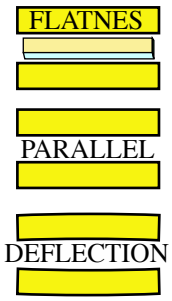
The ABC's of Diemaking & Diecutting

Article Title *"The ABC's of Designing & Fabricating Press Calibration Mapping Tools."*

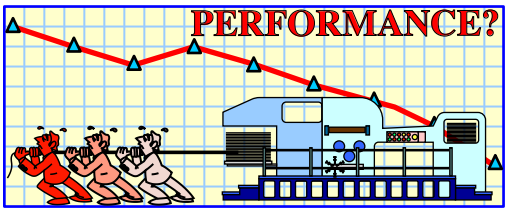
Introduction

"The shortest and surest way of arriving at real knowledge is to unlearn the lessons we have been taught, to mount the first principles, and take nobody's word about them."
Henry Bolingbroke

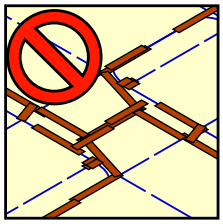


In platen diecutting any deviation in the flatness, in the parallelism, and in the deflection of the mechanism under load causes time, ***see right***, material and resources waste; it results in a slow and inconsistent make-ready; it results in rapid tool and press component damage; it results in poor diecut part quality and consistency; it results in slow speed, missed deadlines, and unpredictable throughput; and it results in ongoing frustration in the press technician and in the work team. ***See below***.

Diecutting make-ready is difficult enough without the sabotage of a non-calibrated press. Using current make-ready methods and practices, which are outdated and outmoded, accurate estimating and scheduling are an impossible task. I am sure you have heard the following quotation... ***"The definition of insanity is the repetition of the same action expecting a different result."*** Therefore, it is vital to find more effective ways and means to achieve a kiss-cut make-ready, and press calibration is the path to performance excellence.

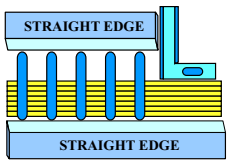


In practice, there are no logical alternatives to press calibration, other than the current unwieldy technique of patching, patching, and more patching. ***See right***. Press calibration must be the foundation discipline of effective diecutting and it should be the cornerstone of training, of skill development and of approved standard operating procedures.



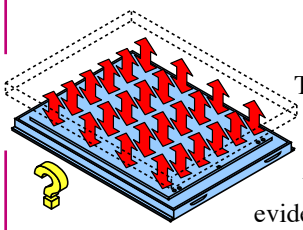
Manufacturing-diecutting is a research and testing discipline, in which closing the learning loop after every production cycle is essential to progressive change and improvement. However, if the methods employed are fundamentally flawed, and subsequent analysis and assessment is arbitrary and unreliable, any conclusions have minimal value. This means that ongoing efforts to simplify the make-ready process are continuously thwarted. We have to go in a different direction.

A failure to implement press calibration makes standardization, streamlining, benchmarking, and training of the most effective practices and procedures impossible. To achieve our productive goals it is essential to change current practices and procedures, and press calibration is the first step in this process.

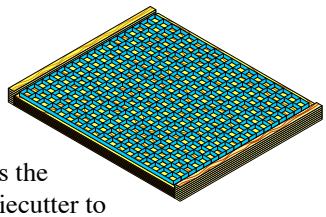


What is Press Calibration?

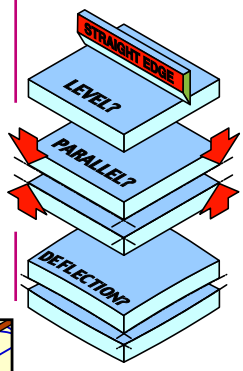
"Those people who develop the ability to continuously acquire new and better forms of knowledge that they can apply to their work and to their lives will be the movers and shakers in our society for the indefinite future."



There is a dangerous assumption, which frequently undermines performance in diecutting. Many professionals seem to believe, in the face of considerable evidence to the contrary, that the three key attributes of an effective diecutter, the flatness of the upper and lower surfaces, the parallel alignment of these surfaces, and the deflection of either or both surfaces under compressive load, are always in optimal condition.



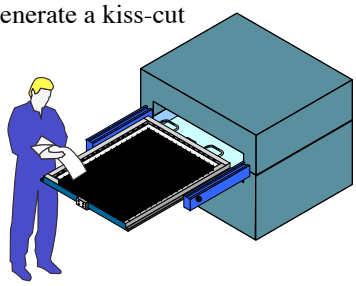
The reality is very different. Every diecutter has a distinct and an inherent pressure distribution imbalance, which significantly undermines the ability of the diecutter to generate a fast, simple and effective kiss-cut impression. The discipline of Press Calibration is used to minimize and eliminate this imbalance.



Press Calibration is the precise mapping of the Z-Axis Measurement under compressive force, to illustrate high areas and low areas in the cutting anvil.

Press Calibration is a simple method of measuring the Flatness, the Parallelism, and the Deflection of the platen mechanism under compressive load.

Press Calibration is a technique designed to eliminate key variables undermining the ability to generate a kiss-cut make-ready.



Press Calibration is an essential converting maintenance action, designed to test and to compensate for deficiencies in the cutting precision of a platen diecutting press.

