

# The NEMES

NEW ENGLAND MODEL ENGINEERING SOCIETY INC.

# Gazette

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**Dues.** It's that time of year again. Please bring your 2017 dues to the February meeting. Dues are \$25 by cash, check or you can try out our credit card system. If you can't make the meeting, send the dues to NEMES, c/o Rich Baker, 288 Middle Street, West Newbury, MA 01985-1610.

**NEMES Apparel.** We have NEMES denim button down shirts, t-shirts, sweatshirts, and aprons for sale. They make great Christmas gifts. The aprons are \$20, the denim shirts \$35, sweatshirts \$25, and the t-shirts \$15. Contact Rich Baker at 978-257-4101 if you would like to own one.

You can also purchase these items on-line at the NEMES Store, located [Here](https://squareup.com/store/new-england-model-engineering-society).  
[<https://squareup.com/store/new-england-model-engineering-society>]

## Next Meeting

**Thursday, March 2, 2017, 7 PM**

Charles River Museum of Industry & Innovation  
154 Moody Street  
Waltham, Massachusetts  
Directions are [Here](#).

## March Speaker

NEMES own "shaper guy", Dave Lefkowitz, speaking on metal shapers.

Deadline for submitting articles is two weeks prior to the next meeting.

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## ShopTalk

### Max ben-Aaron



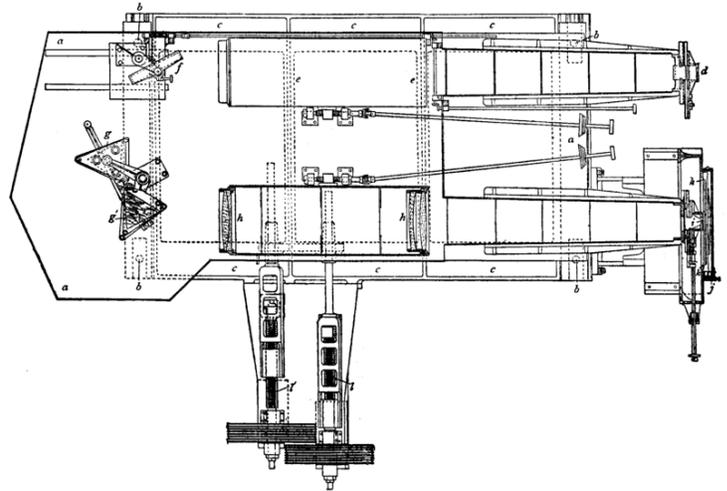
[George Ellery Hale](#) (June 29, 1868 – February 21, 1938) was an American solar astronomer, He is best known for his discovery of magnetic fields in sunspots, I admire him for his unique talent for

getting big telescopes built. He had a knack for getting himself seated next to men who had control of vast sums of money, at ceremonial dinners. By the time the dinner ended, his dinner partner had come to the realization that it was his life's ambition to build the largest telescope in the world.

Hale was born on June 29, 1868 in Chicago, Illinois. When Chicago was reconstructed after the Great Fire of 1871 his father William Ellery Hale made a fortune manufacturing and installing passenger elevators which had been destroyed by the fire. The oldest of three children, George received strong encouragement from his father, who supported the boy's active mind and curiosity. At the age of fourteen, George built his first telescope. His father later replaced it with a second-hand [Clark refractor](#) that they mounted on the roof of their Kenwood house. Soon he was photographing the night skies, observing a partial eclipse of the sun, and drawing sun-spots.

Hale went to MIT where, as an undergraduate, he is known for inventing the [spectroheliograph](#), with which he made his discovery of solar vortices. In 1908, he used the [Zeeman Effect](#) with a modified

spectroheliograph to establish that sunspots were magnetic.



*Mechanical diagram of a spectroheliograph, a scientific instrument for making photographs of the sun at specific wavelengths*

Subsequent work demonstrated the strong tendency of magnetic polarities in sunspots to align themselves east-west, with mirror symmetry across the solar equator. He also established that; the polarity in each hemisphere switched orientation from one sunspot cycle to the next, a systematic property of sunspot magnetic fields that is now commonly referred to as the "[Hale–Nicholson law](#), "[or in many cases simply "Hale's law."]

