Point	0.927	0.927	0.010		
	0.610	0.610	3-Point	3-Point	23.546	23.546	0.254		
Reduced Bead Recycled Fiber	0.024	0.024	3-Point	3-Point	0.927	0.927	0.010		
	0.610	0.610	3-Point	3-Point	23.546	23.546	0.254		
Standard US Calculation	0.044	0.044	2-Point	2-Point	0.927	0.927	0.010		
	1.118	1.118	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.25 Multiple	0.038	0.038	2-Point	2-Point	0.927	0.927	0.010		
	0.965	0.965	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.50 Multiple	0.040	0.040	2-Point	2-Point	0.927	0.927	0.010		
	1.016	1.016	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.75 Multiple	0.042	0.042	2-Point	2-Point	0.927	0.927	0.010		
	1.067	1.067	2-Point	2-Point	23.546	23.546	0.254		
0.009" - 0.229 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.027	0.027	3-Point	3-Point	0.927	0.927	0.010		
	0.686	0.686	3-Point	3-Point	23.546	23.546	0.254		
Reduced Bead Recycled Fiber	0.027	0.027	3-Point	3-Point	0.927	0.927	0.010		
	0.686	0.686	3-Point	3-Point	23.546	23.546	0.254		
Standard US Calculation	0.046	0.046	2-Point	2-Point	0.927	0.927	0.010		
	1.168	1.168	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.25 Multiple	0.039	0.039	2-Point	2-Point	0.927	0.927	0.010		
	0.991	0.991	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.50 Multiple	0.042	0.042	2-Point	2-Point	0.927	0.927	0.010		
	1.067	1.067	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.75 Multiple	0.044	0.044	2-Point	2-Point	0.927	0.927	0.010		
	1.118	1.118	2-Point	2-Point	23.546	23.546	0.254		
0.010" - 0.254 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.030	0.030	3-Point	3-Point	0.926	0.926	0.010	0.001	0.001
	0.762	0.762	3-Point	3-Point	23.520	23.520	0.254	0.025	0.025
Reduced Bead Recycled Fiber	0.030	0.030	3-Point	3-Point	0.927	0.927	0.010		
	0.762	0.762	3-Point	3-Point	23.546	23.546	0.254		
Standard US Calculation	0.048	0.048	2-Point	2-Point	0.927	0.927	0.010		
	1.219	1.219	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.25 Multiple	0.041	0.041	2-Point	2-Point	0.927	0.927	0.010		
	1.041	1.041	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.50 Multiple	0.043	0.043	2-Point	2-Point	0.927	0.927	0.010		
	1.092	1.092	2-Point	2-Point	23.546	23.546	0.254		
Calculation 1.75 Multiple	0.046	0.046	2-Point	2-Point	0.927	0.927	0.010		
	1.168	1.168	2-Point	2-Point	23.546	23.546	0.254		

Caliper Range 0.011" - 0.015" 0.279 mm - 0.00 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.011" - 0.279 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.033	0.033	3-Point	3-Point	0.926	0.926	0.010	0.001	0.001
	0.838	0.838	3-Point	3-Point	23.520	23.520	0.254	0.025	0.025
Reduced Bead Recycled Fiber	0.033	0.031	3-Point	3-Point	0.927	0.927	0.010		
	0.838	0.787	3-Point	3-Point	23.545	23.545	0.254		
Standard US Calculation	0.050	0.050	2-Point	2-Point	0.926	0.926	0.011		
	1.270	1.270	2-Point	2-Point	23.520	23.520	0.279		
Calculation 1.25 Multiple	0.042	0.042	2-Point	2-Point	0.926	0.926	0.011		
	1.060	1.060	2-Point	2-Point	23.520	23.520	0.279		
Calculation 1.50 Multiple	0.045	0.045	2-Point	2-Point	0.926	0.926	0.011		
	1.143	1.143	2-Point	2-Point	23.520	23.520	0.279		
Calculation 1.75 Multiple	0.047	0.047	2-Point	2-Point	0.926	0.926	0.011		
	1.200	1.200	2-Point	2-Point	23.520	23.520	0.279		
0.012" - 0.304 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.036	0.036	3-Point	3-Point	0.926	0.926	0.010	0.001	0.001
	0.914	0.914	3-Point	3-Point	23.520	23.520	0.254	0.025	0.025
Reduced Bead Recycled Fiber	0.036	0.034	3-Point	3-Point	0.927	0.927	0.010		