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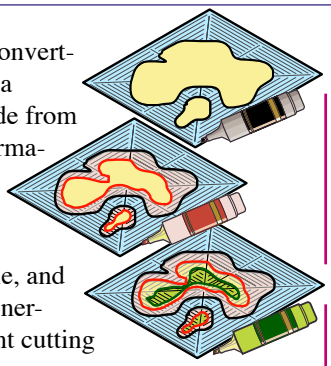
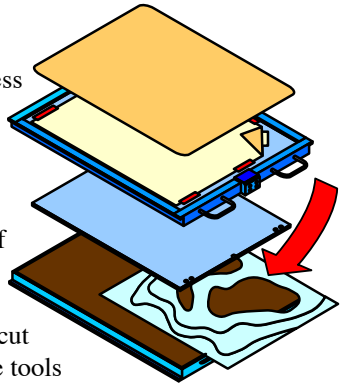


Press Calibration is a discipline of converting the pressure mapping image into a compensation underlay, which is made from industrial grade foil, and which is permanently inserted into the platen stack, usually under the cutting plate.

Press Calibration is a sound, a simple, and an effective technique designed to generate a stable, a precise, and a consistent cutting platform.

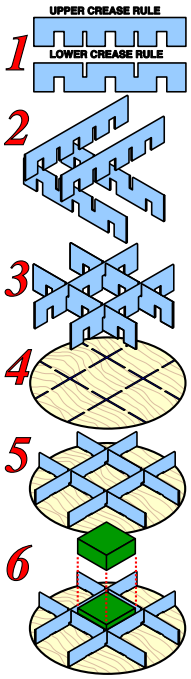
Press Calibration is a technique which is used to compensate for the cutting variables, which frequently undermine press make-ready, production performance, and product quality and consistency.



Press Calibration is basically a press physical, which is built around a mechanical stress test.

This failure to implement this foundation and proven discipline of effective platen diecutting is the primary source of variation and difficulty in generating a fast, kiss-cut impression. Therefore, what are the tools we need to test and validate the performance of the platen diecutting press? The answer is the Press Calibration Mapping Steel Rule Die.

What is a Press Calibration Mapping Die?



"A moment's insight is sometimes worth a life's experience." *Oliver Wendell Holmes*

The Press Mapping Tool is a steel rule die, using standard techniques and standard materials, however, it is a steel rule die with some critical and important attributes. There are three basic tool components, which when combined and fabricated, will make up the Mapping Die. ***See left***.

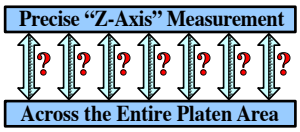
1: The Dieboard

2: The Rule

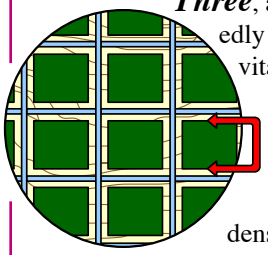
3: The Ejection Material

These components will be combined into a finished tool, which must integrate some important performance features.

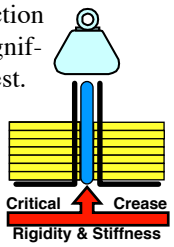
First, it is important to recognize ***the Mapping Tool*** is a critical Measurement Tool, and the accuracy of the results, will clearly mirror the accuracy of the Mapping Tool.



Second, ***the Mapping Tool*** is designed to measure the ***Z-Axis*** integrity of the press, ***see right***, and the platen mechanism, under considerable pressure, which will expose hidden weaknesses in the impressional surfaces.

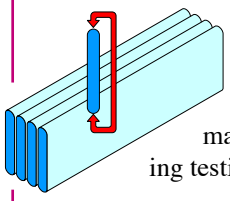


Three, as ***the Mapping Tool*** will be used repeatedly in successive mapping procedures, it is vital the dieboard or the toolholder, is either made from an inert and stable material, or it is stabilized using proven techniques.



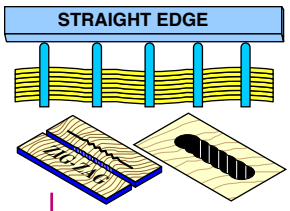
Four, ***the Mapping Tool*** relies upon dense, consistently applied ejection material, ***see above***, to generate significant compressive resistance during the mapping test. This will simulate production diecutting conditions, and expose any pressure induced distortion under load.

Five, ***the Mapping Tool*** is designed to measure the entire platen cutting area, therefore, it is vital the finished tool is perfectly flat and level, and the rules are perfectly vertical, and precisely seated in the dieboard. ***See above***.

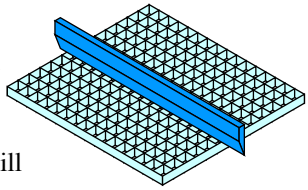


Six, as the integrity of ***the Mapping Tool*** in the first mapping procedure is just as important as the integrity of ***the Mapping Tool*** in the tenth mapping procedure, the rule used in ***the Mapping Tool*** is Double Ended Creasing Rule. This will make the tool far less susceptible to damage during testing and/or during handling and storage.

Seven, as the height of the rule is being used as the measurement of consistency, it is obviously vital the Creasing Rule used for this task, is from the same batch and is of a consistent height. ***See above***.



Eight, as the height of the Creasing Rule is being used as the measurement device, and accurate measurement in every area of the die and the platen mechanism is important, it is essential the kerf allows the rule to self level. ***See left***.



Nine, to ensure the most comprehensive and the most detailed Pressure Variation Map, the Crease Rule is formed into a grid, ***see right***, which will

both map the platen area consistently, and it will simplify capturing the pressure distribution information.

