

Square Design Process and Rationale

Intro

The ironbark range of try squares, mitre squares, and setup triangle are unique in the market for their usefulness in any woodworker's workshop. These tools offer a unique combination of precision, longevity, and quality at a price that no other square matches.

For woodworkers, the try squares and mitre squares are an excellent set of tools for joinery layout and assembly reference. The Try squares and calibration triangle also excel at machine setup and are useful tools for those who work with materials other than wood, such as machinists or fabricators.

The precision and accuracy of these tools are best in class with the only comparable options with guaranteed tolerances being far more expensive and requiring substantial regular maintenance. The longevity of Ironbark squares and mitres is unmatched in any category due to its overbuilt design and ability to be recalibrated and disassembled. Only two other tools on the market (Vesper and Hillview) can boast similar materials and quality craftsmanship as these Ironbark measuring tools, however those options are far more expensive and do not guarantee comparable precision or future serviceability.

Detailed sections with in-depth discussions follow on each topic:

Precision/Accuracy

Longevity/Maintenance

Quality Materials and Usability

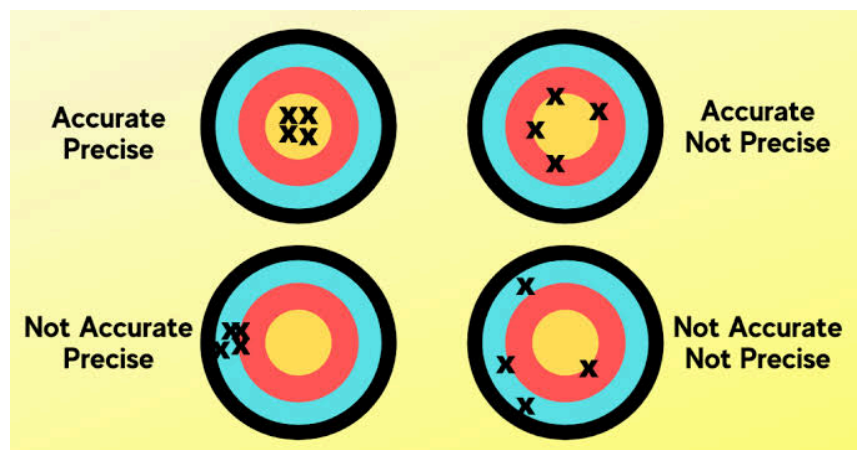
Market Comparison

Precision/Accuracy

Because a square is a metrology tool, the obvious immediate question is about its precision. A square is only useful if it's trustworthy. This means that it must be reliably square every time it is used. Generally in woodworking, squareness isn't quantified (either something is square or it isn't), but metrologically squareness must be quantified in order to decide how 'good' a square is. This section will cover how to think about that quantification and how the Ironbark square achieves its standards. It will also briefly cover some information about other squares on the market, but a more detailed market analysis will be done in a later section. Before going into detail about how precise the Ironbark squares are, we should cover terminology; specifically the distinction between precision and accuracy.

Frequently precision and accuracy are described using an analogy of a game of darts. If all of your darts land in exactly the same spot on the left side of the board, you threw the darts with a lot of precision (repeatedly getting the same result), but poor accuracy (missing the bullseye). If your darts are all over the board with no preference to one side or the other, you may have actually been quite accurate since each dart is similarly close to the bullseye, but that accuracy isn't very useful because there was low precision. An ideal game is both precise (all the darts are in the same place) and accurate (that place is the bullseye).