	0.914	0.864	3-Point	3-Point	23.545	23.545	0.254		
Standard US Calculation	0.052	0.052	2-Point	2-Point	0.926	0.926	0.010		
	1.321	1.321	2-Point	2-Point	23.520	23.520	0.254		
Calculation 1.25 Multiple	0.043	0.043	2-Point	2-Point	0.927	0.927	0.010		
	1.092	1.092	2-Point	2-Point	23.545	23.545	0.254		
Calculation 1.50 Multiple	0.046	0.046	2-Point	2-Point	0.927	0.927	0.010		
	1.168	1.168	2-Point	2-Point	23.545	23.545	0.254		
Calculation 1.75 Multiple	0.049	0.049	2-Point	2-Point	0.927	0.927	0.010		
	1.245	1.245	2-Point	2-Point	23.545	23.545	0.254		
0.013" - 0.330 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.039	0.039	3-Point	3-Point	0.924	0.924	0.012	0.001	0.001
	0.991	0.991	3-Point	3-Point	23.724	23.724	0.305	0.025	0.025
Reduced Bead Recycled Fiber	0.039	0.037	3-Point	3-Point	0.925	0.925	0.012		
	0.991	0.940	3-Point	3-Point	23.749	23.749	0.305		
Standard US Calculation	0.054	0.054	2-Point	2-Point	0.924	0.924	0.013		
	1.372	1.372	2-Point	2-Point	23.724	23.724	0.330		
Calculation 1.25 Multiple	0.044	0.044	2-Point	2-Point	0.924	0.924	0.013		
	1.124	1.124	2-Point	2-Point	23.724	23.724	0.330		
Calculation 1.50 Multiple	0.048	0.048	2-Point	2-Point	0.924	0.924	0.013		
	1.207	1.207	2-Point	2-Point	23.724	23.724	0.330		
Calculation 1.75 Multiple	0.051	0.051	2-Point	2-Point	0.924	0.924	0.013		
	1.289	1.289	2-Point	2-Point	23.724	23.724	0.330		
0.014" - 0.355 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.042	0.042	3-Point	3-Point	0.924	0.924	0.012	0.001	0.001
	1.067	1.067	3-Point	3-Point	23.724	23.724	0.305	0.025	0.025
Reduced Bead Recycled Fiber	0.042	0.040	3-Point	3-Point	0.925	0.925	0.012		
	1.067	1.016	3-Point	3-Point	23.749	23.749	0.305		
Standard US Calculation	0.056	0.056	2-Point	2-Point	0.923	0.923	0.014		
	1.422	1.422	2-Point	2-Point	23.444	23.444	0.356		
Calculation 1.25 Multiple	0.046	0.046	2-Point	2-Point	0.923	0.923	0.014		
	1.156	1.156	2-Point	2-Point	23.444	23.444	0.356		
Calculation 1.50 Multiple	0.049	0.049	2-Point	2-Point	0.923	0.923	0.014		
	1.245	1.245	2-Point	2-Point	23.444	23.444	0.356		
Calculation 1.75 Multiple	0.053	0.053	2-Point	2-Point	0.923	0.923	0.014		
	1.334	1.334	2-Point	2-Point	23.444	23.444	0.356		
0.015" - 0.381 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.045	0.043	3-Point	3-Point	0.923	0.923	0.012	0.002	0.002
	1.143	1.143	3-Point	3-Point	23.444	23.444	0.305	0.051	0.051
Reduced Bead Recycled Fiber	0.043	0.039	3-Point	3-Point	0.924	0.924	0.012	0.001	0.001
	1.143	0.991	3-Point	3-Point	23.724	23.724	0.305	0.025	0.025
Standard US Calculation	0.058	0.054	2-Point	2-Point	0.922	0.922	0.015		
	1.473	1.372	2-Point	2-Point	23.419	23.419	0.381		
Calculation 1.25 Multiple	0.047	0.047	2-Point	2-Point	0.922	0.922	0.015		
	1.187	1.187	2-Point	2-Point	23.419	23.419	0.381		
Calculation 1.50 Multiple	0.051	0.051	2-Point	2-Point	0.922	0.922	0.015		
	1.283	1.283	2-Point	2-Point	23.419	23.419	0.381		
Calculation 1.75 Multiple	0.054	0.054	2-Point	2-Point	0.922	0.922	0.015		
	1.372	1.372	2-Point	2-Point	23.419	23.419	0.381		

Caliper Range 0.016" - 0.020" 0.406 mm - 0.508 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.016" - 0.406 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.048	0.046	3-Point	3-Point	0.921	0.921	0.014	0.002	0.002
	1.219	1.168	3-Point	3-Point	23.393	23.393	0.356	0.051	0.051
Reduced Bead Recycled Fiber	0.046	0.042	3-Point	3-Point	0.922	0.922	0.014	0.001	0.001
	1.168	1.067	3-Point	3-Point	23.419	23.419	0.356	0.025	0.025
Standard US Calculation	0.060	0.058	2-Point	2-Point	0.921	0.921	0.016		