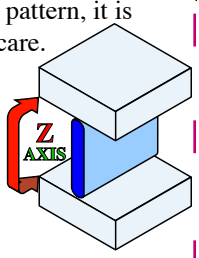
Ten, as with any valuable measurement equipment, ***the Mapping Tool*** must be stored in a manner, and in a location, which will preserve its key operating attributes.

Essentially the Press Mapping Tool is a measurement instrument, which is designed to detect variation in flatness, parallelism, and deflection of the platen mechanism under simulated operating conditions. Therefore, it is critical this foundation tool of diecutting must be designed and fabricated, and used effectively to generate accurate and consistent results.

How is the Mapping Dieboard Designed & Machined?

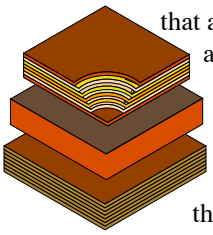
"There is no original truth, only original error." *Gaston Bachelard*

The first of the three primary components of the Mapping Die, the Dieboard, plays a key role as the Tool Holder for the Creasing Rule Grid, and as a Platform for the Ejection Material. As the dieboard will provide the foundation for the measurement and testing of platen mechanism pressure distribution pattern, it is important it is specified and designed with some care. There are two parts to this. The Specification and Design of the Dieboard and the Machining of the Dieboard.

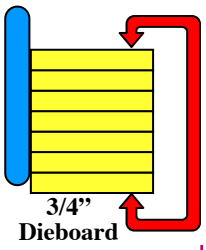


Specification & Design

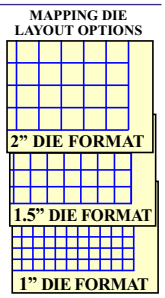
The first step in this process is to choose the dieboard material. As Z-Axis precision is critical, ***see above***, it is obvious that a stable dieboard material, such as Rayform and derivatives from Rayner, ***see left***, and Permaplex from Weidmann Industries, would be effective choices.



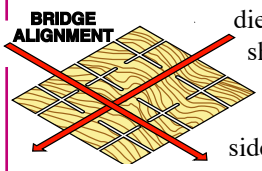
If plywood is being used to form the dieboard, there are some preventative measures which must be taken to ensure dieboard stability and Mapping Tool precision. The most effective thickness for the mapping dieboard is 3/4 of an inch or 18 millimeters. ***See right***. This is important as this thickness of plywood will provide maximum support for each creasing rule, to prevent deflection under load.

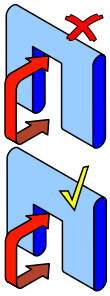


The first step in designing the Mapping Tool is to choose the size of the grid, which will be machined into the dieboard. For most large format presses the most effective grid size is 2 inches or 50 millimeters, however, for smaller presses, and for smaller format presses. 1.5 inches and 1 inch are also effective. ***See right***. The next step is to focus on the bridging pattern.

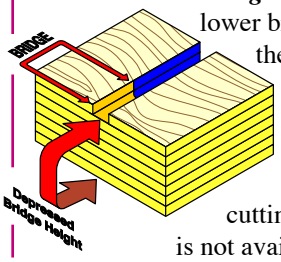


One of the primary causes of dieboard warping, is a combination of too few and too small; and improperly positioned and aligned bridges. To ensure maximum stiffness and stability in the finished dieboard, each grid section should have the maximum sized bridges, and the bridges must align from grip to back-edge and from side-to-off lay. ***See left***.



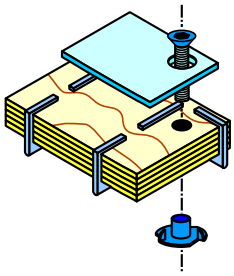


Although aligned, maximum width bridges are essential for dieboard stability. The use of the thicker dieboard would result in the standard bridge severely weakening the crease rule. ***See right***. The solution to enable the lower bridge height in the illustration to the right, is to implement Bridge Depression in the dieboard. ***See left***.



This can be accomplished on many laser cutting systems automatically, however, if this is not available bridge depression can be executed manually.

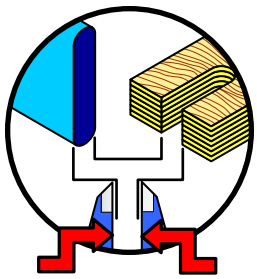
It is useful during the design stage to program the dieboard to be formatted precisely to the diecutting chase it will be used in, and obviously that would include pre-cutting the bolt hole pattern. ***See right***.



Machining the Dieboard

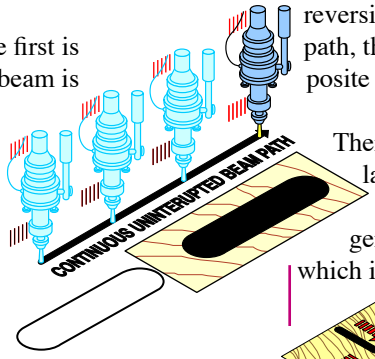
There are a number of choices to be made at this point if using plywood to fabricate the mapping tool dieboard. Applying a thin coat of shellac to a dieboard after laser cutting is a standard practice to prevent excess changes in veneer moisture content. This practice helps to prevent dieboard warping and kerf expansion, which could lead to loose rules. For this application it is recommended to apply a thin coat of shellac to the dieboard both before and after lasercutting, as pre-coating provides an additional degree of protection, and it limits the degree of moisture loss during laser cutting.

