# X or Y Axis Zero Set on a Mill, Version 2

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## *Accuracy?*

The word "accuracy" can be extremely misleading. A carpenter may be thrilled to get within 1/16" while a tool and die maker needs to be into the ten thousandths of an inch before they are satisfied. For me, accuracy means being within +/- 0.001". In certain test situations, I do try to get below a thou. In this article, I'm shooting for +/- 0.001" but can't promise this procedure will deliver it in all cases. Too much depends on how much metal is being removed and how fast it is removed. All machines have their limits beyond which things flop around and accuracy goes out the door.

The following assumes you are not exceeding what is commonly called a "light cut" when you need accuracy. It is standard practice to make a roughing cut that is not accurate and follow it with a finish cut which is removing only a small amount of metal.

Besides heavy versus light cuts, we have the issue of which part of the end mill is doing most of the cutting. Heavy side milling imparts a side load on the cutter and causes it to bend. This load can also shift the spindle in its bearings. If there is little side milling and mostly end milling, the force is mostly tending to pull the cutter down into the part[1]. I get more accurate results in this case.

## *The Problem to be Solved*

There are many ways to establish a point on the X or Y axis as zero. The most accurate that I know of is to make a light cut on the part stop with the end mill and set 0. This is the key idea in soft jaws[2]. It is fine as long as all cuts are on that side of the end mill. If you switch to the other side, error can creep in if you don't know the exact diameter of the end mill. It is also not always practical to cut the stop. Lets take these problems one at a time.

## *Effective End Mill Diameter*

Ever try to mic an end mill? Not easy to do accurately. Besides, is that a true reading of the width of the cut given that there might be some run out in the cutter, collect, and/or spindle. Instead, I prefer to directly measure what I will call the effective end mill diameter. Even this can be misleading if the cut you measure is significantly different from the cuts you plan to make on the part being made. I must assure that my test cut will be on the same material as the part and the rate and quantity of metal being removed is similar.

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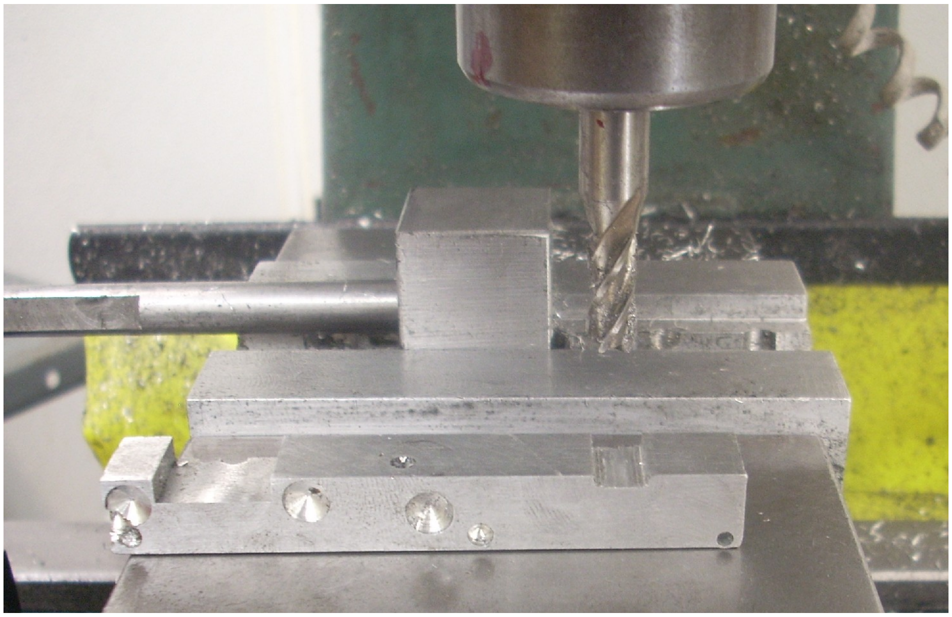
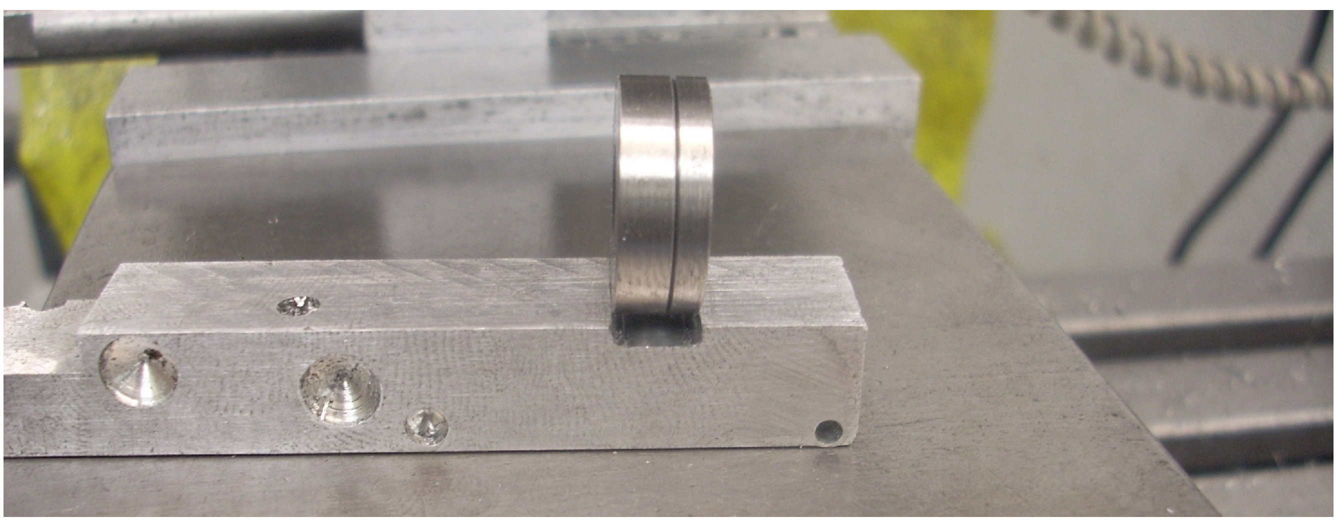
1 I use an R-8 end mill holder which prevents end mill slippage.

