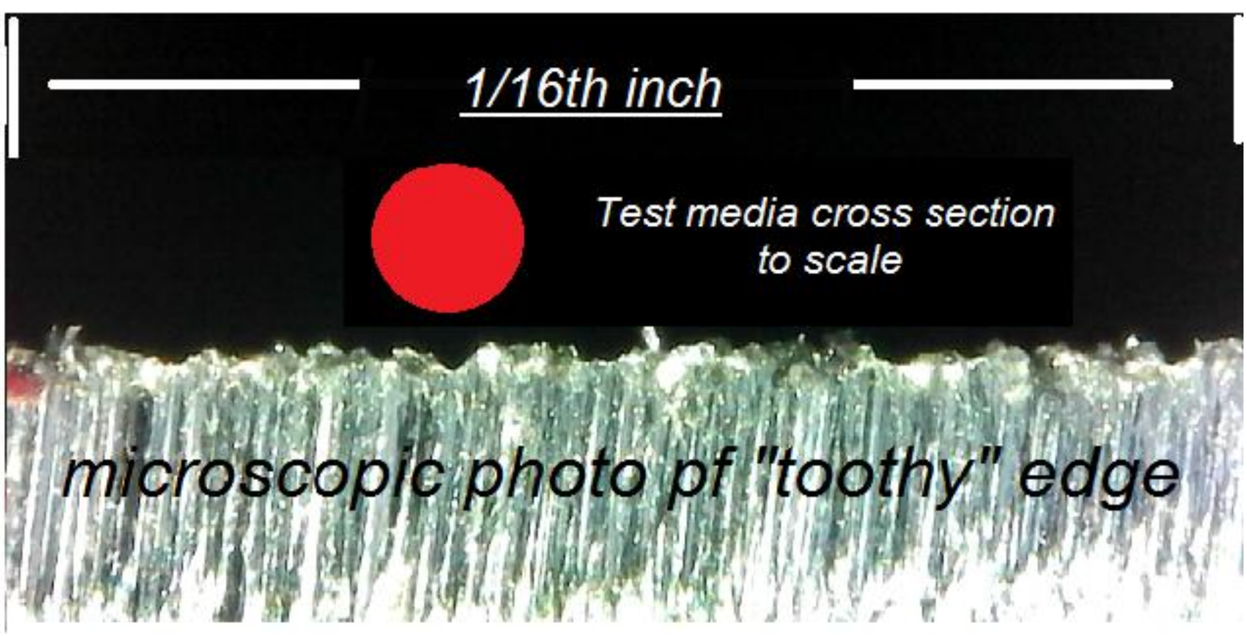
Additional Information That may be Relevant and Helpful to the Advanced Sharpener and Edge Tester

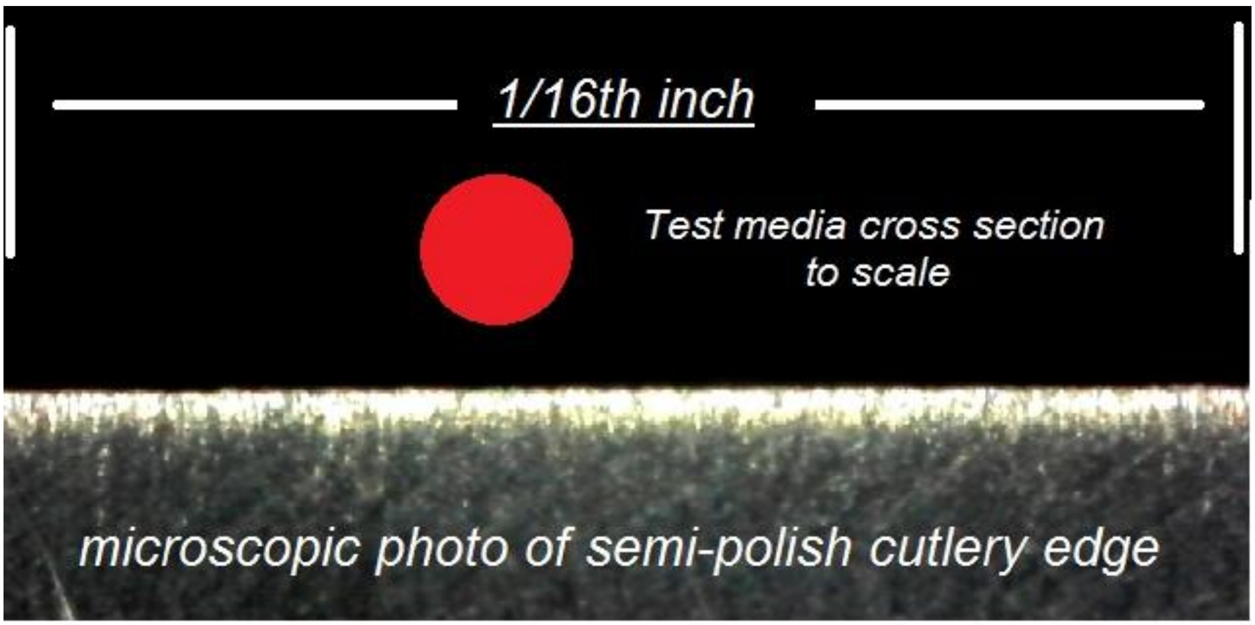
The following is intended to serve two purposes - but just for those who are interested. First we will have a discussion that will, hopefully, help users understand and interpret the data they receive from their instrumentation and secondly, answer a common question that we receive "how does this work?". Our short answer to that question is "how could it not work?" but we'll detail the basis for that short answer in the form of a question later in this document. First let's talk about edges and interpreting data derived from individual edges.