The next choice is the type of lasercut kerf to use. However, an important requirement is to use the rule from the batch to be used to fabricate the creasing grid, to verify the fit of the kerf. To ensure the machined dieboard will have the self-leveling characteristics, important to mapping die performance, it is vital to integrate the rule to be used, ***see right***, with the set-up and

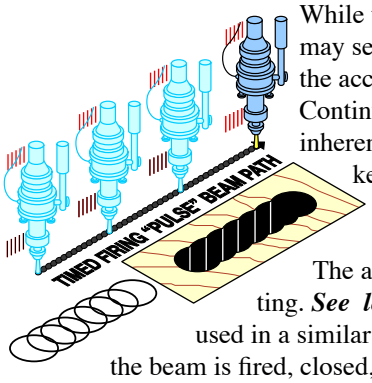


verification of the laser cut kerf.

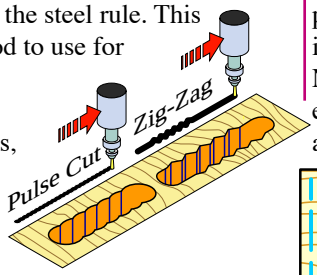
There are two forms of lasercutting. The first is ***Continuous Wave***. ***See right***. When the beam is released, laser cutting of the kerf channel begins, and either the dieboard is moved under the laser head, or the laser is traversed across the dieboard. Continuous Wave or CW Lasercutting creates a kerf channel with straight sides, which theoretically provides continuous contact with the steel rule it is securing.



While that may seem an advantage, because of the accumulation of excess heat in Continuous Wave cutting, and the inherent variability of plywood, the kerf is often too tight or it is too loose.

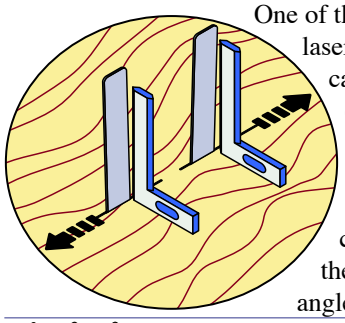


The alternative is to use Pulse Cutting. ***See left***. In pulse cutting the laser is used in a similar fashion to a drill press, in that the beam is fired, closed, fired, closed and fired again, in a sequence tied to the speed of the laser nozzle or the traversing dieboard. This provides a kerf channel with serrated sides, which enables the rule to be held with a flexible pressure which can accommodate variation in the kerf and in the steel rule. This is the most effective lasercutting method to use for the Mapping Die.

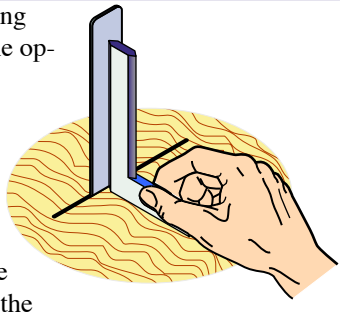


For those with Continuous Wave Lasers, which are not capable of Pulse Cutting, the alternative is to cut a slightly ***"loose"*** kerf, but integrate a programmed ***"Zig-Zag"*** mode at regular intervals. ***See right***. The Zig-Zag Technique is basically replicating the profile of the pulse channel, however, it is an effective, if complex alternative.

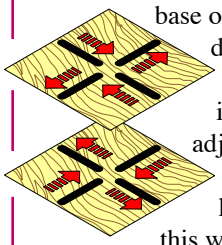
Which ever method is selected it is important to set the kerf width to provide a very ***"light"*** hold on the rule. When setting up the kerf it should be relatively easy to push the crease rule into the slot, and remove it with equal ease. The bottom line in kerf parameters, is if the kerf is too ***"tight"*** you must begin again!



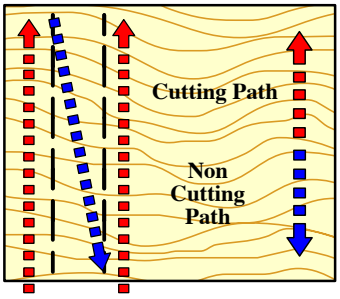
One of the ***"potential"*** Achilles Heels of lasercutting is how the ***"beam mode"*** can impact the vertical alignment of the kerf, and subsequently the rule inserted into the dieboard. In the ***illustration shown to the left,*** this phenomena demonstrates that cutting a channel in one direction, the verticality of a rule inserted is angled in one direction, and by simply reversing the direction of the cutting path, the verticality is angled in the opposite direction.

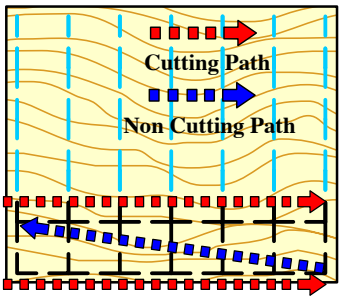


There is a common danger in lasercutting of assuming the system will consistently generate a kerf channel, which is a perfect right angle to the base or the surface of the dieboard. However, for any dieboard, and particularly the Mapping Dieboard, the verticality of the kerf should be verified carefully and adjusted precisely if necessary. It is obviously a requirement to check the parameters of the kerf channel in all cutting directions, ***see left***, as this will provide a guide when laser cutting the mapping dieboard.