2 See the article on Soft Jaws on my web site: http://rick.sparber.org/Articles/sj/sj6.pdf



The block of aluminum resting on the vise was previously clamped in the vise jaws and a 0.075” deep slot cut by this end mill. The width of that slot is exactly how wide that end mill will cut when mounted in this collet and spindle when cutting aluminum to this depth. It is reasonable to assume that a heavier cut, a higher feed rate, and/or harder material will increase the effective end mill diameter. Beyond these caveats, long cuts can suffer from variations in the ways.

All that is left is to accurately measure this slot. Not all that easy to do with a caliper since the bottom of the slot is not perfectly square and the slot is rather shallow. The trick is simple: use spacer blocks. Don't forget to carefully deburr all surfaces.



I bought a set of these blocks[3] from Enco for less than $40. They are in steps of 0.001” and accurate to +/- 0.0001”. I get a snug fit at 0.278” and they don't fit at 0.279”. These blocks go about half way into the slot before hitting the rounded bottom edges. My effective diameter for this cutter is therefore 0.278” and I wrote it on its container. I also entered it into my Shumatech DRO tool offset table.

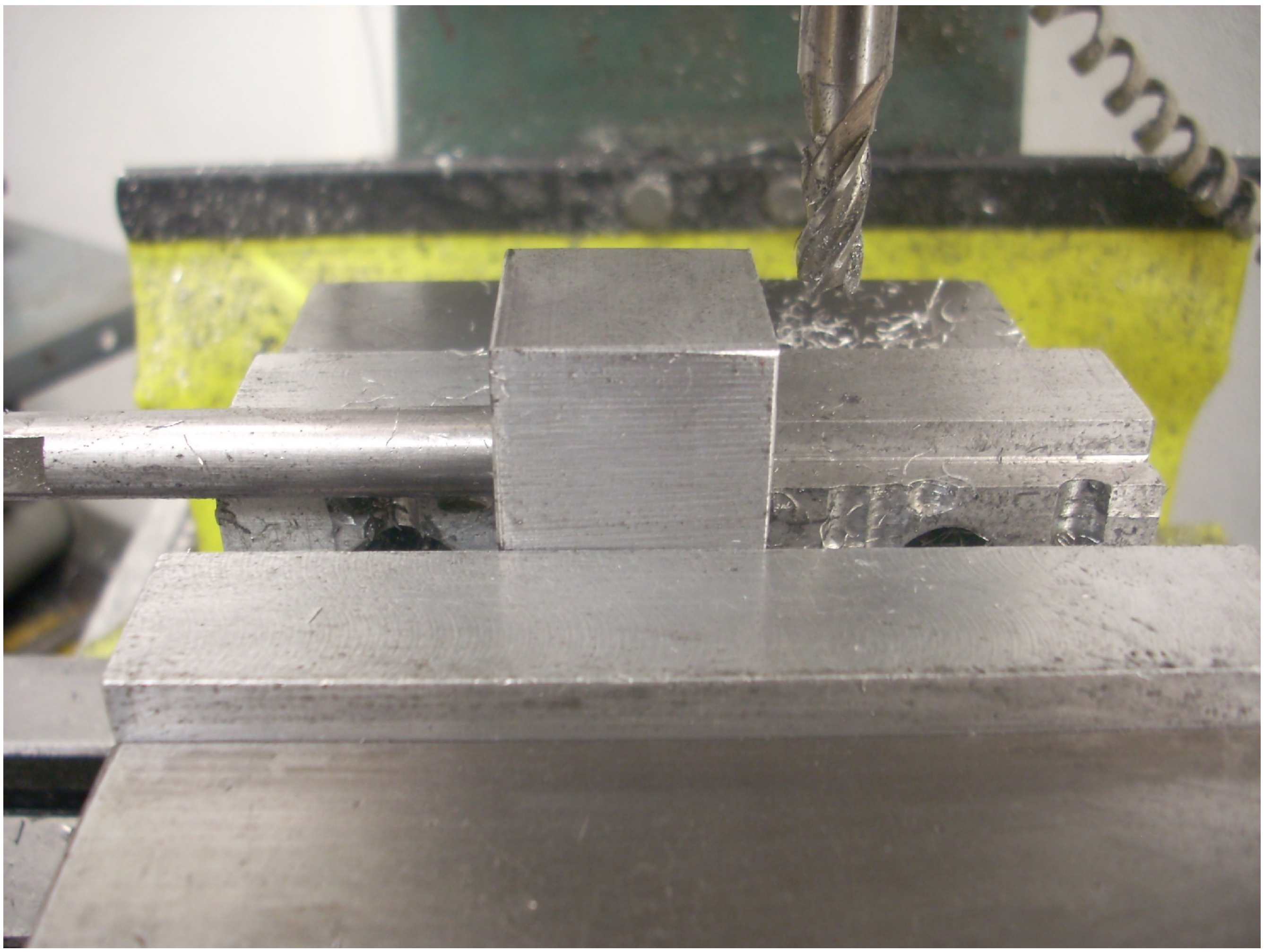
3 Enco model number 630-4050.

Eventually this cutter will wear and its effective diameter will shrink. A reground end mill will most likely not have a diameter equal to the value engraved on its body.

On critical jobs, repeated direct measurement of the part is the only way to insure you will be happy with the results.

## *Setting Zero on the X Axis*

For this task I need a block of scrap aluminum that has a close to perfect right angle formed on two adjacent faces. One face will be down on my soft jaws which means the other face should be perfectly vertical. It should go without saying that all burrs are removed.



My X axis stop is that steel rod on the left. For a number of reasons, I do not want to side mill it to define my zero point. Instead I will take my block of aluminum, press it solidly against the stop and against the soft jaws[4]

I then take a very light cut on the right face. Feed back and forth along the Y axis until no more metal is removed. That should minimize the side load on the end mill and therefore how much it bends. Deburr

4 Note that I press it in place with my fingers and not beat the crap out of it with a hammer. Properly fitted and cut soft jaws should eliminate the need to tap the part down.

as needed. Then measure the width of the block from the left face to this cut area. In the above case I measured 0.9960” with my digital caliper. I then preset my DRO's X axis to -0.9960”. The left side of the end mill is now even with the stop when X = 0. Feeding over by the end mill's radius and setting a new zero finishes the alignment. The center of the spindle is now lined up with X = 0 to within the accuracy of the DRO and digital caliper.