Hale's motto was "Make no small plans. He convinced the Chicago tycoon, [Charles Tyson Yerkes](#), to finance the largest refracting telescope in the world. Yerkes was a convicted embezzler with a reputation for dishonest deals, but he liked the idea of his name being attached to a famous telescope. He said he would pay whatever it took, but insisted repeatedly that the telescope had to be the largest in the world. Hale promised that this would happen and, in 1895, workers finished the largest [achromatic refractor](#) that would ever be created: the Yerkes telescope.

Alvan Clark and his son were a team of expert telescope builders; they had designed the U. S. Naval Observatory. Hale hired them to build the [Yerkes telescope](#), a 40-inch (101-centimeter) [lens doublet](#), placed in a 60-foot-long (18-meter) telescope. The whole thing weighs 20 tons and is balanced so finely that it can be moved with the slightest touch of a finger. The telescope is actually controlled by electric motors, operated by the observer. The floor, designed to move up and

down to let the observer reach the eyepiece regardless of the position of the telescope, is also powered by motors. The telescope is surrounded by a dome with shutters that can be opened by hand, although they, too, are electrically powered.

The 40-inch Yerkes refractor was destined to be the last of the great refractors because lenses had grown as large as they could be. Any bigger, thicker lens would either sag under its own weight or absorb too much of the light it collected. The telescope, still used today, was renovated in 1969 to allow astronomers to position the telescope more quickly and to allow it to automatically follow objects in the sky.

Although refracting telescopes remained in use, future advances demanded that astronomers turn to the refractor's nearly constant competitor — the [reflecting telescope](#). Even though he was primarily a solar astronomer, Hale also built stellar telescopes: a 60-inch reflector installed at [Mount Wilson](#) in 1908, and a 100-inch telescope 100-inch Hooker reflecting telescope at Mount Wilson, inaugurated in 1917. In 1928 the International Educational Board of the Rockefeller Foundation agreed to finance Hale's \$6 million proposal to build a 200-inch telescope on [Mount Palomar](#). This was his final project. Delayed by World War II, it was dedicated in 1948.

In October 1913, Hale received a letter from Albert Einstein, asking whether certain astronomical observations could be done that would test Einstein's hypothesis concerning the effects of gravity on light. Hale replied in November, saying that such observations could be done only during a total eclipse of the sun. And so it was that, in 1919 when [Eddington](#) verified, during a solar eclipse, that the gravitational field of the sun deflected light from stars positioned near the sun's disk.

During the last few days of his life, Hale is said to have looked up at the sky and rejoiced, "It is a beautiful day. The sun is shining, and they are working on Palomar." Hale would not live to see that telescope finished, but today the 200-inch Hale Telescope on Palomar Mountain is named for him.

Hale not only contributed to astronomy by building four of the world's largest telescopes, he also founded an astronomical society, started the *Astrophysical Journal*, and was the first person to be officially called an astrophysicist.



## *Tool Corner* Frank Dorian

*[Editor – Starting this month, I'll be reprising Frank Dorian's excellent "Tool Corner" articles, that ran from July 2011 to June 2013]  
From the July 2011 Gazette*

In the most recent Gazette, Frank Hill, our esteemed editor, wrote of his frustration over the apparently poor readership of the Gazette and the lack of content contributions from the membership (that's you and me!). Having edited a similar newsletter for many years for another group, I'm sympathetic to Frank's plight. So, to try to do a little to improve the situation, my thought is to provide a regular piece for the Gazette, hopefully monthly, on the subject of tools, both simple and complex, that we use in pursuit of our hobby. There are so many neat tools out there and so many ways to use them that I think I can keep a series going for quite a while without running out of material. There is an opportunity for member participation here too. If you have an unusual or interesting tool that you feel would be of interest to the NEMES membership, please let me know and I will be happy to photograph it and write it up for the Gazette.

So, let's talk about this month's feature tool, a variation on the adjustable bevel. The simple adjustable bevel is a very handy tool with many applications, but it has its limitations. In this case, the most significant limitation is that, while a single bevel works well for measuring obtuse angles, as the angle you are measuring becomes more acute, you start running out of room on the bevel's gauging surfaces. To see what I mean, take a look at Photo 1 below.



The simple bevel works fine at 45 degrees, but when you get down to 30 degrees, there's not enough contact area on the bevel's gauging surfaces to assure an accurate measurement. An acute angle of 10 degrees can't be measured at all. There were a few solutions developed to address this problem, but we are going to limit this discussion to the simplest one, the universal bevel.



