Is it Square?, version 2

By R. G. Sparber

This article is based on an amazing video produced by Phil Kerner, the "Tool and Die Guy". His web site is:

http://www.thetoolanddieguy.com/

You can also go to YouTube to see his method of checking if a block is square. It simply blew me away. I never thought to check square with such an elegant technique.

http://www.youtube.com/watch?v=0tu9uyRG8ZM

After some thought, I think I understand the essence of what he demonstrated. That is what fills the rest of this article. I will start with the practical and end with theory.

Equipment

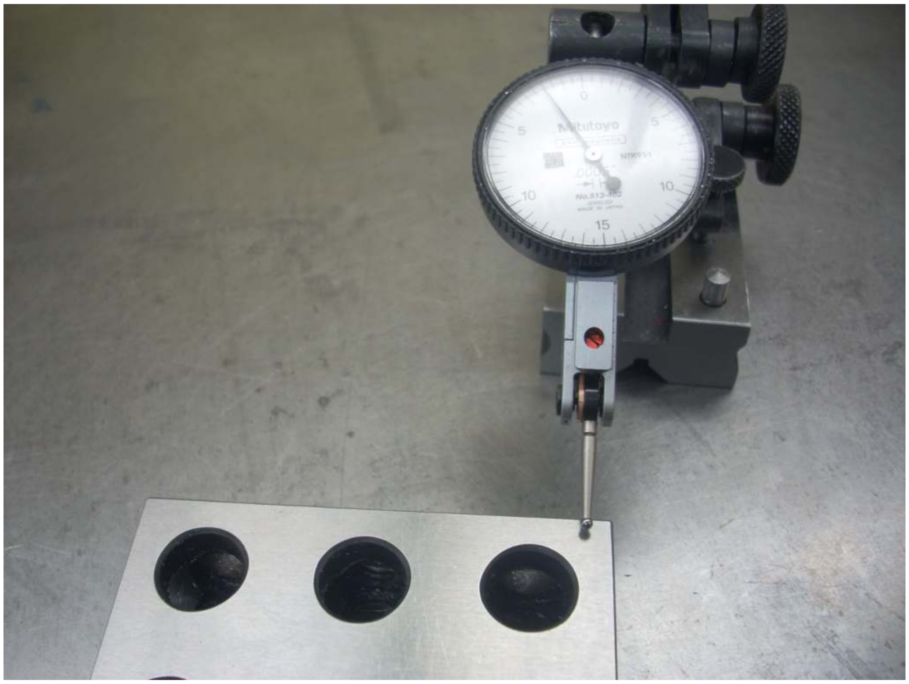
You will need

1. a dead flat surface. Ideally this is a surface plate but many alternative exist including a machine surface or even a piece of float glass.
2. a finger Dial Test Indicator mounted on a support.

All surfaces must be absolutely clean. I use alcohol and a clean rag to wipe down the surface plate, the underside of the DTI support, and all surfaces of the block being tested.