The main reason why accuracy and precision get confused is because they are measured the same way. For example, if I wanted to describe how good a tape measure is, I would want a number to represent its accuracy and precision. To measure its precision, I would look at each centimeter mark and compare them. Is the distance between the 3cm



and 4cm mark the same as the difference between the 16cm and 17cm marks? Inevitably, they will have some variation and I can measure that variation. I may need a microscope to see the difference, but there will be a difference, and I can quantify that difference with a length measurement (usually measured in microns or ten-thousands of an inch). To measure accuracy, I would compare the tape measure to a known standard. A steel bar known to be 1m long (as validated by a lab that is equipped to measure it to a known standard) can be measured with the tape measure and the difference between the 1m mark on the tape and the end of the steel bar can be measured. This difference will also be a length measurement in either microns or 0.0001", so it will be easily confused with the precision value. It is important to be aware of the difference between these two metrics since they are fundamentally different things and are useful in very different ways.

When considering squareness, accuracy boils down to the question of "how close is this to 90 degrees?" This question pulls the physical tool of a try square out of the real world and compares it to the abstract geometric concept of 90 degrees. Just like we compared the tape measure to a trusted and validated reference in order to determine its accuracy, we must do the same for the square; the only difference being that we are able to derive that

reference ourselves rather than needing an interferometry lab. For woodworking, the go-to method to verify squareness is to either use a calibrated square (eg. The Ironbark calibration triangle), or to compare the square to itself by referencing it off of a straight edge and comparing the line marked off of the square in the right-handed orientation to the equivalent left-handed mark.

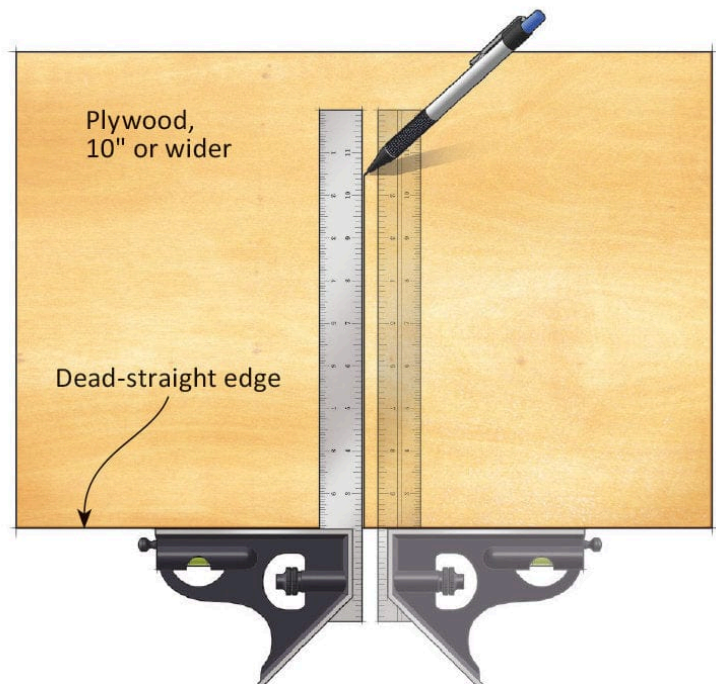
More precise squareness can be measured using a dial indicator as a squareness comparator. Dial indicators frequently measure 0.001" and 0.01mm with more precise models measuring 0.0001" and 1µm (further mechanical precision requires gauge amplifiers or mikrocators). This means that a setup that can measure squareness using an indicator will give you that kind of tolerance on your measurement of accuracy. If you are

checking a square for metrology or machinist purposes rather than woodworking, then you may want that extra precision, so the indicator would be set up on a stand with a bumper calibrated such that the indicator reads 0 when the bumper is pressed against a reference square standing on a surface plate. When the reference square is replaced with the square intended for validation, the indicator will read its deviation from the true square. It is worth noting that the same self checking method shown in the photo above can be used with the indicator by replacing the reference square with a known parallel surface that is held at an angle where both sides read the same on the indicator.

What if the square tests to be inaccurate? An inaccurate square will read as deviating from the true square by some amount, (or deviating from itself by twice that amount). This measurement can be converted to degrees trigonometrically, but we are more interested in fixing the square than doing math, so how do we fix an out-of-square square? Ideally we would just rotate the beam a bit until it is square, but this option isn't available on most squares. This is why many square refurbishment procedures involve either filing/lapping the beam and body to remove the out-of-square material, or hammering the surface of the beam to push material outwards on the acute side of the beam, rotating it closer to square. Neither of these methods are necessary on the Ironbark square since it has a built-in adjustment mechanism that allows the beam to rotate around a pivot pin using a fine-threaded screw and a countering locking screw.