	1.524	1.473	2-Point	2-Point	23.393	23.393	0.406		
Calculation 1.25 Multiple	0.048	0.044	2-Point	2-Point	0.921	0.921	0.016		
	1.219	1.118	2-Point	2-Point	23.393	23.393	0.406		
Calculation 1.50 Multiple	0.052	0.048	2-Point	2-Point	0.921	0.921	0.016		
	1.321	1.219	2-Point	2-Point	23.393	23.393	0.406		
Calculation 1.75 Multiple	0.056	0.052	2-Point	2-Point	0.921	0.921	0.016		
	1.422	1.321	2-Point	2-Point	23.393	23.393	0.406		
0.017" - 0.432 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.051	0.049	3-Point	2-Point	0.921	0.921	0.014	0.002	0.002
	1.295	1.245	3-Point	3-Point	23.393	23.393	0.356	0.051	0.051
Reduced Bead Recycled Fiber	0.049	0.045	3-Point	3-Point	0.922	0.922	0.014	0.001	0.001
	1.245	1.143	3-Point	3-Point	23.419	23.419	0.356	0.025	0.025
Standard US Calculation	0.062	0.058	2-Point	2-Point	0.920	0.920	0.017		
	1.575	1.473	2-Point	2-Point	23.368	23.368	0.432		
Calculation 1.25 Multiple	0.049	0.045	2-Point	2-Point	0.920	0.920	0.017		
	1.245	1.143	2-Point	2-Point	23.368	23.368	0.432		
Calculation 1.50 Multiple	0.054	0.050	2-Point	2-Point	0.920	0.920	0.017		
	1.359	1.270	2-Point	2-Point	23.368	23.368	0.432		
Calculation 1.75 Multiple	0.058	0.054	2-Point	2-Point	0.920	0.920	0.017		
	1.473	1.359	2-Point	2-Point	23.368	23.368	0.432		
0.018" - 0.457 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.054	0.052	3-Point	3-Point	0.920	0.920	0.015	0.002	0.002
	1.359	1.321	3-Point	3-Point	23.368	23.368	0.381	0.051	0.051
Reduced Bead Recycled Fiber	0.052	0.048	3-Point	3-Point	0.921	0.921	0.015	0.001	0.001
	1.321	1.219	3-Point	3-Point	23.393	23.393	0.381	0.025	0.025
Standard US Calculation	0.078	0.074	3-Point	3-Point	0.919	0.919	0.018		
	1.981	1.880	3-Point	3-Point	23.343	23.343	0.457		
Calculation 1.25 Multiple	0.065	0.061	3-Point	3-Point	0.919	0.919	0.018		
	1.638	1.549	3-Point	3-Point	23.343	23.343	0.457		
Calculation 1.50 Multiple	0.069	0.065	3-Point	3-Point	0.919	0.919	0.018		
	1.753	1.638	3-Point	3-Point	23.343	23.343	0.457		
Calculation 1.75 Multiple	0.074	0.070	3-Point	3-Point	0.919	0.919	0.018		
	1.880	1.778	3-Point	3-Point	23.343	23.343	0.457		
0.019" - 0.483 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.057	0.055	3-Point	3-Point	0.920	0.920	0.015	0.002	0.002
	1.448	1.397	3-Point	3-Point	23.368	23.368	0.381	0.051	0.051
Reduced Bead Recycled Fiber	0.055	0.051	3-Point	3-Point	0.921	0.921	0.015	0.001	0.001
	1.397	1.295	3-Point	3-Point	23.393	23.393	0.381	0.025	0.025
Standard US Calculation	0.080	0.076	3-Point	3-Point	0.918	0.918	0.019		
	2.032	1.930	3-Point	3-Point	23.317	23.317	0.483		
Calculation 1.25 Multiple	0.066	0.062	3-Point	3-Point	0.918	0.918	0.019		
	1.670	1.575	3-Point	3-Point	23.317	23.317	0.483		
Calculation 1.50 Multiple	0.071	0.067	3-Point	3-Point	0.918	0.918	0.019		
	1.791	1.702	3-Point	3-Point	23.317	23.317	0.483		
Calculation 1.75 Multiple	0.075	0.071	3-Point	3-Point	0.918	0.918	0.019		
	1.905	1.791	3-Point	3-Point	23.317	23.317	0.483		
0.020" - 0.508 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.060	0.058	4-Point	3-Point	0.919	0.919	0.016	0.002	0.002
	1.524	1.473	4-Point	3-Point	23.343	23.343	0.406	0.051	0.051
Reduced Bead Recycled Fiber	0.058	0.054	4-Point	3-Point	0.920	0.920	0.016	0.001	0.001
	1.473	1.372	4-Point	3-Point	23.368	23.368	0.406	0.025	0.025
Standard US Calculation	0.068	0.064	3-Point	3-Point	0.917	0.917	0.020		
	1.727	1.626	3-Point	3-Point	23.292	23.292	0.508		
Calculation 1.25 Multiple	0.067	0.063	3-Point	3-Point	0.917	0.917	0.020		
	1.702	1.600	3-Point	3-Point	23.292	23.292	0.508		