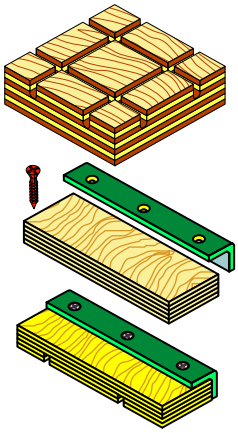
To eliminate potential problems, lasercutting of the dieboard should be constrained to two directions to minimize any potential variation in verticality. This would mean cutting all of the kerf channels in one direction, and against the plywood grain, to minimize the impact of shrinkage during the lasercutting process. ***See above***. Naturally, this is rather wasteful in non-cutting laser moves, however, the additional time consumed is offset by the elimination of another potential source of variation.



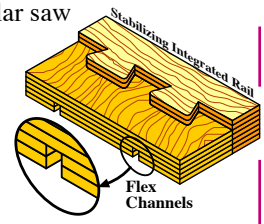


The second pass, cutting the kerf channels parallel to the grain of the dieboard, would follow the same practice. ***See left***. This will certainly reduce the degree of potential variation in key kerf parameters and it will minimize the impact of shrinkage impacting the integrity of the grid design.

Now that the dieboard has been lasercut and the kerf parameters verified and approved, there are a number of additional factors which should be considered. When using a plywood dieboard, and even a Rayform or Permaplex dieboard, warping is caused by a moisture imbalance, by poor kerf parameters, by a poor bridging pattern, and by the stress of ruling. There are two actions designed to further minimize the possibility of dieboard distortion. The first is the use of Flex Channels, and the second, the integration of Metal or Wooden Rails. ***See right***.



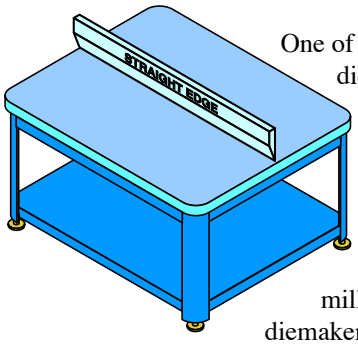
The channels are routed or cut with a circular saw into the underside of the finished dieboard, and the slot should penetrate through at least two veneer layers. ***See right.*** This also shows wooden rails, which are programmed into a matching dovetail pattern in the end of the mapping dieboard. The wooden rails can be made from 7/8 inch plywood, Permaplex, and/or Rayform, and are glued or epoxied into position while the dieboard and the rails are clamped flat.



The final factor, is the dieboard must be ***ruled as soon as possible***, as the exposed end grain in the walls of each kerf channel, will enable the dieboard to continue leaching moisture into the surrounding drier atmosphere. Now we are ready to rule the Mapping Dieboard.

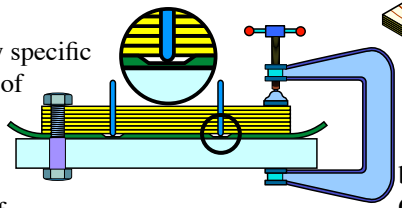
How is the Mapping Dieboard Fabricated & Finished?

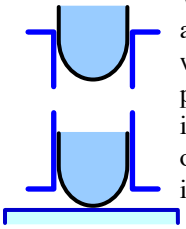
"As a general rule, you have to accept that no matter where you work, you are not an employee; you are in a business with one employee -- yourself." *Andrew S. Grove*



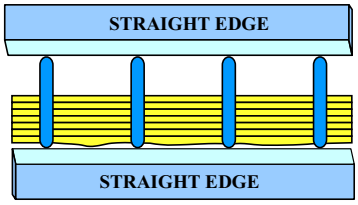
One of the hidden causes of poor diecutting performance in steel rule dies, is generated by assembling on a steel ruling surface which is not flat or level enough. The standard tolerance of most steel rule is plus or minus 0.001 inches or 0.025 millimeters. The steel surface of the diemakers table is ground to a specific degree of flatness, and this flatness should be as accurate and as consistent as possible. Therefore, the dieboard should be ruled on a Mattison Ground, Calibrated Steel Rule Die Table. ***See above***.

The ruling procedure is equally specific and equally important. A sheet of 0.005" thick machined finished paper is placed on the surface of the ruling table, the dieboard is placed on top of the paper, and then the dieboard is clamped or bolted to the ruling surface. ***See above***.

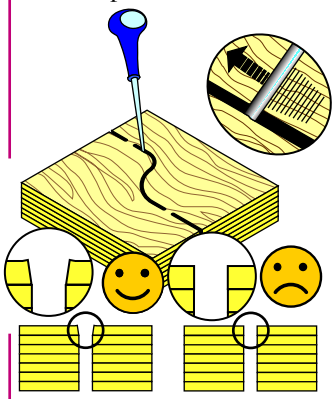




When the rule is inserted into the dieboard, the action of driving the crease rule into the dieboard will cause the round tip of the crease rule to protrude though the underside of the dieboard and indent the paper. Clearly, some of the advantages of using Double Round Creasing Rule, ***see left***, is it is easy to drive into the kerf channel, it is less likely to cause damage to the kerf walls, and it will protrude very easily through the dieboard.

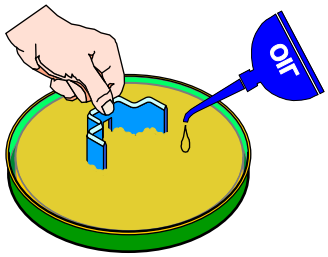


Remember, the dieboard is only the toolholder, the heavy lifting of the mapping die will be done by the creasing rule grid, therefore, it is important that no variation in dieboard veneer flatness or moisture change, interfere with the performance of the rule. ***See above***.