With the ability to adjust the position of the square beam, the question of accuracy dissolves. The square is arbitrarily accurate since you can control its accuracy to be as good as you want. By designing an adjustment mechanism into the tool, the only quantification of metrological quality that remains is precision which dictates how repeatable the square is.

Parallelism: At first it may seem that the repeatability of the square comes down to how rigidly the adjustment mechanism locks, but it is actually a bit more complicated than that. A try square can be used to measure squareness in four ways, and it must be the same in all four methods in order to be repeatable. These four methods are the inside of the beam



to the inside of the stock, the outside of the beam to the outside of the stock, and the two inside to outside combinations. This complexity is reduced on framing squares by not having an 'inside' of the beam, and many older try squares were designed with an ornamental feature on the stock to force the other side to be used exclusively. While those solutions do make it easier to achieve a precise tool, they also cripple its utility. Ideally, a try square should be able to be used in all four ways which means we need to quantify how similar each of the four methods are to each other.

At first, comparing these four options may seem like it will quickly devolve into a bunch of charts and permutations, but it actually simplifies into just two things: the parallelism of the beam and the parallelism of the stock. To demonstrate this, let's consider the difference between measuring the squareness of the inside of the stock to the inside of the beam and the outside of the beam. Since we are using the inside of the stock both times, we are really just comparing the inside of the beam to the outside of the beam, which is a measurement of parallelism. The same logic can be used to show that the stock needs to be parallel.

To verify that both parts are parallel, both sides are machined in one setup. This means that the machine that cuts the two reference surfaces on either part by moving the exact same way without moving the part between cuts. This is a very usual method to make a square due to its expense, but it is one of the best ways to ensure parallelism. Most woodworking try squares (Including all competing adjustable squares) have a wooden body with metal (usually brass) wear plates screwed to the reference surfaces. This method will not ensure parallelism both because there is a stackup of multiple materials whose tolerances all add up, and because the wooden body will move with changes in humidity. The Ironbark square has a stable solid brass body which will not change over time with wooden inlays which both protect the inner workings of the calibration mechanism and provide an attractive appearance. While the wooden infill may make the square look like an ornamental tool, its construction is far more similar to high precision metrology tools than its competitors. The result of this manufacturing method and design are parts that are parallel with tolerances better than 0.001" or 25 microns. While we do not guarantee better parallelism, the majority of our squares measure better than those numbers

Parallelism isn't the only important factor in the precision of an adjustable square. The straightness of the beam and body also impact its precision since a curve in either part could mean that the square marks a different angle near its extremity when compared to the area where the two parts meet. This issue is also addressed by the manufacturing method described before which means that the Ironbark try squares and mitres (when calibrated) meet or exceed the DIN 875/2 specification for machinist squares; a more stringent specification than specified for woodworking squares.

While specification standards are a rabbit hole of their own, it is worth briefly noting that there are many standards and they are not all the same. The DIN 875 and BS 939 standards are the most relevant for precision squares depending on whether squareness is measured in metric or imperial units. The two methods are roughly comparable and well defined. Some squares use less stringent standards for carpentry squares or more general definitions of angles rather than precision or accuracy. There are also manufacturers who make up their own grading systems such as A++ to imply comparable performance, but the actual tolerance of the square must be measured to fairly compare it.

Longevity/Maintenance

A square is unlikely to be used if it is fragile or gives the user the feeling that he's operating a time bomb every time he takes it out of storage. That is why the Ironbark square was designed with longevity and maintenance in mind. While some of these qualities come from the materials used (which will be covered in the next section), there were many design considerations that uniquely position the Ironbark square ecosystem as more operable than its competitors.