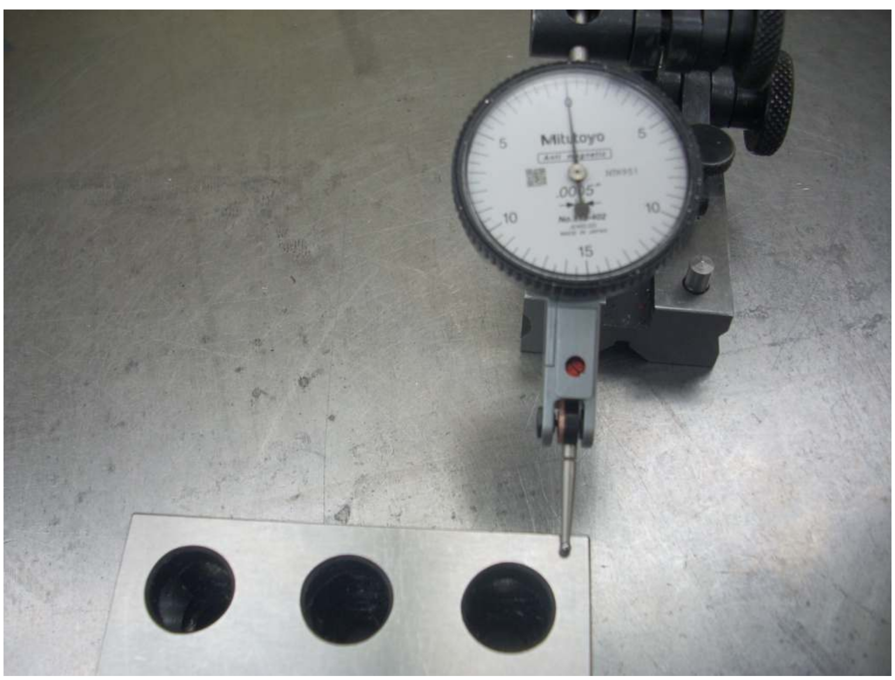
The test block is a 1-2-3 block made by SPI.

Step 1: verify opposite faces are parallel



I start by setting the DTI dial to read about -0.002". This minimizes