Photo 2 shows an assortment of three universal bevels I have in my tool chest. The smallest one and the middle size were made by Starrett. Brown & Sharpe made similar bevels. The largest bevel in Photo 2 is a cheap tool with a pot metal beam and a stamped steel blade made in the USA by TWIX a few decades ago.



In Photo 3, you can see one of these bevels being used to measure a 1 degree angle, something that's not possible to do with a simple bevel. Another nice feature of universal bevels is that they will also measure any angle that can be measured with a simple adjustable bevel.



Photo 4 shows a "Universal Bevel" that is still in Starrett's catalog, but I don't think it's nearly as versatile as others. The "dog leg" section has been shrunken down to just a little jog in the blade slot, limiting its usefulness in measuring acute angles. Plus, it's a pain to move the beam from one slot to the other. And, trust me, the beam will always be in the wrong slot when you pick it up to use it.

So, why aren't all bevels made in the universal pattern? The additional complexity of grinding the "dog leg" on the universal bevel increases the cost of manufacture significantly. Also, the universal style blade would be tricky to heat-treat without getting some spoilage due to warping. Add to that the general decline in the use of machinist's hand tools and you have another tool slipping quietly from the pages of the Starrett catalog into obsolescence.

By the way, if you happen across one of the TWIX bevels shown above, don't turn your nose up at it because it's a cheap utility tool. Spend a bit of time taking a skim cut off each edge of the beam to remove

the casting flash and then refine the stamped edge of the bevel blade a bit. You will then have a very serviceable tool that will prove to be a valuable addition to your toolbox. And if you want one, but can't find one, how about making one from scratch? For home use, an unhardened version, handled carefully, will remain accurate for a very long time.

## Thoughts about Precision

### Milling

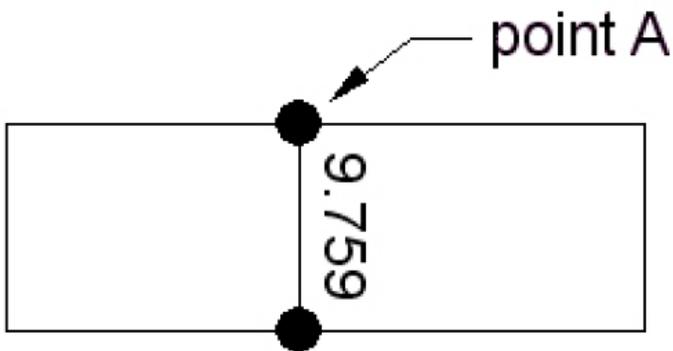
By R. G. Sparber  
May 14, 2007

My journey to gaining the highest precision with my RF 30 mill/drill has taught me many lessons. One of those lessons relates to how to think about the measuring and machining of a thickness. These concepts can be introduced with a single dimension and then expanded until we are dealing with the real world of 3 dimensional parts.

The central concept here is using a single control point to guide your cutting while monitoring the contour of the resulting machined surface.

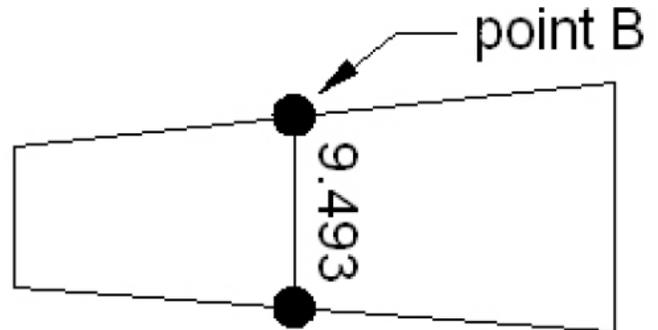
#### The One Dimensional Model

In the world of one dimension, we limit our thoughts to the length of a line. Ideally this line has no thickness. Due to limitations in my measuring instruments, some thickness can't be avoided. More on this later.