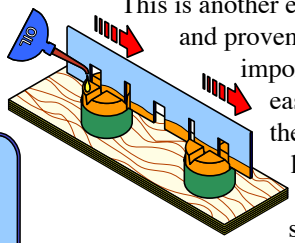


Although we are using double round creasing, which will make entry of the rule into the top of the kerf channel far easier, we will be using some very long lengths of rule. Therefore, it is an advantage to take a Marlin Spike, and with slight downward pressure, track every kerf in the dieboard to slightly open the top veneer. ***See left***.

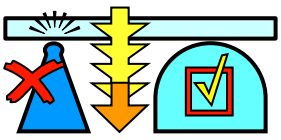
This is called the ***Kerf Open Technique***. This is a very common practice in diemaking as it makes it easier, safer and faster to insert rule, particularly long lengths of rule; it does so with minimal damage to the kerf channel and upper veneer layers of the dieboard; and it ensures precise rule seating, and a reduction in the challenge of cleaning the underside of the finished die.



The next diemaking technique to consider is Oil Ruling. ***See right***. This is another established and proven practice, which provides a number of important benefits. First it makes the rule easier to insert, second, it seals and protects the exposed end-grain in the walls of the kerf channel from losing moisture, and third, it generates better seating, better self leveling capability, and ultimately, better diecutting. Dipping each piece of rule into an inverted Cookie Tin Lid which is filled with oil soaked sponge, is difficult with long lengths of knife. Therefore, a simple jig is constructed for coating the lower portion of each long length of creasing rule. ***See above***.



Before we discuss ruling it is important to reiterate the use of crease rule rather than knife in the Mapping Die. If we use knife in the Mapping Tool, there is always the chance of over-pressurization, and the possibility the knife edges will be damaged by the existing press imbalance. ***See right***. This would render the Map-



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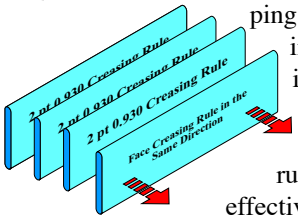
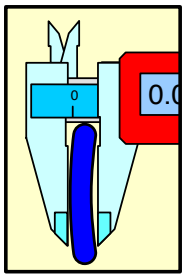
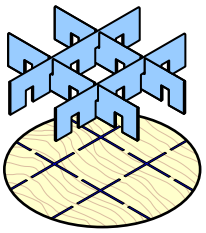


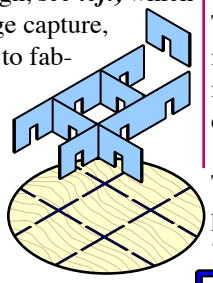
ping Tool useless, it would compromise the integrity of the mapping procedure, and it would require the tool to be reruled for every mapping procedure. Crease rule is by far the most effective choice, and it will generate a clearer image during mapping.



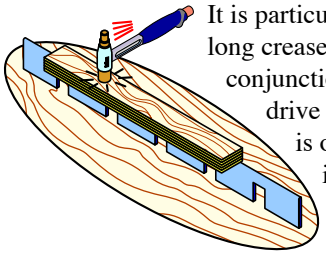
It is also important to further minimize variation by orienting all of the crease rules in the mapping die in one direction, either all toward the grip or toward the side lay. ***See above***. This is designed to minimize the impact of potential crease rule dish. ***See above.***



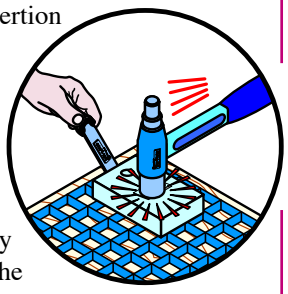
In the illustrations of the crease rule grid, it is shown as an interlocked design, ***see left,*** which provides more effective image capture, however, it is more complex to fabricate and rule the dieboard.



However, as long as care is used, it is equally effective to use full lengths of crease rule in one direction, and short bridging pieces in the other direction. ***See right***.

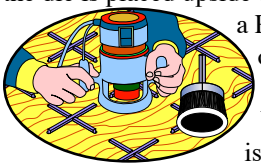


It is particularly critical when inserting the long crease rules, to use strips of wood in conjunction with a mallet or a hammer to drive them into the dieboard. ***See left***. It is obviously important to avoid creating a kink in the rule, weakened by the necessary bridging process, or to create damage to the upper veneer layers of the dieboard. It is an advantage to use two people in the insertion of these full length creasing rules.

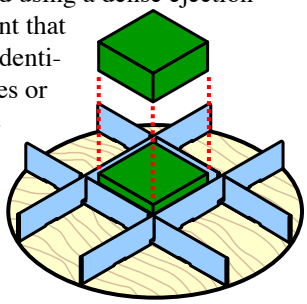


On completion of the ruling process, the entire die, meaning all of the rule forming the grid, should be planed flat using a planer with a dead blow hammer. ***See right***. This is intended to ensure every rule is properly seated, and are all set at the exact same height in the dieboard.

When this is completed the ruled die is unbolted or unclamped from the bend, the paper removed, the table cleaned, and then the die is placed upside down on the bench. Using a Router with a Rotary Wire Brush attachment, the back of the dieboard is carefully scoured and thoroughly cleaned. ***See left***.



When this is completed, the Mapping Die is re-bolted or re-clamped to the bench, and the planing process repeated. With the dieboard still clamped to the bench the die should be rubbered using a dense ejection material. ***See right***. Note, it is important that the square of rubber in each cavity is identical in size, and the rubber is 0.25 inches or 6.5 millimeters smaller than the inside dimensions of the cavity, formed by the creasing rules.