the spring tension on the finger when the DTI reads zero.

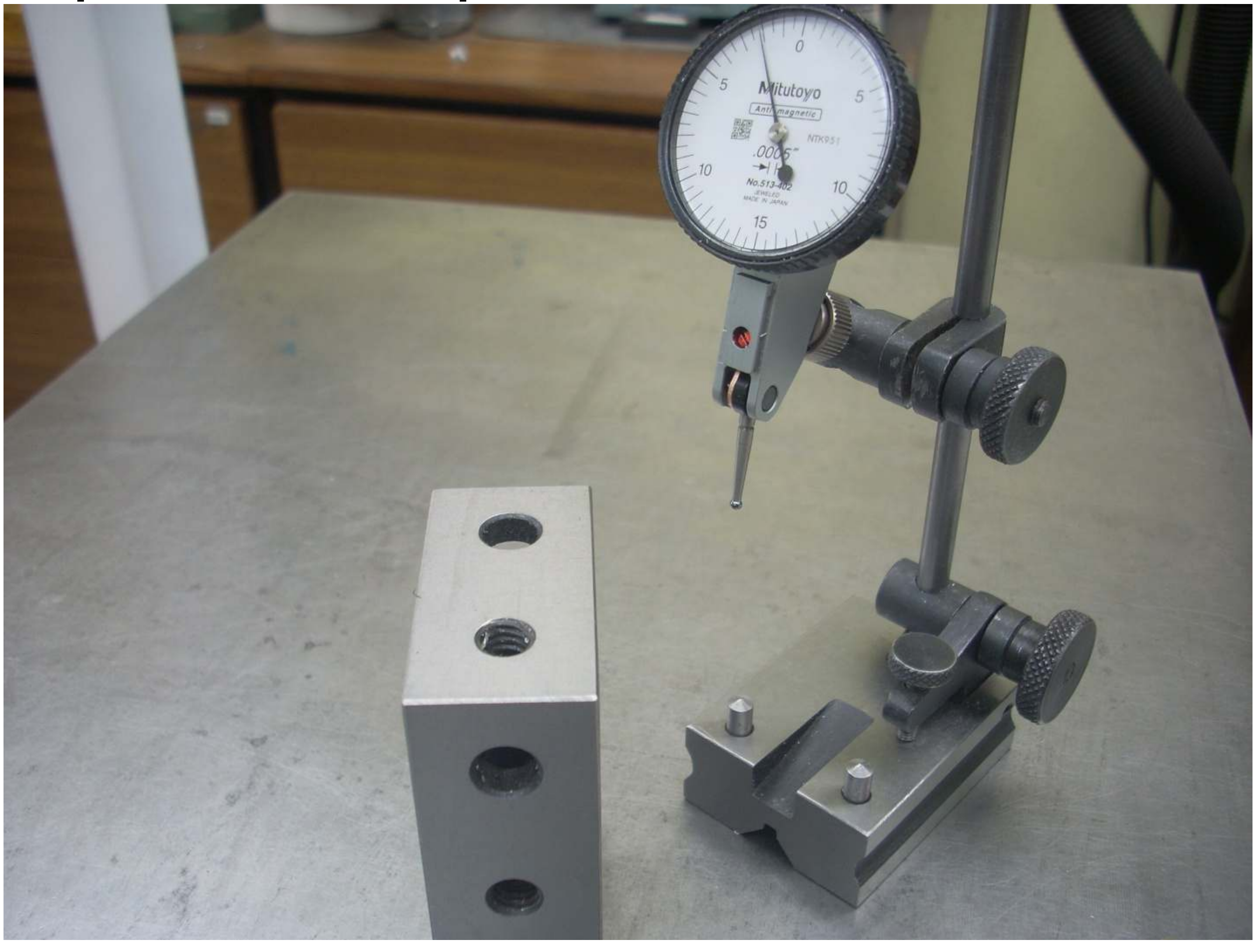
The more pressure on the finger, the more distorting force will be placed on the DTI support.