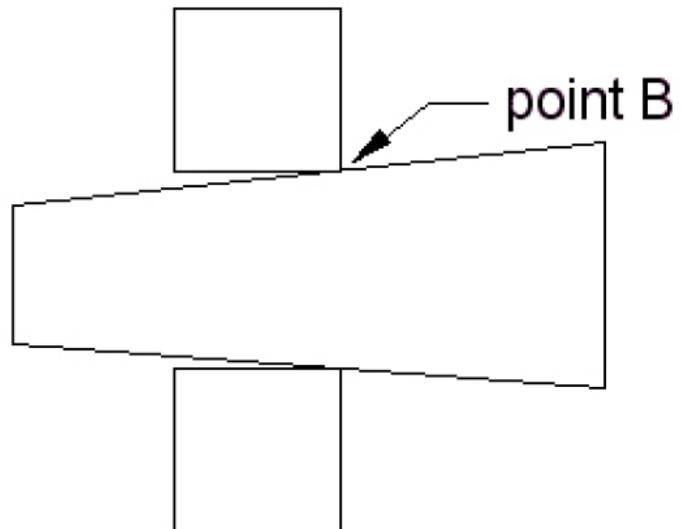


Consider a block of metal that is perfectly square. We can put a mic at "point A" and measure a thickness. Since the block is perfectly square, this measurement accurately represents the thickness of the block from end to end. I will call this measurement my "control point". As I machine the thickness of my block, I want to always measure

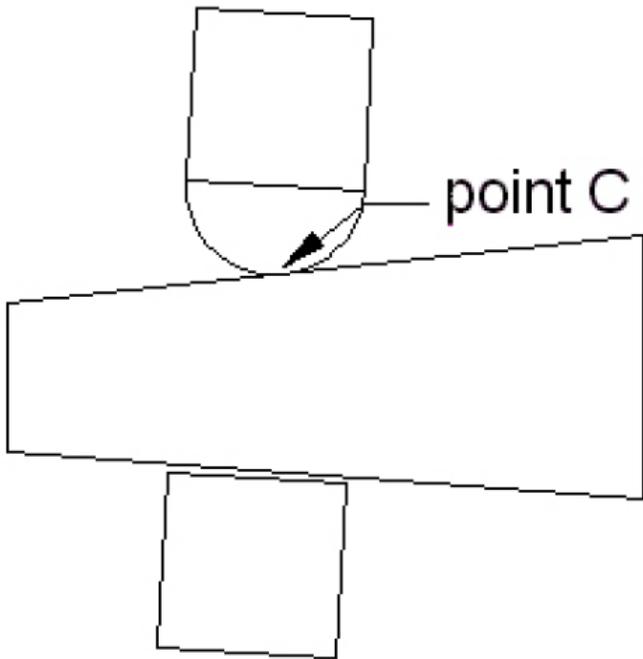
at this control point. If the measurement at this point says I need to feed in .005", I will advance my cutter by this amount and make my cut. Then I must return to my control point and assess the results. Ideally my thickness at the control point will now be .005" less than before my cut.



Now consider a block of the type found in my shop. It is never perfectly square. I can pick a "point B", and put my mic on it. The reading is an accurate measure of a thickness only at this point. If we look a bit closer, we see how hard it is to take a meaningful measurement.



You can see that the mic's anvils only make contact on the up hill side of the block. A small movement of the mic will produce a different reading of the block's thickness.



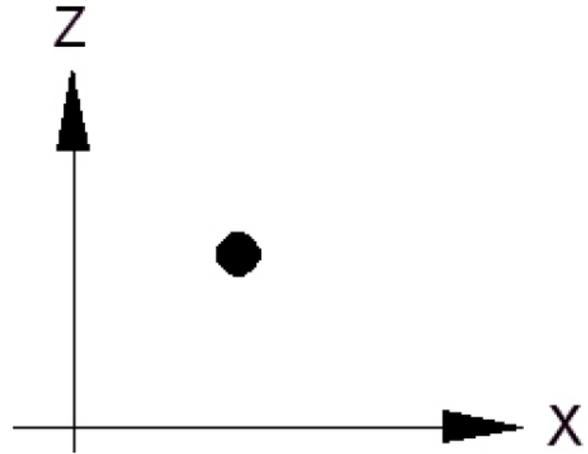
One solution to the problem of having a poorly defined set of contact points is to put a precision ball on the end of the mic's anvil. The bottom anvil is now free to make full contact on the bottom surface while the top anvil contacts at essentially a single point. The mic is now solidly on the part. Note that the thickness measured with the ball anvil is slightly different than the one measured with square anvils. The thickness with a square anvil at point B will be larger than the thickness with a ball anvil at point C. Hopefully, after machining, the top surface will be much closer to being parallel with the bottom surface so this effect will become minimal.