Calculation 1.50 Multiple	0.072	0.068	3-Point	3-Point	0.917	0.917	0.020		
	1.829	1.727	3-Point	3-Point	23.292	23.292	0.508		
Calculation 1.75 Multiple	0.077	0.073	3-Point	3-Point	0.917	0.917	0.020		
	1.956	1.854	3-Point	3-Point	23.292	23.292	0.508		

Caliper Range 0.021" - 0.025" 0.533 mm - 0.635 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.021" - 0.533 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.063	0.059	4-Point	3-Point	0.916	0.916	0.018	0.003	0.003
	1.600	1.499	4-Point	3-Point	23.266	23.266	0.457	0.076	0.076
Reduced Bead Recycled Fiber	0.059	0.053	4-Point	3-Point	0.917	0.917	0.018	0.002	0.002
	1.499	1.346	4-Point	3-Point	23.292	23.292	0.457	0.051	0.051
Standard US Calculation	0.084	0.082	3-Point	3-Point	0.916	0.916	0.021		
	2.134	2.083	3-Point	3-Point	23.266	23.266	0.533		
Calculation 1.25 Multiple	0.068	0.064	3-Point	3-Point	0.916	0.916	0.021		
	1.727	1.626	3-Point	3-Point	23.266	23.266	0.533		
Calculation 1.50 Multiple	0.074	0.070	3-Point	3-Point	0.916	0.916	0.021		
	1.880	1.778	3-Point	3-Point	23.266	23.266	0.533		
Calculation 1.75 Multiple	0.079	0.075	3-Point	3-Point	0.916	0.916	0.021		
	2.007	1.905	3-Point	3-Point	23.266	23.266	0.533		
0.022" - 0.559 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.066	0.062	4-Point	3-Point	0.916	0.916	0.018	0.003	0.003
	1.616	1.575	4-Point	3-Point	23.266	23.266	0.457	0.076	0.076
Reduced Bead Recycled Fiber	0.062	0.056	4-Point	3-Point	0.917	0.917	0.018	0.002	0.002
	1.575	1.422	4-Point	3-Point	23.292	23.292	0.457	0.051	0.051
Standard US Calculation	0.086	0.082	3-Point	3-Point	0.915	0.915	0.022		
	2.184	2.083	3-Point	3-Point	23.241	23.241	0.559		
Calculation 1.25 Multiple	0.070	0.066	3-Point	3-Point	0.915	0.915	0.022		
	1.766	1.676	3-Point	3-Point	23.241	23.241	0.559		
Calculation 1.50 Multiple	0.075	0.071	3-Point	3-Point	0.915	0.915	0.022		
	1.905	1.803	3-Point	3-Point	23.241	23.241	0.559		
Calculation 1.75 Multiple	0.081	0.077	3-Point	3-Point	0.915	0.915	0.022		
	2.045	1.956	3-Point	3-Point	23.241	23.241	0.559		
0.023" - 0.584 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.069	0.065	4-Point	3-Point	0.914	0.914	0.020	0.003	0.003
	1.753	1.651	4-Point	3-Point	23.216	23.216	0.508	0.076	0.076
Reduced Bead Recycled Fiber	0.065	0.059	4-Point	3-Point	0.915	0.915	0.020	0.002	0.002
	1.651	1.499	4-Point	3-Point	23.241	23.241	0.508	0.051	0.051
Standard US Calculation	0.088	0.084	3-Point	3-Point	0.914	0.914	0.023		
	2.235	2.134	3-Point	3-Point	23.216	23.216	0.584		
Calculation 1.25 Multiple	0.071	0.067	3-Point	3-Point	0.914	0.914	0.023		
	1,797	1.702	3-Point	3-Point	23.216	23.216	0.584		
Calculation 1.50 Multiple	0.077	0.073	3-Point	3-Point	0.914	0.914	0.023		
	1.956	1.854	3-Point	3-Point	23.216	23.216	0.584		
Calculation 1.75 Multiple	0.082	0.078	3-Point	3-Point	0.914	0.914	0.023		
	2.083	1.981	3-Point	3-Point	23.216	23.216	0.584		
0.024" - 0.610 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.072	0.068	4-Point	3-Point	0.914	0.914	0.020	0.003	0.003
	1.829	1.727	4-Point	3-Point	23.216	23.216	0.508	0.076	0.076
Reduced Bead Recycled Fiber	0.068	0.062	4-Point	3-Point	0.915	0.915	0.020	0.002	0.002
	1.727	1.575	4-Point	3-Point	23.241	23.241	0.508	0.051	0.051
Standard US Calculation	0.090	0.086	3-Point	3-Point	0.913	0.913	0.024		
	2.286	2.184	3-Point	3-Point	23.190	23.190	0.610		
Calculation 1.25 Multiple	0.072	0.068	3-Point	3-Point	0.913	0.913	0.024		
	1.829	1.727	3-Point	3-Point	23.190	23.190	0.610		
Calculation 1.50 Multiple	0.078	0.074	3-Point	3-Point	0.913	0.913	0.024		