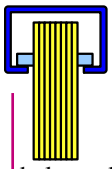
The die is ready to be used or ready for management and storage.

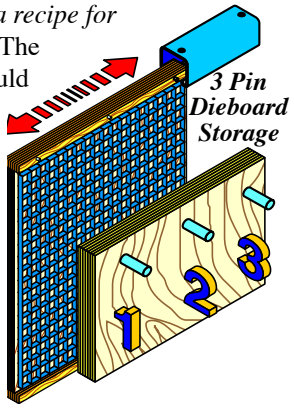
The Management & Care of the Mapping Tool?

"Shallow men believe in luck. Strong men believe in cause and effect." *Ralph Waldo Emerson*

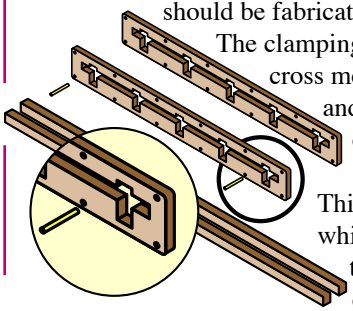
The Press Mapping Tool is both important in terms of accurate measurement and precise press calibration, and it is a key investment, which must be protected and preserved in optimal operating condition.

The most common method of storing a Mapping Die is in suspended storage systems, ***see left***, where the tool is exposed to ***"all-around"*** balanced exposure. *(The goal is to eliminate a storage method where one surface or one edge is covered and the rest exposed. That is a recipe for warping and tool distortion.)* The selected storage location, should be in an area with the most balanced exposure to the elements, *(not close to a door which is opened in the summer, or close to a heater, which comes on in the winter)*, and the storage location should remain consistent throughout the life of the tool. Note the clamping system uses three pins for suspension, rather than the ineffective, and dangerous, two pin system.





An alternative which is used for critical dies, is to create a Clamping System which keeps the tool under pressure, and which compresses the tool flat when it is in storage. The clamping system should be fabricated from Permaplex or Rayform. The clamping system consists of two or three cross members, which the tool slides into, and a number of rails, which brace one side of the tool. ***See left***.



This is a great stabilizing system, which is inexpensive and simple to fabricate. It is often used for overnight or weekend storage for

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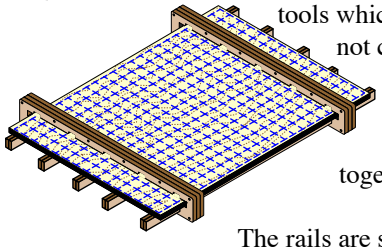
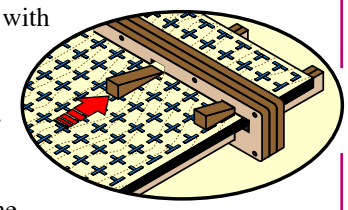
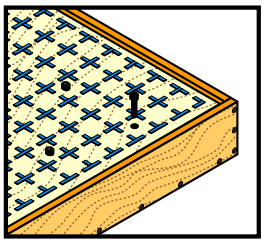


tools which are in process, but which are not complete. The cross members are usually fabricated from two or three pieces of material, which are screwed or dowelled together.

The rails are slid into the cross members and the dieboard is inserted in position, with one, two, or three cross members positioned across the dieboard, depending upon the size of the tool. ***See above***.

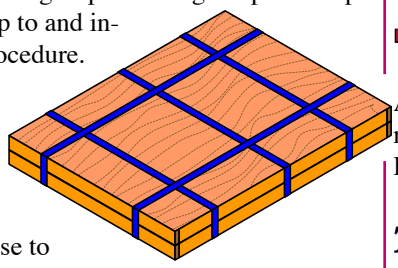


Each lower rail, which slides into the cross member, is matched by an upper aperture, into which a wooden wedge is driven to clamp the dieboard to the lower rails. ***See above***. This is very effective, as it clamps the tool securely, it keeps the tool perfectly flat, and yet the tool has balanced exposure on all sides.



For ultimate protection, many companies fabricate a storage container which matches the dimension of the mapping tool. The tool is inserted into the lower part of the box or crate, and the tool is bolted in position. ***See above***. The top of the container is either screwed into position, or banded, using metal or plastic banding materials.

One of the dangers when fabricating or purchasing the press mapping tool, is to take care of it, up to and including the press calibration procedure. Unfortunately, after this critical activity, the tool is often left waiting for storage or stacked behind the press! It is important to be able to rely upon the integrity of this tool from one use to the next, so do not create problems in storage and management of this key resource.



Why is this Degree of Care and Precision Necessary?

"To know, yet to think that one does not know is best; Not to know, yet to think that one knows will lead to difficulty." *Lao Tzu*

One of the important concepts of effective platen diecutting is the recognition that the press make-ready begins during the specification and design of the steel rule die, and diecutting performance is established in the machining and the fabrication of this primary cutting tool. There are many reasons it is vital to take exceptional care and pay meticulous attention to detail when designing and fabricating the Press Calibration Mapping Die, but the most important reason is the importance of isolating and amplifying the variation in the pressure distribution pattern. We need to remove all of the variables impacting this measurement discipline, and obviously the measurement tool, the mapping die, has the potential for adding many variables and has the potential to undermine the precision of the calibration discipline.

Simply stated, the press mapping die should be part of the solution and not part of the problem!