The important idea here is that we now have a far more repeatable measurement. The ability to repeatedly measure a given thickness is essential to precision machining. Recall that we are measuring the thickness at our single control point between cuts in order to judge how accurately we are feeding in our cutter and the depth of subsequent cuts. If our measurements are at random points along the line, error will be introduced.

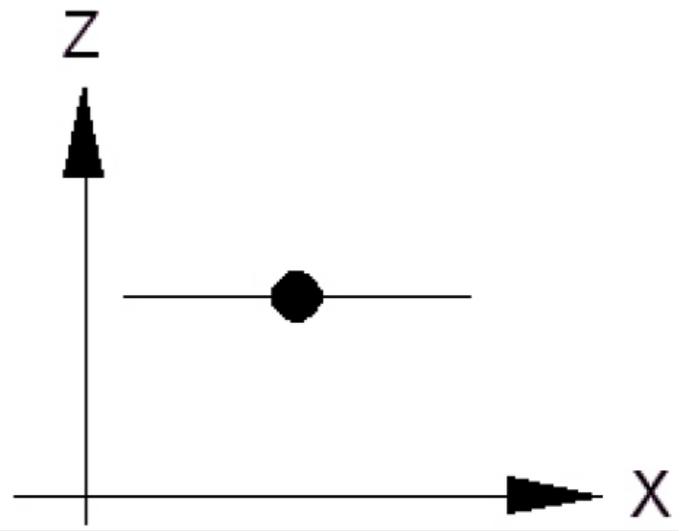
When I first started to improve the accuracy of my machine, I focused on just my control point. It was time well spent, as you will soon see. The concept of having a single control point turns out to be valid right through the three dimensional case.

Once I was able to repeatedly machine a thickness at a given point, it was time to broaden my work. The next step was to machine a plane. Before we launch into all three dimensions, let's look at two dimensions first.

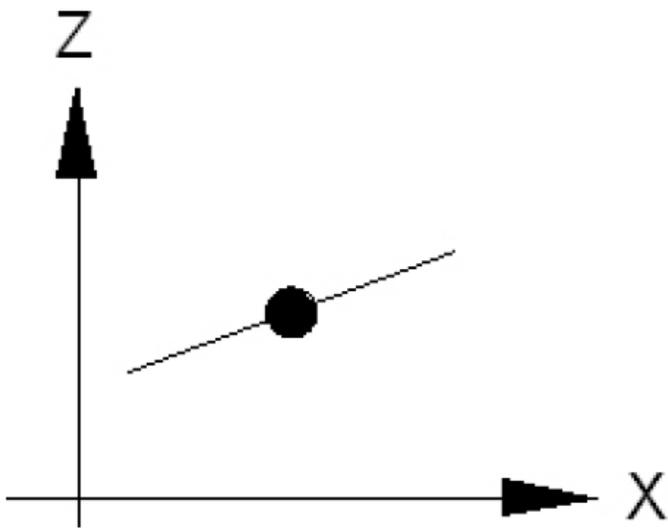
### The Two Dimensional Model



When we thought about the one dimensional world, a single number was sufficient to tell us all about our single point. If I look at this case in a two-dimensional world, we have a single point at a distance from the X axis along the Z axis.

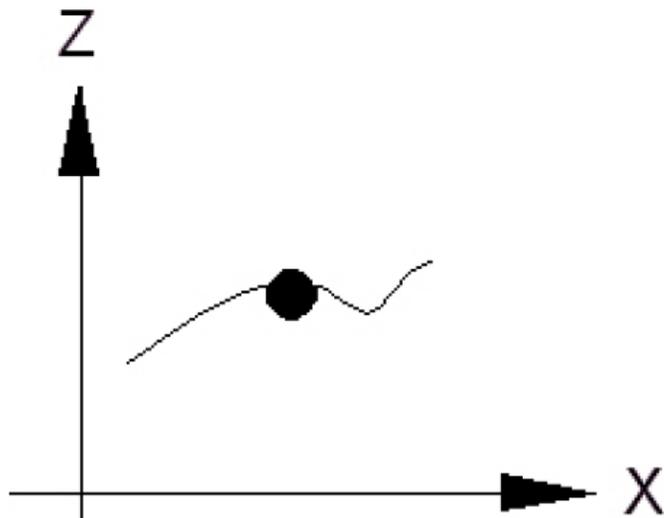


If I now draw a line through this point that is parallel to the X-axis, we have the ideal case of a dead flat line. It is parallel to the X-axis at a distance along the Z-axis.