I then turned the fine adjustment on the support's base until the finger came in contact with the face of my 1-2-3 block. I stopped when the DTI read zero.

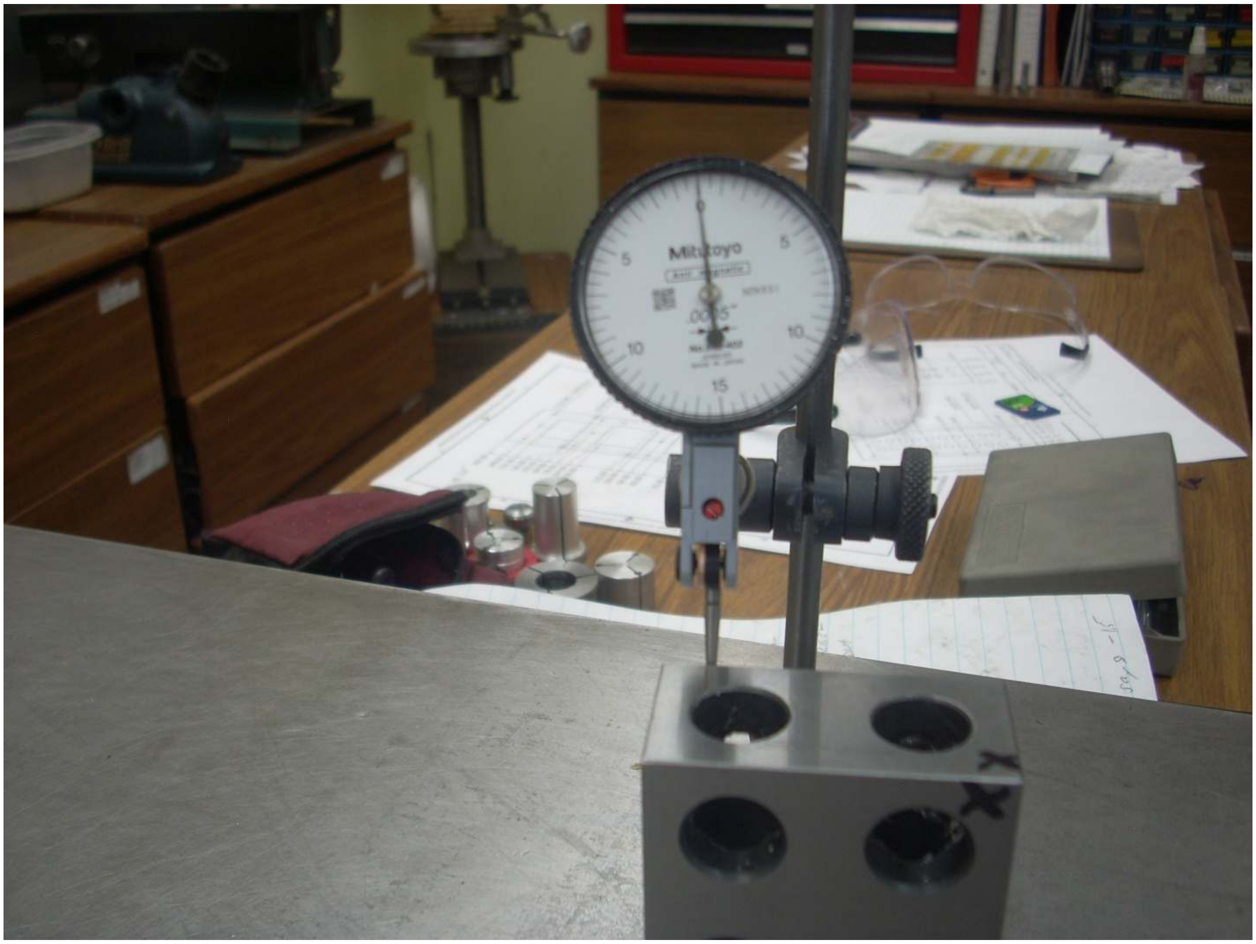
I then slowly moved the block around on the surface plate while monitoring the DTI. Since the dial didn't move more than 0.0001", I was assured that this top surface is parallel to the surface plate. I then turned the block over and repeated the test. In this way I was able to detect if one side was cupped. To my delight, the DTI movement was always less than 0.0001". As a final check, I moved the finger off of the block to verify it would return to -0.002". It did. So now I know these two faces are reasonably flat and parallel.