	1.981	1.880	3-Point	3-Point	23.190	23.19	0.610		
Calculation 1.75 Multiple	0.084	0.080	3-Point	3-Point	0.913	0.913	0.024		
	2.134	2.032	3-Point	3-Point	23.190	23.190	0.610		
0.025" - 0.635 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.075	0.071	4-Point	4-Point	0.914	0.914	0.020	0.003	0.003
	1.905	1.803	4-Point	4-Point	23.216	23.216	0.508	0.076	0.076
Reduced Bead Recycled Fiber	0.071	0.065	4-Point	4-Point	0.915	0.915	0.020	0.002	0.002
	1.803	1.651	4-Point	4-Point	23.241	23.241	0.508	0.051	0.051
Standard US Calculation	0.092	0.088	3-Point	3-Point	0.912	0.912	0.025		
	2.337	2.235	3-Point	3-Point	23.165	23.165	0.635		
Calculation 1.25 Multiple	0.073	0.069	3-Point	3-Point	0.912	0.912	0.025		
	1.854	1.753	3-Point	3-Point	23.165	23.165	0.635		
Calculation 1.50 Multiple	0.080	0.078	3-Point	3-Point	0.912	0.912	0.025		
	2.032	1.981	3-Point	3-Point	23.165	23.165	0.635		
Calculation 1.75 Multiple	0.086	0.082	3-Point	3-Point	0.912	0.912	0.025		
	2.184	2.083	3-Point	3-Point	23.165	23.165	0.635		

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Caliper Range 0.026" - 0.030" 0.660 mm - 0.762 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.026" - 0.660 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.078	0.072	4-Point	4-Point	0.913	0.913	0.020	0.004	0.004
	1.981	1.829	4-Point	4-Point	23.190	23.190	0.508	0.102	0.102
Reduced Bead Recycled Fiber	0.072	0.066	4-Point	4-Point	0.913	0.913	0.020	0.003	0.003
	1.829	1.676	4-Point	4-Point	23.190	23.190	0.508	0.076	0.076
Standard US Calculation	0.108	0.102	4-Point	3-Point	0.911	0.911	0.026		
	2.243	2.591	4-Point	3-Point	23.139	23.139	0.660		
Calculation 1.25 Multiple	0.089	0.083	4-Point	3-Point	0.911	0.911	0.026		
	2.248	2.108	4-Point	3-Point	23.139	23.139	0.660		
Calculation 1.50 Multiple	0.095	0.089	4-Point	3-Point	0.911	0.911	0.026		
	2.413	2.248	4-Point	3-Point	23.139	23.139	0.660		
Calculation 1.75 Multiple	0.102	0.096	4-Point	3-Point	0.911	0.911	0.026		
	2.578	2.438	4-Point	3-Point	23.139	23.139	0.660		
0.027" - 0.686 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.081	0.075	4-Point	4-Point	0.913	0.913	0.020	0.004	0.004
	2.057	1.905	4-Point	4-Point	23.190	23.190	0.508	0.102	0.102
Reduced Bead Recycled Fiber	0.075	0.067	4-Point	4-Point	0.913	0.913	0.020	0.003	0.003
	1.905	1.702	4-Point	4-Point	23.190	23.190	0.508	0.076	0.076
Standard US Calculation	0.110	0.104	4-Point	3-Point	0.910	0.910	0.027		
	2.794	2.642	4-Point	3-Point	23.114	23.114	0.686		
Calculation 1.25 Multiple	0.090	0.084	4-Point	3-Point	0.910	0.910	0.027		
	2.280	2.134	4-Point	3-Point	23.114	23.114	0.686		
Calculation 1.50 Multiple	0.097	0.091	4-Point	3-Point	0.910	0.910	0.027		
	2.451	2.311	4-Point	3-Point	23.114	23.114	0.686		
Calculation 1.75 Multiple	0.103	0.097	4-Point	3-Point	0.910	0.910	0.027		
	2.616	2.451	4-Point	3-Point	23.114	23.114	0.686		
0.028" - 0.711 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.084	0.078	4-Point	4-Point	0.911	0.911	0.022	0.004	0.004
	2.134	1.981	4-Point	4-Point	23.139	23.139	0.559	0.102	0.102
Reduced Bead Recycled Fiber	0.078	0.070	4-Point	4-Point	0.911	0.911	0.022	0.003	0.003
	1.981	1.778	4-Point	4-Point	23.139	23.139	0.559	0.076	0.076
Standard US Calculation	0.112	0.106	4-Point	3-Point	0.909	0.909	0.028		
	2.845	2.692	4-Point	3-Point	23.089	23.089	0.711		
Calculation 1.25 Multiple	0.091	0.085	4-Point	3-Point	0.909	0.909	0.028		
	2.311	2.159	4-Point	3-Point	23.089	23.089	0.711		
Calculation 1.50 Multiple	0.098	0.092	4-Point	3-Point	0.909	0.909	0.028		