Consider the case of a line with a slope. At our control point, the distance from the X axis is known. But when we move away from this point, the distance to the X axis will either increase or decrease.

What does this mean when machining? We can use our mic to monitor our control point but can only passively observe how the line behaves. We control the point by measuring only at this point and feeding the end mill down in a precise fashion. The slope of the line depends entirely on our ability to hold the part and the repeatability of our machine. An excellent means to canceling much of the error in a set up is to use soft jaws. Soft jaws are machined in place just before they are used to machine the part. My favorite way to precisely feed my end mill down is to use a sine bar and DTI. See my web site for articles on these topics.



In the general case, the line is not straight. If you use your best measurement instrument and

technique, the most you can hope for is that the line is straight and flat to the limits of your equipment. Look close enough and you will always see a line that is not perfect.

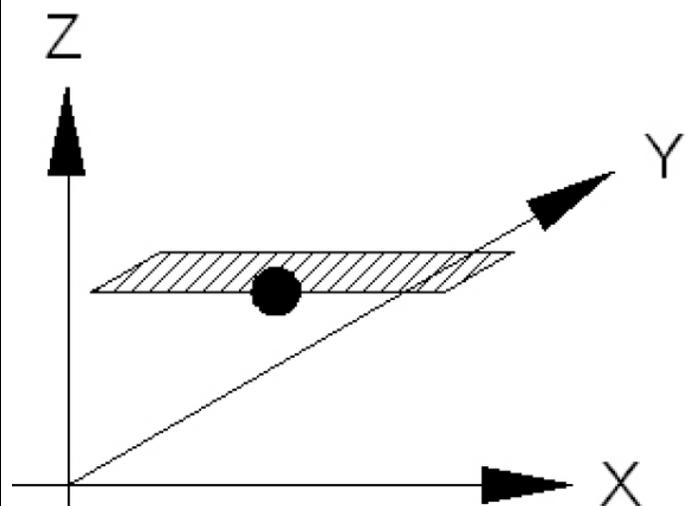
How can we describe our non-ideal line? Well, it turns out there are many ways to do it. Which one to use depends on your applications.

One way to characterize a line is to measure along the line and find the extremes. For example, say at one end of the line you measured a low of 0.818" and part way to the other end you saw a high of 0.822". You can, they say that the line is  $0.820 \pm 0.002$ ". When the + is the same magnitude as the - , we call it a "bilateral" tolerance. This approach is simple to do and does completely specify the worst case limits of the line.

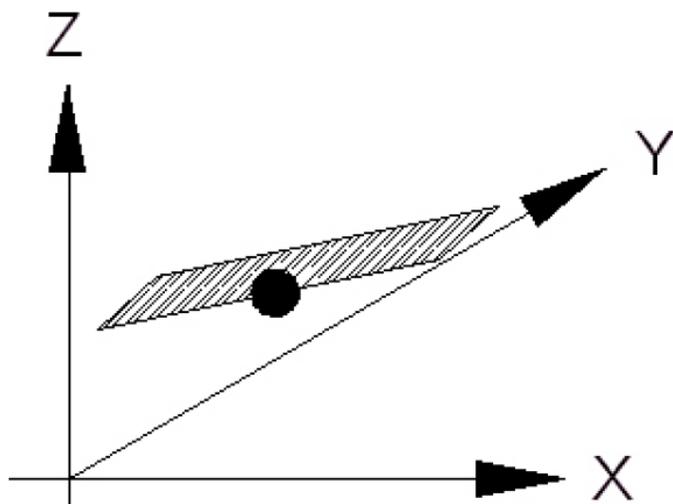
Another method is to take a lot of measurements along the line and take an average. Deviation from this average can be as simple as noting how far the worst case points are from this average. You will probably end up with one value for + and a different value for -. In this case we have a "unilateral" tolerance. If you are trying to get the best possible fit between two machined surfaces, this approach may give a clearer picture of how well you are doing.