There are 10 key requirements of the mapping die fabrication process. These include:

- ***A Stable & a Stabilized Dieboard***
- ***A Pulse Cut Laser Kerf Profile***
- ***Integration of Kerf & Verified Rule Parameters***
- ***A Precise, Mattison Ground Bench Surface***
- ***Dieboard Clamping with Protrusion Paper***
- ***Oil Ruling and Balanced Rule Insertion***
- ***Aggressive Planed Rule Seating***
- ***Careful Cleaning of the Dieboard***
- ***Re-Planing and Re-Calibration***
- ***Secure, Optimal Tool Storage***

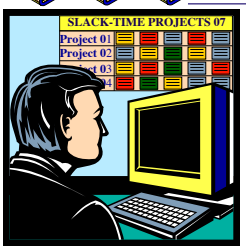
A successful Press Calibration discipline is predicated upon accurate measurement, and to end it is vital to make the Press Mapping Die with care, with precision, and with consistency.

The Commercial Mapping Die Program?

"The person determined to achieve maximum success learns the principle that progress is made one step at a time. A house is built one brick at a time. Football games are won a play at a time. A department store grows bigger one customer at a time. Every big accomplishment is a series of little accomplishments." *David J. Schwartz*

One of the basic principles and the practical reality of diecutting, is it is always a partnership between the Commercial or the In-House Diemaker, and the Diecutter. The majority of companies will choose to purchase this tool from their commercial diemaker, and this presents a unique opportunity for the diemaker.

The design and fabrication of the press mapping die, inevitably results in this tool being one of the more expensive tools in the cus-

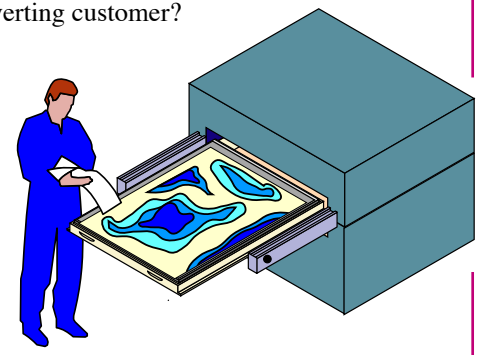


tomer steel rule die inventory. Therefore, it is a pragmatic commercial opportunity for the Diemaking Company to manufacture Press Mapping Dies for standard press sizes, and then rent them to each customer each quarter for Press calibration, and for updating the press underlay.

Making these Mapping Tools is a great Slack Time Project in a Diemaking Company, as there are often slow periods between the daily explosion of activity to meet delivery deadlines. The diemaking operation is also able to precisely fabricate optimal transportation-storage containers, to protect the tool between uses and in shipping.

The Mapping Tool would be rented on a daily or a weekly basis, with specific terms for shipping, of usage, and of return condition. It would certainly be an advantage, and a commercial and a strategic benefit if the diemaking company were capable of executing and teaching the Press Calibration procedure to the customer. What more effective way could a company form a close technical partnership with a converting customer?

This is a great opportunity for the commercial diemaker, as it increases their income potential, while it reduces the cost to the customer.



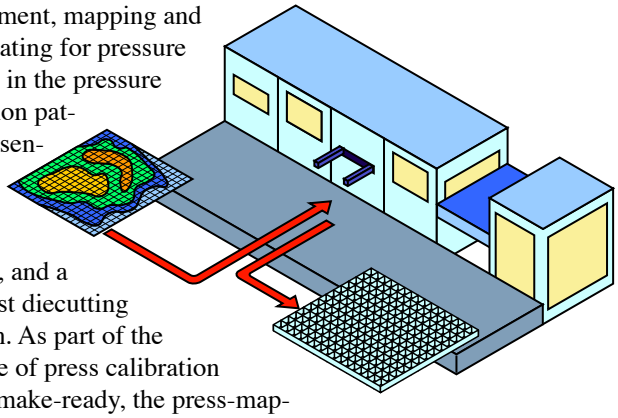
Summary

"There are three principal means of acquiring knowledge available to us: observation of nature, reflection, and experimentation. Observation collects facts; reflection combines them; experimentation verifies the result of that combination. Our observation of nature must be diligent, our reflection profound, and our experiments exact. We rarely see these three means combined; and for this reason, creative geniuses are not common." *Dennis Diderot*

Press Calibration is the foundation of effective make-ready and fast press changeover, in an operation where selling the first impression is the primary goal. Press Calibration is a key step in executing fast make-ready, maximizing press speed and yield, improving quality and consistency, and in reducing operating cost.

In press calibration, accurate measurement of the pressure distribution pattern of a press is an important precursor to calibration and stabilization of the platen diecutter. As the press-mapping tool is critical to accurate measurement, it is vital to build it with precision and accuracy, and eliminate any variables and inconsistencies which may distort the pressure distribution mapped image.

As the mapping tool is a cornerstone of effective diecutting, it is vital the diemaker and the diecutter understand the principles and practices of tool design and fabrication. The mapping tool should be treated and regarded as a valuable measurement instrument and like any precision instrument the tool should be continually verified, before and after each use, and it should be managed in a way which should protect the integrity of the tool.



Measurement, mapping and compensating for pressure variation in the pressure distribution pattern is essential for a faster, a more effective, and a lower cost diecutting operation. As part of the discipline of press calibration and fast make-ready, the press-mapping tool is the most important tool in diecutting, and everyone involved in the process should master the technique of press calibration using this critical measurement instrument.

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