	2.489	2.337	4-Point	3-Point	23.089	23.089	0.711		
Calculation 1.75 Multiple	0.105	0.099	4-Point	3-Point	0.909	0.909	0.028		
	2.667	2.515	4-Point	3-Point	23.089	23.089	0.711		
0.029" - 0.737 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.087	0.081	4-Point	4-Point	0.911	0.911	0.022	0.004	0.004
	2.210	2.057	4-Point	4-Point	23.139	23.139	0.559	0.102	0.102
Reduced Bead Recycled Fiber	0.081	0.073	4-Point	4-Point	0.911	0.911	0.022	0.003	0.003
	2.057	1.854	4-Point	4-Point	23.139	23.139	0.559	0.076	0.076
Standard US Calculation	0.114	0.108	4-Point	4-Point	0.909	0.909	0.029		
	2.896	2.743	4-Point	4-Point	23.089	23.089	0.737		
Calculation 1.25 Multiple	0.092	0.086	4-Point	4-Point	0.909	0.909	0.029		
	2.343	2.184	4-Point	4-Point	23.089	23.089	0.737		
Calculation 1.50 Multiple	0.100	0.094	4-Point	4-Point	0.909	0.909	0.029		
	2.540	2.388	4-Point	4-Point	23.089	23.089	0.737		
Calculation 1.75 Multiple	0.107	0.101	4-Point	4-Point	0.909	0.909	0.029		
	2.718	2.565	4-Point	4-Point	23.089	23.089	0.737		
0.030" - 0.762 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.090	0.084	6-Point	4-Point	0.909	0.909	0.024	0.004	0.004
	2.286	2.134	6-Point	4-Point	23.089	23.089	0.610	0.102	0.102
Reduced Bead Recycled Fiber	0.084	0.076	6-Point	4-Point	0.909	0.909	0.024	0.003	0.003
	2.134	1.930	6-Point	4-Point	23.089	23.089	0.610	0.076	0.076
Standard US Calculation	0.116	0.110	4-Point	4-Point	0.907	0.907	0.030		
	2.946	2.794	4-Point	4-Point	23.038	23.038	0.762		
Calculation 1.25 Multiple	0.094	0.088	4-Point	4-Point	0.907	0.907	0.030		
	2.388	2.235	4-Point	4-Point	23.038	23.038	0.762		
Calculation 1.50 Multiple	0.101	0.095	4-Point	4-Point	0.907	0.907	0.030		
	2.565	2.413	4-Point	4-Point	23.038	23.038	0.762		
Calculation 1.75 Multiple	0.109	0.103	4-Point	4-Point	0.907	0.907	0.030		
	2.756	2.616	4-Point	4-Point	23.038	23.038	0.762		

Caliper Range 0.031" - 0.035" 0.787 mm - 0.889 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.031" - 0.787 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.093	0.085	6-Point	4-Point	0.908	0.908	0.024	0.005	0.005
	2.362	2.159	6-Point	4-Point	23.063	23.063	0.610	0.127	0.127
Reduced Bead Recycled Fiber	0.085	0.075	6-Point	4-Point	0.909	0.909	0.024	0.004	0.004
	2.159	1.905	6-Point	4-Point	23.089	23.089	0.610	0.102	0.102
Standard US Calculation	0.118	0.114	4-Point	4-Point	0.906	0.906	0.031		
	2.997	2.896	4-Point	4-Point	23.012	23.012	0.889		
Calculation 1.25 Multiple	0.095	0.091	4-Point	4-Point	0.906	0.906	0.031		
	2.407	2.311	4-Point	4-Point	23.012	23.012	0.889		
Calculation 1.50 Multiple	0.103	0.099	4-Point	4-Point	0.906	0.906	0.031		
	2.604	2.515	4-Point	4-Point	23.012	23.012	0.889		
Calculation 1.75 Multiple	0.110	0.106	4-Point	4-Point	0.906	0.906	0.031		
	2.800	2.692	4-Point	4-Point	23.012	23.012	0.889		
0.032" - 0.813 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.096	0.088	6-Point	4-Point	0.908	0.908	0.024	0.005	0.005
	2.438	2.235	6-Point	4-Point	23.063	23.063	0.610	0.127	0.127
Reduced Bead Recycled Fiber	0.088	0.078	6-Point	4-Point	0.909	0.909	0.024	0.004	0.004
	2.235	1.981	6-Point	4-Point	23.089	23.089	0.610	0.102	0.102
Standard US Calculation	0.148	0.144	6-Point	4-Point	0.905	0.905	0.032		
	3.759	3.658	6-Point	4-Point	22.987	22.987	0.813		
Calculation 1.25 Multiple	0.124	0.120	6-Point	4-Point	0.905	0.905	0.032		
	3.150	3.048	6-Point	4-Point	22.987	22.987	0.813		
Calculation 1.50 Multiple	0.132	0.128	6-Point	4-Point	0.905	0.905	0.032		
	3.353	3.251	6-Point	4-Point	22.987	22.987	0.813		