Step 2: Check for Square

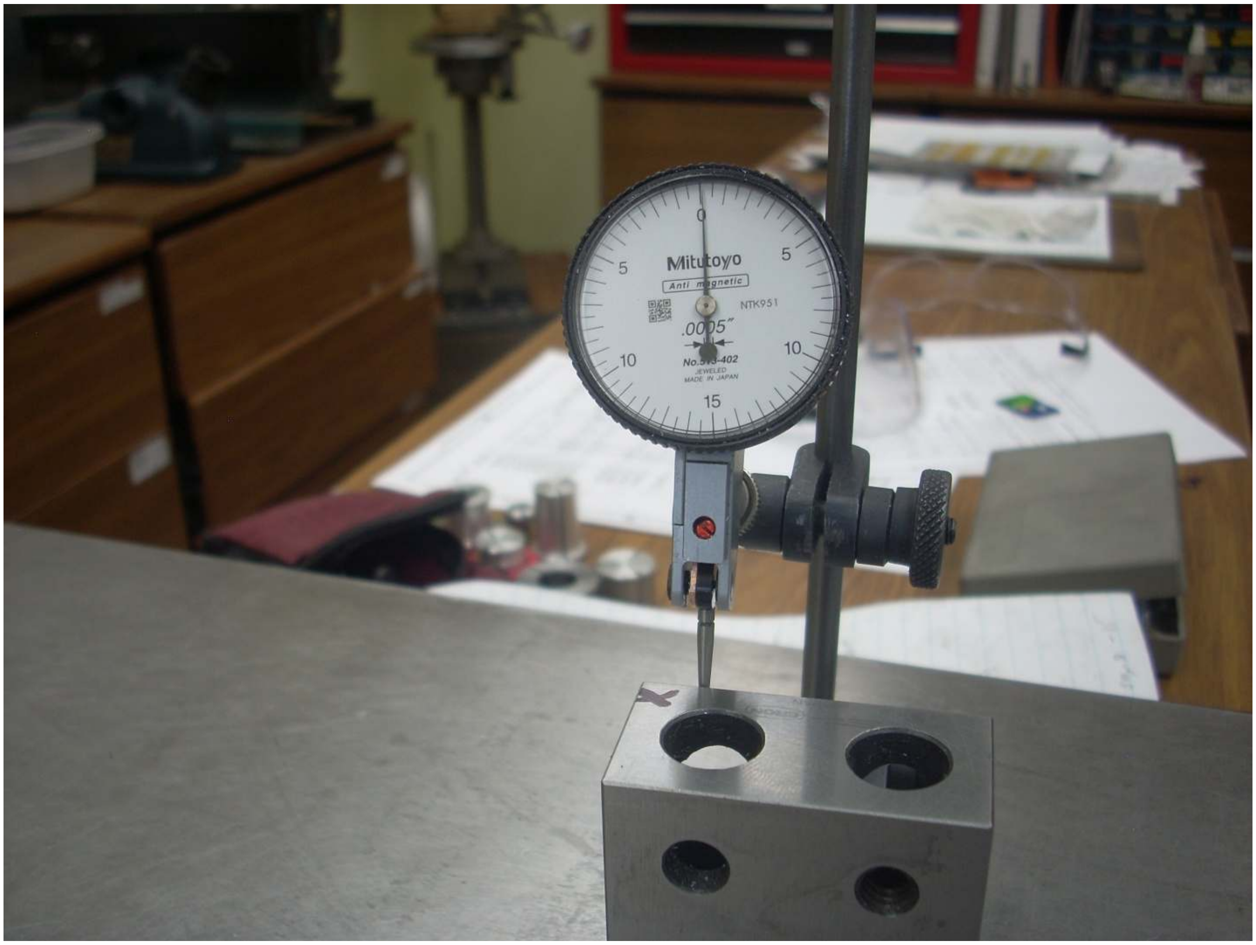


I next repositioned the DTI so it would touch near the top of the block when put on end.

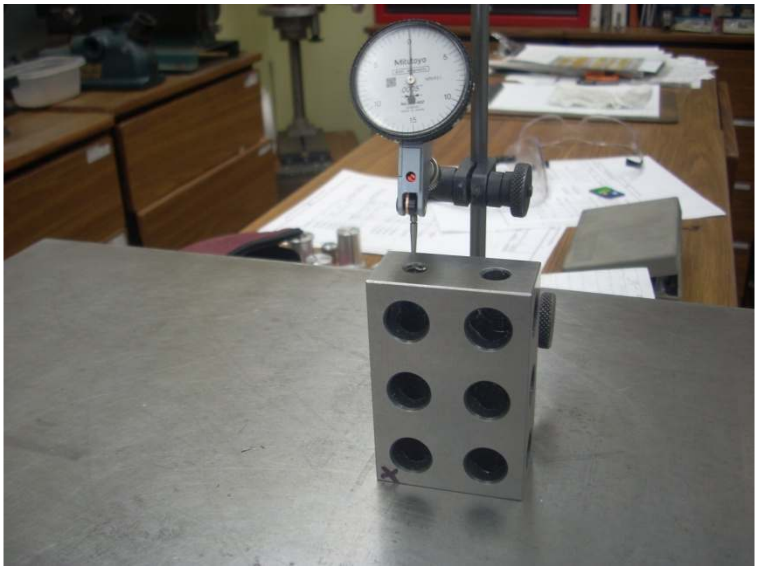
The finger is set near the same plane as the front of the DTI support.