## *Evaluation*

OK, how do I really know this works?

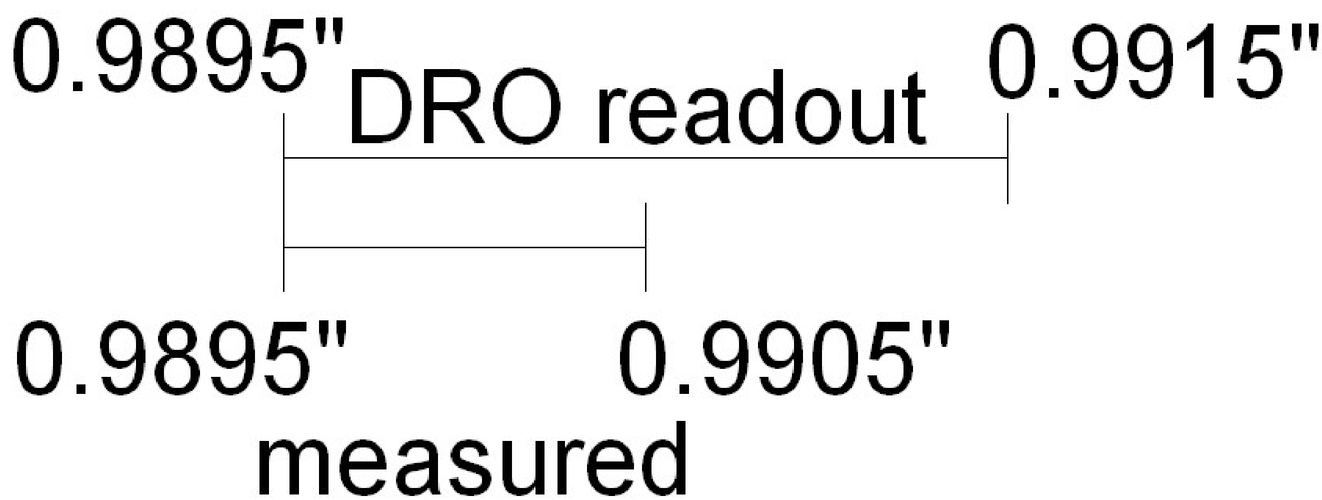
One way is to blue the block's left face and set the tool offset to the end mill's right side. Move the table until X = 0. Then run the end mill along the Y axis. You should see small angled cuts in the bluing. Feed over to X = +0.001” and all of the bluing should be removed.

My next test involves taking a test cut on the other side of the end mill. I changed the tool offset to cut on the left side and moved over to the right face of the block. My cut was less than 0.01”. My X axis readout said 0.9905”. My DRO is good to +/- 0.001” for such a change in distance.

I then ran the end mill along the Y axis until no more metal was removed. My digital caliper measured the block as 0.9905”. My digital caliper is good to +/- 0.001” for such a change in distance. In order to squeeze a bit more accuracy out of the caliper, I selected a stack of spacer blocks to give me 0.990”. My caliper across these spacer blocks read 0.9905”. This tells me that the cut block's width is 0.990 +/- 0.0005” given the repeatability of the caliper.

## *Conclusions*

My DRO told me I would cut a width of 0.9905” +/- 0.001” and my digital caliper with spacer blocks told me I cut 0.990 +/- 0.0005”.




In other words, within the accuracy of my equipment, I got what I asked for.

I hesitate to claim that I have proved anything here but am brave enough (brazen enough?) to say that this test implies that I have an overall accuracy between my X axis zero set and my end mill's effective diameter of +/- 0.001”. As mentioned periodically in this article, many factors can degrade this accuracy.

A truly scientific study would require many more cuts to be made but, alas, I loose interest when it becomes that rigorous. My present project must be within +/- 0.005” so this is plenty good enough.


## *Acknowledgements*

I wish to thank Glenn N, Lou (FocusKnobs), Tom Davis, Andy Wander, and Ray Livingston. Their insights and suggestions have improved this article.


I welcome questions and comments, especially from my metrology friends. My goal is to gather sage advice in this document so have no problem with going through a few more versions. You may have noticed that the soft jaw article ended up at version 6. That means a lot of people helped write it which is a wonderful thing.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