Calculation 1.75 Multiple	0.140	0.136	6-Point	4-Point	0.905	0.905	0.032		
	3.556	3.454	6-Point	4-Point	22.987	22.987	0.813		
0.033" - 0.838 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.099	0.091	6-Point	4-Point	0.906	0.906	0.026	0.005	0.005
	2.515	2.311	6-Point	4-Point	23.012	23.012	0.660	0.127	0.127
Reduced Bead Recycled Fiber	0.091	0.081	6-Point	4-Point	0.907	0.907	0.026	0.004	0.004
	2.311	2.057	6-Point	4-Point	23.038	23.038	0.660	0.102	0.102
Standard US Calculation	0.150	0.146	6-Point	4-Point	0.904	0.904	0.033		
	3.810	3.708	6-Point	4-Point	22.962	22.962	0.838		
Calculation 1.25 Multiple	0.125	0.121	6-Point	4-Point	0.904	0.904	0.033		
	3.181	3.073	6-Point	4-Point	22.962	22.962	0.838		
Calculation 1.50 Multiple	0.134	0.130	6-Point	4-Point	0.904	0.904	0.033		
	3.391	3.302	6-Point	4-Point	22.962	22.962	0.838		
Calculation 1.75 Multiple	0.142	0.138	6-Point	4-Point	0.904	0.904	0.033		
	3.600	3.454	6-Point	4-Point	22.962	22.962	0.838		
0.034" - 0.864 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.102	0.094	6-Point	4-Point	0.906	0.906	0.026	0.005	0.005
	2.591	2.388	6-Point	4-Point	23.012	23.012	0.660	0.127	0.127
Reduced Bead Recycled Fiber	0.094	0.084	6-Point	4-Point	0.907	0.907	0.026	0.004	0.004
	2.388	2.134	6-Point	4-Point	23.038	23.038	0.660	0.102	0.102
Standard US Calculation	0.152	0.148	6-Point	4-Point	0.903	0.903	0.034		
	3.861	3.759	6-Point	4-Point	22.936	22.936	0.864		
Calculation 1.25 Multiple	0.127	0.123	6-Point	4-Point	0.903	0.903	0.034		
	3.213	3.124	6-Point	4-Point	22.936	22.936	0.864		
Calculation 1.50 Multiple	0.135	0.131	6-Point	4-Point	0.903	0.903	0.034		
	3.429	3.327	6-Point	4-Point	22.936	22.936	0.864		
Calculation 1.75 Multiple	0.144	0.140	6-Point	4-Point	0.903	0.903	0.034		
	3.645	3.556	6-Point	4-Point	22.936	22.936	0.864		
0.035" - 0.889 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.105	0.097	6-Point	4-Point	0.904	0.904	0.028	0.005	0.005
	2.667	2.464	6-Point	4-Point	22.962	22.962	0.711	0.127	0.127
Reduced Bead Recycled Fiber	0.097	0.087	6-Point	4-Point	0.905	0.905	0.028	0.004	0.004
	2.464	2.209	6-Point	4-Point	22.987	22.987	0.711	0.102	0.102
Standard US Calculation	0.154	0.150	6-Point	4-Point	0.902	0.902	0.035		
	3.912	3.810	6-Point	4-Point	22.911	22.911	0.889		
Calculation 1.25 Multiple	0.128	0.124	6-Point	4-Point	0.902	0.902	0.035		
	3.245	3.150	6-Point	4-Point	22.911	22.911	0.889		
Calculation 1.50 Multiple	0.137	0.133	6-Point	4-Point	0.902	0.902	0.035		
	3.467	3.378	6-Point	4-Point	22.911	22.911	0.889		
Calculation 1.75 Multiple	0.145	0.141	6-Point	4-Point	0.902	0.902	0.035		
	3.689	3.581	6-Point	4-Point	22.911	22.911	0.889		

Caliper Range 0.036" - 0.040 0.914 mm - 1.016 mm	Channel Width AG	Channel Width WG	Crease Point AG	Crease Point WG	Crease Height AG	Crease Height WG	Counter Thickness	Compress Gap AG	Compress Gap WG
0.036" - 0.914 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.108	0.098	6-Point	4-Point	0.904	0.904	0.028	0.005	0.005
	2.743	2.489	6-Point	4-Point	22.961	22.961	0.711	0.127	0.127
Reduced Bead Recycled Fiber	0.098	0.086	6-Point	4-Point	0.905	0.905	0.028	0.004	0.004
	2.489	2.184	6-Point	4-Point	22.987	22.987	0.711	0.102	0.102
Standard US Calculation	0.156	0.152	6-Point	4-Point	0.901	0.901	0.036		
	3.962	3.861	6-Point	4-Point	22.885	22.885	0.914		
Calculation 1.25 Multiple	0.129	0.125	6-Point	4-Point	0.901	0.901	0.036		
	3.277	3.175	6-Point	4-Point	23.012	23.012	0.914		
Calculation 1.50 Multiple	0.138	0.134	6-Point	4-Point	0.901	0.901	0.036		