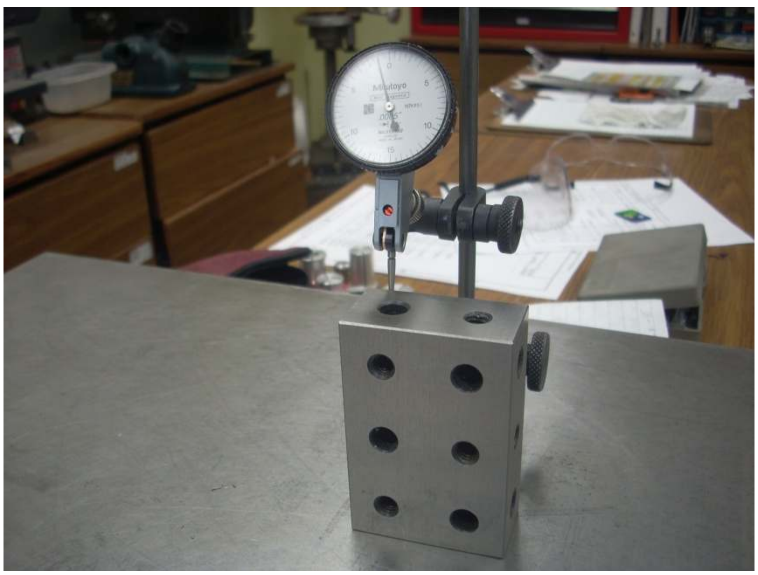
I again used the DTI support’s fine adjust to move the finger into the block until it read zero. Note the two “X” marks on the front top corner. They will help us keep track of where we are on the block.



I turned the block around with the same end resting on the surface plate. Note that the DTI still reads about zero. This tells me that the 2-3 faces are reasonably perpendicular to the non-X end. If this deflection was 0.0001", then it would mean that the 2-3 faces were at an angle of $90 - \tan^{-1}\left(\frac{0.00005"}{3"}\right) = 89.9991°$.



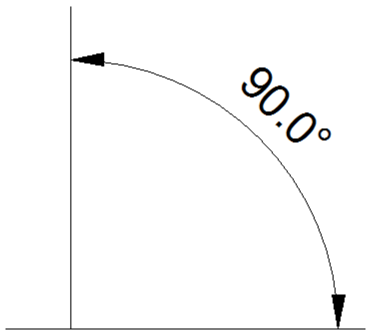
Now the procedure is repeated with the X end at the bottom. I again zero the DTI.



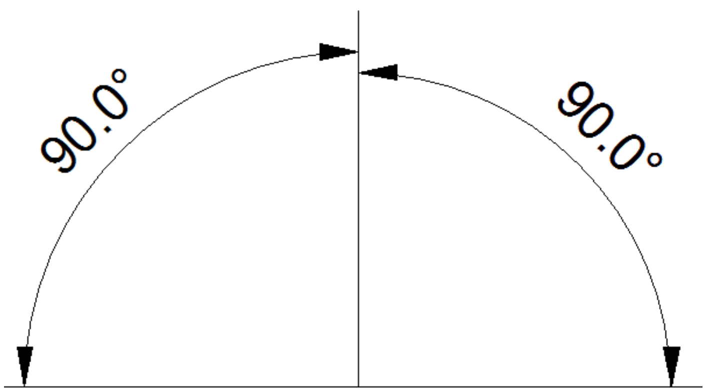
But this time the DTI reads -0.001" which tells me the 2-3 faces are not as close to perpendicular to the X end as the non-X end. This is still rather good since this 0.001" error is the total error between two faces. So each face is off by 0.0005" over a distance of 3". That translates to an angle of 89.990°.

Theory

Although the procedure is performed in three dimensional space, it can be explained using only two dimensions because all surfaces have been assumed to be dead flat. I'm sort of squishing my 3D world down to 2D.



Here you see a horizontal line with a vertical line attached. The vertical line is set 90 ° from the horizontal.



It should come as no surprise that if I measure the angle formed on the left side of the figure, it must also come out 90 °.

Less obvious may be that if I measure the angle on the right and it equals the angle on the left, this angle has got to be 90 °. It can't be any other value. This is because the sum of the two angles must equal 180 ° and we have