As mentioned in the previous section, The Ironbark square is designed with a wooden infill which does not interfere with the stability of the stock. This means that the square can be calibrated, put away, and used again in the future without being any different from today. This may seem like a small and obvious feature, but the wooden stock construction of many competing squares doesn't guarantee it (in fact, it may guarantee the opposite). This already puts the Ironbark square ahead of most other woodworking squares, but it doesn't finish the longevity conversation. The design considerations in these squares relevant to longevity generally revolve around the materials, dimensions, and serviceability of the tool.

While the next section will go into more detail about the materials of the square, the choice to use an austenitic stainless for the beam is mostly to improve the lifespan of the tool. Most precision squares are made top to bottom from a carbon steel which may or may not be hardened. While the brushed or ground surfaces may look bright and attractive out of the box, these carbon steels will inevitably rust which has an impact on its precision and requires regular maintenance and a controlled environment. We don't think that a tool can be considered 'heirloom quality' if it requires an air conditioner to be worth keeping. This leads to the decision to use materials that don't patina in a way that impacts the quality of the tool: stainless steel, timber, and brass. Many woodworking squares have embraced timber and brass, but neither material is ideal for the beam as a marking knife can easily damage those materials and impact the precision of the tool. Brass can be used on the body since it isn't as extreme of a wear surface, but the beam should be made from a more robust material: stainless steel.

There are many stainless steels available, but some will still rust a bit in extreme environments. This is why we picked a 300 series steel which will resist rust more than the other steels available to us. Those who are familiar with stainless steels may recognize that the 300 series doesn't harden the way some other steels like 420, however hardness isn't always a good thing. When the same steel is compared to itself in its hardened and unhardened forms, you'll find that the same force of deformation will make both pieces bend almost exactly the same until the 'failure' point. The soft steel will fail first by taking on a permanent kink while the hardened steel will continue to flex a little more before it shatters. Realistically, there are not many cases where the misuse of the tool will be enough to bend the unhardened version but not enough to break the hardened one, so the hardness of the beam isn't meaningfully important with regards to the beam's ability to resist abuse. We can also compensate for this shortcoming by making the beam thicker. The stiffness of the beam goes up with the cube of its thickness, so doubling the thickness makes it 8 times more resistant to deformation ($2^3=8$). While most squares have a beam around 1mm thick, the Ironbark square is 3mm thick meaning it is 27 times more resilient!

So far an unhardened beam seems like it isn't a liability, but it isn't necessarily better either. This is where the Ironbark design philosophy needs to make a choice. On one hand, the hardened beam slightly outperforms on a spec sheet, but if it is dropped, it may fatally break and it cannot be filed flat if any surface dents come from the fall. On the other hand,

the unhardened beam is thicker so it will survive a greater fall, it will bend when pushed past its limit rather than breaking, and any dents or deep scratches that impact its function can be filed out easily. While there are arguments both ways, we believe the unhardened beam is the better option for the longevity of the tool.

The Ironbark square has other unique design features to make it serviceable even if the worst happens. Unlike most other try squares, the Ironbark square can be completely disassembled. Backing off the set screws and using a 3mm dowel to press the pivot pin out allows the body and beam to come apart. In the worst case scenario where irreparable damage somehow happens (we are yet to see if this is even possible), the damaged part can be replaced and the square will operate as well as a brand new tool. If there is superficial damage or upset material that is difficult to access, it is much easier to file or lap true with the pieces separated. Even if the tool gets uncomfortably dirty and cleaning in the crisp internal corners is difficult, the tool can be disassembled and the original brushed surfaces can be easily restored. We are not aware of any other try square with this kind of access to its parts which means other squares are only one bad accident away from being scrap while the Ironbark try squares will survive more robust use and can be revived from inadvertent abuse.

We understand that the square has a very premium look and feel which can lead to some fear, the serviceability designed into it should encourage the user to use it confidently. All Ironbark tools are designed to be used and they do not punish the user for making a mistake.