	3.505	3.403	6-Point	4-Point	22.885	22.885	0.914		
Calculation 1.75 Multiple	0.147	0.143	6-Point	4-Point	0.901	0.901	0.036		
	3.734	3.632	6-Point	4-Point	22.885	22.885	0.914		
0.037" - 0.939 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.111	0.101	6-Point	4-Point	0.902	0.902	0.030	0.005	0.005
	2.819	2.565	6-Point	4-Point	22.911	22.911	0.762	0.127	0.127
Reduced Bead Recycled Fiber	0.101	0.089	6-Point	4-Point	0.903	0.903	0.030	0.004	0.004
	2.565	2.261	6-Point	4-Point	22.936	22.936	0.762	0.102	0.102
Standard US Calculation	0.158	0.154	6-Point	4-Point	0.900	0.900	0.037		
	4.013	3.911	6-Point	4-Point	22.860	22.860	0.940		
Calculation 1.25 Multiple	0.130	0.126	6-Point	4-Point	0.900	0.900	0.037		
	3.302	3.200	6-Point	4-Point	22.860	22.860	0.940		
Calculation 1.50 Multiple	0.139	0.135	6-Point	4-Point	0.900	0.900	0.037		
	3.531	3.429	6-Point	4-Point	22.860	22.860	0.940		
Calculation 1.75 Multiple	0.149	0.145	6-Point	4-Point	0.900	0.900	0.037		
	3.785	3.683	6-Point	4-Point	22.860	22.860	0.940		
0.038" - 0.965 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.114	0.104	6-Point	4-Point	0.902	0.902	0.030	0.005	0.005
	2.895	2.642	6-Point	4-Point	22.911	22.911	0.762	0.127	0.127
Reduced Bead Recycled Fiber	0.104	0.092	6-Point	4-Point	0.903	0.903	0.030	0.004	0.004
	2.642	2.337	6-Point	4-Point	22.936	22.936	0.762	0.102	0.102
Standard US Calculation	0.160	0.156	6-Point	4-Point	0.899	0.899	0.038		
	4.064	3.962	6-Point	4-Point	22.835	22.835	0.965		
Calculation 1.25 Multiple	0.132	0.128	6-Point	4-Point	0.899	0.899	0.038		
	3.353	3.251	6-Point	4-Point	22.835	22.835	0.965		
Calculation 1.50 Multiple	0.141	0.137	6-Point	4-Point	0.899	0.899	0.038		
	3.581	3.480	6-Point	4-Point	22.835	22.835	0.965		
Calculation 1.75 Multiple	0.150	0.146	6-Point	4-Point	0.899	0.899	0.038		
	3.810	3.708	6-Point	4-Point	22.835	22.835	0.965		
0.039" - 0.990 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.117	0.107	6-Point	4-Point	0.900	0.900	0.032	0.005	0.005
	2.972	2.718	6-Point	4-Point	22.860	22.860	0.813	0.127	0.127
Reduced Bead Recycled Fiber	0.107	0.095	6-Point	4-Point	0.901	0.901	0.032	0.004	0.004
	2.718	2.413	6-Point	4-Point	22.885	22.885	0.813	0.102	0.102
Standard US Calculation	0.162	0.156	6-Point	4-Point	0.898	0.898	0.039		
	4.115	3.962	6-Point	4-Point	22.809	22.809	0.991		
Calculation 1.25 Multiple	0.133	0.129	6-Point	4-Point	0.898	0.898	0.039		
	3.378	3.277	6-Point	4-Point	22.809	22.809	0.991		
Calculation 1.50 Multiple	0.143	0.139	6-Point	4-Point	0.898	0.898	0.039		
	3.632	3.531	6-Point	4-Point	22.809	22.809	0.991		
Calculation 1.75 Multiple	0.152	0.148	6-Point	4-Point	0.898	0.898	0.039		
	3.861	3.759	6-Point	4-Point	22.809	22.809	0.991		
0.040" - 1.016 Millimeter Paperboard Thickness									
Reduced Bead Virgin Fiber	0.120	0.110	6-Point	6-Point	0.900	0.900	0.032	0.005	0.005
	3.048	2.794	6-Point	6-Point	22.860	22.860	0.813	0.127	0.127
Reduced Bead Recycled Fiber	0.110	0.098	6-Point	6-Point	0.901	0.901	0.032	0.004	0.004
	2.794	2.489	6-Point	6-Point	22.885	22.885	0.813	0.102	0.102
Standard US Calculation	0.164	0.160	6-Point	6-Point	0.897	0.897	0.040		
	4.166	4.064	6-Point	6-Point	22.784	22.784	1.016		
Calculation 1.25 Multiple	0.134	0.130	6-Point	6-Point	0.897	0.897	0.040		
	3.404	3.302	6-Point	6-Point	22.784	22.784	1.016		
Calculation 1.50 Multiple	0.144	0.140	6-Point	6-Point	0.897	0.897	0.040		
	3.658	3.556	6-Point	6-Point	22.784	22.784	1.016		
Calculation 1.75 Multiple	0.154	0.150	6-Point	6-Point	0.897	0.897	0.040		
	3.912	3.810	6-Point	6-Point	22.784	22.784	1.016		