$$\boldsymbol{x} + \boldsymbol{x} = 180°$$

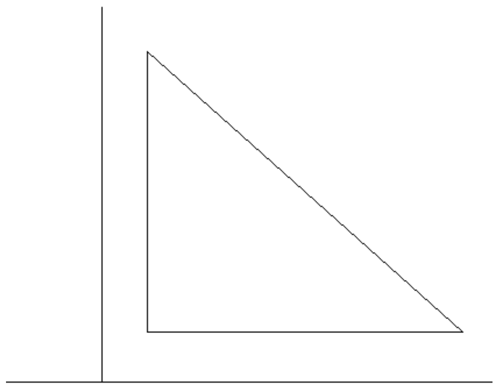
or

$$2\,\boldsymbol{x} = 180°$$

so

$$\boldsymbol{x} = 90°$$

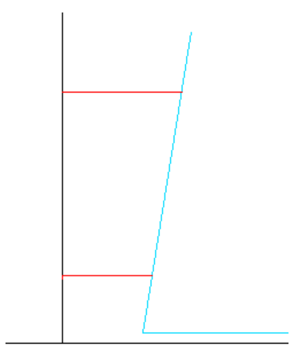
Next, consider how we could measure this angle. A protractor could be used to measure each angle and then we would compare the readings. This approach is only as accurate as the ability to read those values.



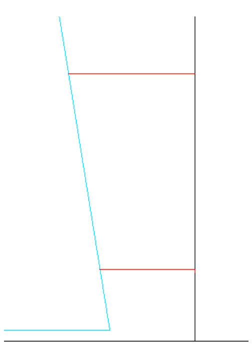
We could also cut a triangle to exactly fit the unknown angle on the right. Then flip it over and see how well it fits on the left. If it is a perfect fit on both sides, the angle must be exactly 90 °.

Consider what is going on here. As we adjust the triangle to match the angle on the right, we are picking up the angle formed by two straight lines.

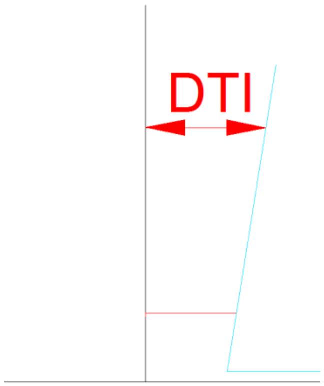
I really don't need an entire surface in contact with the vertical line to pick up the angle, having two contact points is enough.



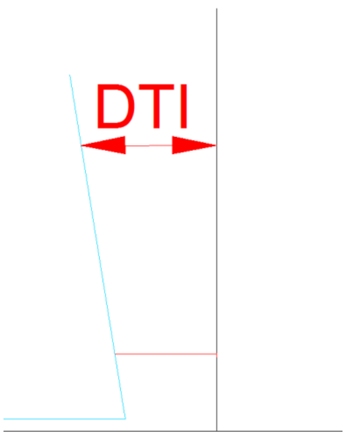
What if I used a support, shown here in blue, with a dead flat bottom? I have attached two red sensing arms that contact my vertical in two places. Since I only need two points to define a line, this instrument is sufficient for capturing the angle.



Flip it over to check the angle on the left side, and if both arms touch, my angle must be 90 ° .

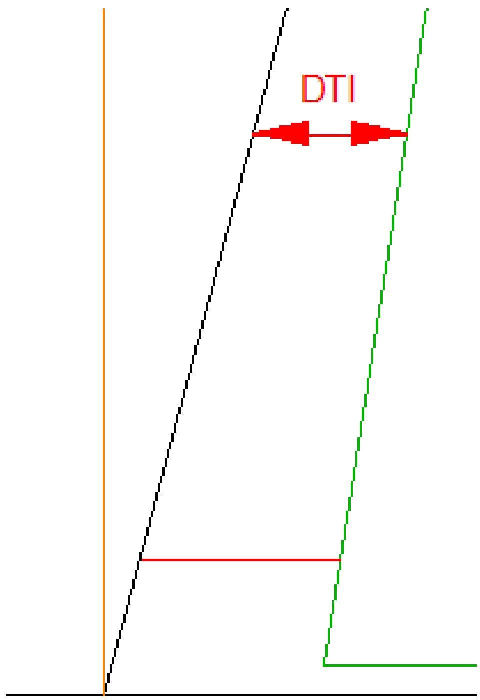


But what if I replaced the top red line with my DTI? Push the support up against the vertical line until the lower red line touches it. Then zero the DTI. We don't know the angle, but we will be able to tell if we contact it again.