Quality Materials and Usability

Ironbark try squares are made using three materials: stainless steel, brass, and a custom timber infill. The choice of stainless for the beam was briefly discussed in the previous section, but there are more reasons to pick these materials over the alternatives. While all these materials are known for their quality and durability, these materials are used for reasons beyond the obvious.

Every Ironbark try square has a unique infill in our iconic keyhole shape. While we prefer Australian hardwoods for their beauty and durability, the infill material doesn't impact the reliability of the tool and can be a different species without changing our confidence in the tool. This might imply that the infill doesn't matter, but that couldn't be farther from the truth. The keyhole shape to the inlay is not purely ornamental since it also outlines the access shape for the adjustment mechanism used to calibrate the tool. A small hole near the 'neck' of the keyhole is required in manufacturing to create the internal space required for the calibration screws to act against the beam. Without the wooden infill, this space could fill with dust over time and cause the calibration screws to jam or create an imprecise sponginess in the adjustment. The infill caps that manufacturing feature in a way that is both beautiful and functional. It also provides a warmer touch point when picking up the square.

The choice of brass for the stock comes both from its material properties and its attractive look and feel. Brass has a higher density than most other machining metals which gives it a better heft and balance against the extra thick beam. It also has a much lower thermal coefficient of expansion than aluminum or plastic making it more suitable for high precision metrology. Its thermal expansion is fairly close to that of stainless steel, meaning that the entire square will behave consistently. While most other precision squares use steel throughout, that is only an option for fixed tools with no facility for calibration since a stainless steel to stainless steel pivot is likely to gall or seize. Brass has appropriate hardness to keep

its reference surfaces reliable over time, but it also has better ductility than bronze ensuring that it won't crack if the square takes a tumble.

We already discussed the use of austenitic stainless steel for its longevity benefits, but there are also reasons to use it for quality purposes. In workshops that use both wood and metal, or woodworking shops where a square is used to check tools that are being sharpened, the non-magnetic quality of the austenitic crystal structure is crucial. And sharpening swarf or steel filings that get onto the tool will fall right off and slurry from water stones that might transfer from a blade will wipe off without leaving rust. Using it for marking with a knife doesn't run the risk of damaging the beam and the thicker cross section helps keep the tip of your thumb from being nicked by the passing knife blade.

As will be shown in the market comparison section, all of these premium features do not come at a financial cost.

Market Comparison

The try square market can generally be broken into three categories with very few offerings serving multiple purposes: woodworking try squares, premium woodworking try squares, and machinist/metrology try squares. In Australia, the standard woodworking try squares are served by Shinwa, Crown, Marples, and Narex. These brands also offer some offerings intended to be more premium, however those options tend to be much more expensive without offering much more performance. In the premium category, there are handmade squares from Vesper, Colen Clenton, Woodpeckers, Bridge City, and overseas imports such as Hillview Wood and Metal. Premium machinist squares are primarily made by metrology companies such as Starrett, Brown and Sharpe/Tesa, and Mitutoyo. The pricing of the Ironbark Tools squares lines up with the high end of the standard woodworking square category (lining up with the price of the comparable Crown adjustable square) and drastically undercutting the price of the premium squares and metrology squares which are 2-10x more expensive. Only the Colen Clenton Woodpecker, Bridge City and Crown have calibration abilities while the others are all fixed and of various precisions. Of these, the Bridge City and Woodpeckers do not have reliable calibration mechanisms and are simply bolted together, and their precision is as much as 3 times worse. Neither Crown nor Colen Clenton specify tolerances, however only the Ironbark square has a solid body, so the others may drift over time and have unreliable precision when comparing internal and external measurements. The only squares with comparable precision that are not recalibrateable are the metrology tools and the upcharge version of the Vesper squares (which are nearly 10 times the price). All of these may rust over time and have no way to revive them if they are damaged as only the Ironbark square can be disassembled.