Many other statistical methods exist including standard deviation and Root Means Square. I'm sure Google will find plenty to read on these subjects.

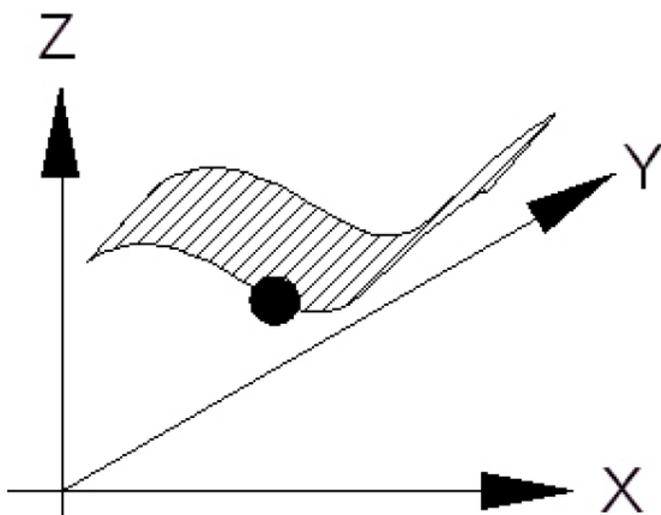
### The Three Dimensional Model



Entering the world of three dimensions means adding the Y-axis to our existing model of X and Z axes. Our line now expands to become a plane. All of our discussion related to two dimensions will apply here. We can define a single control point on our plane and use it to monitor and control the distance this point is from the XY surface. Ideally, our plane is parallel to this XY surface.

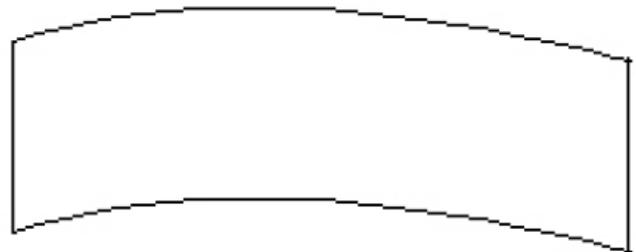


Recall in the two dimensional case that we can have a line that passes through our point with a slope. The same is true in the three dimensional case. Our plane can have areas that are closer to the XY surface and other areas that are farther away from this surface. As in the 2D case, we can control the point with careful feeding in of the end mill but the condition of the surface depends on machining technique and your machine's stability.



In the general case, we have our control point on a curved surface. As in the 2D case, there are many ways to describe this surface. One common way is to measure the surface at all 4 corners and also in the middle. This will give you a good idea of its contour. For a clearer picture of how the surface deviates from ideal, place the part on a surface plate and use a finger Dial Test Indicator to search the top for lows and highs. The finger is typically in contact with a much smaller area than the area of a square ended mic anvil and often is smaller than even the ball attachment to the mic's anvil. See my article on DTIs for more details.

Don't be surprised if the mic shows one thickness and the DTI does not agree. You might be looking at a warped part.



Consider the case of a 2D box that is curved on the top and bottom. You can mic the thickness and find it uniform. Yet if you put it on a surface and measure the height at various points, you will see the bend.

The take home message here is to use both mic and a surface plate to get a complete picture. Do not assume difference between these methods can be blamed on defective instruments. It might just be a shape like this that is driving you crazy. A second lesson here is that when you measure the thickness of a 3D part, be mindful that non-ideal contours on the hidden underside of the part directly affect your readings as you concentrate on the top side.

I welcome comments and corrections to this article. All of us are smarter than any one of us.

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# Coming Events

Errol Groff

12 March Train Collectors Assn. Show,  
Manchester CT, Show Flyer [HERE](#)

19 March Worcester Model RR, Auburn MA,  
Show Flyer [HERE](#)

## Sources for Model Engineering Parts and Supplies

**BREAKHEART TOOL COMPANY**  
 (p) 1-800-746-8767 (fax) 603-286-8274  
 Est. 1970

5-C EXP. ARBOR SET .50-1.5-1.75-2 (dia's) \$79.95	5-C COLLET STOPS 20-pc Set \$79.95	EXP. ARBOR SET 1.5-1.75-2 (dia's) \$59.95	8-PC. EXP. ARBOR SET .250-1.25 (dia's) \$34.95
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