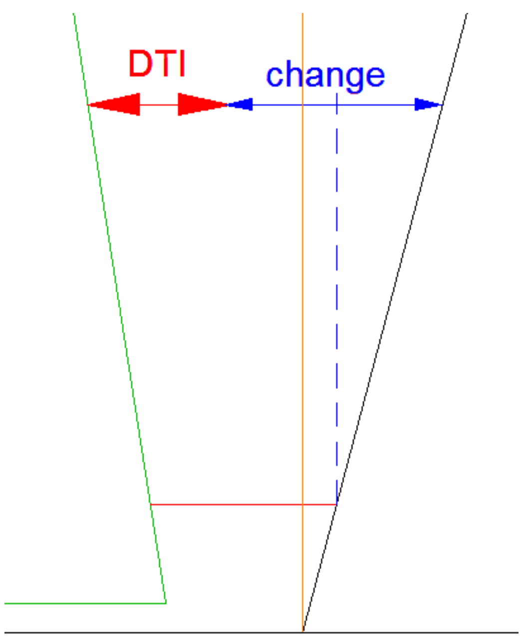


When we flip the instrument around and measure the left angle, the DTI will read zero only if the two angles are equal. This can only happen if the angle is exactly 90 ° .

Now, at least in my shop, nothing is perfect. So I expect to always see some movement on the DTI's dial. Consider what this means.



The angled black line to the right of my vertical represents the surface of my work piece. My instrument has been set so the DTI reads zero.

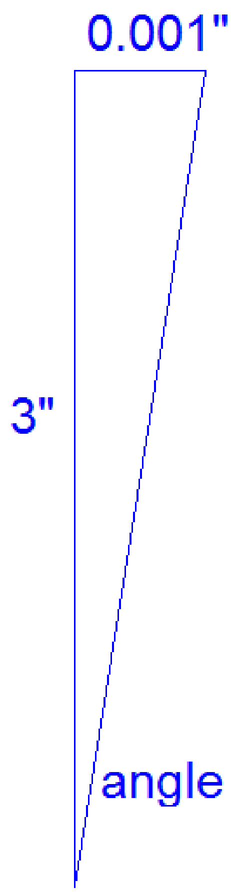


When I flip the instrument over, I will measure that same angle from the other side.

My original DTI reading, shown in red, was set to zero. The blue, double headed arrow line represents the movement of my DTI needle.

If I draw a vertical line from the lower contact point up through this blue arrowed line, it will cut the blue line in half. This means that my DTI needle change equals twice the distance from my right side angle reading and a perfect 90 °.

It is time for a little trigonometry and a practical example.



Say my DTI moved 0.002" and my DTI was 3" above the lower contact point[2]. Then "change" equals 0.002" which means my distance from my work piece to vertical is half of that or 0.001".

I end up with a right triangle. My angle equals the arc tangent of the opposite side divided by the adjacent side:

$$angle = \tan^{-1}\left(\frac{0.001''}{3''}\right) = 0.0191°$$

This is the angle formed between work piece and a perfect vertical. To find the angle from our work piece to the horizontal, we subtract our angle from 90 ° and get 90 ° - 0.0191 ° = 89.9809° .

We often just talk about the error in terms of rise versus base so would forget about the angle and just say 0.001" rise over 3".

Acknowledgements

First and foremost, thanks to Phil Kerner for giving this technique to the community. I would also like to thank Malcolm Parker-Lisberg for sending me the link.

I welcome your comments and questions.

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[2] To be entirely correct, I need to take into account the thickness of my contact point. When used on the right side, my work piece touches my contact *surface* at its top. But when I flip the instrument over to the left side, I am contacting the back side of the work piece with the bottom of the contact surface. The closer to 90° that I am, the less this matters.