Measuring sharpened edges is not like measuring the speed of light in a vacuum. It's more like asking "What is the air temperature inside your home?". It may be 65ºF in the back bedroom and 77ºF in the family room so the question is difficult to answer with great accuracy even though the instrument we are using to measure those room temperatures, a thermometer, may be extremely accurate. The same is true of measuring the sharpness level of edges. We will be using an extremely precise system to measure a relatively imprecise edge.

Yes, we might have placed our thermometer in the hallway and taken an average of the two room temperatures but that would be less information, not better information. Some may prefer a homogenous temperature throughout the home and others may prefer it cooler in the bedroom. The analogy is appropriate for edge sharpeners because they have their individual goals and preferences as well. So let's look at a magnified image of the knife edge version of the family room and the back bedroom.

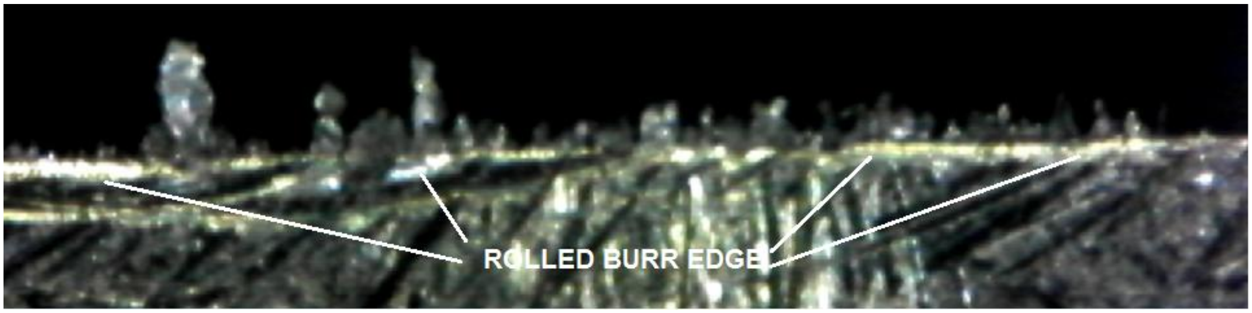


The above pictured edge was ground with 240 grit ceramic and then deburred. Keep in mind that you are looking at only 1/16th of an inch of the edge. It measured anywhere from 230 to 290 (an edge the average home chef would die for) on the BESS. If this were your edge and if your intent had been to produce a sharp edge with "bite" your instrument has confirmed that you were successful. It is not difficult to see why this variation in measurement existed. The "peaks" of the edge are composed of thinner metal than the "valleys" so dependent upon placement of the test media on the edge, a difference in measurement value will likely occur. To the thumb, this edge felt incredibly sharp. Test Media is .009 inch in diameter so as you can plainly see, placement of the test media on the edge with a variance of only the radius of the test media (.0045 inch) might produce significantly skewed results.

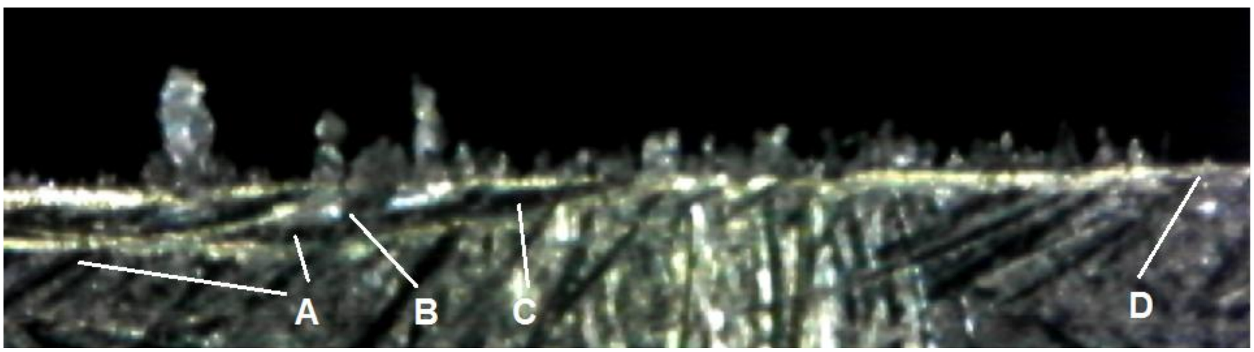


Pictured Above: The same knife edge but finished with 30 micron S/C film but keep in mind that S/C has very high friability so the last strokes could have been at 15 micron easily. This edge measured from 190 to 215 on the BESS. A few small peaks and valleys are still visible but nothing like the toothy edge. Interestingly enough, to the thumb, this edge won't feel nearly as sharp as the toothy edge.

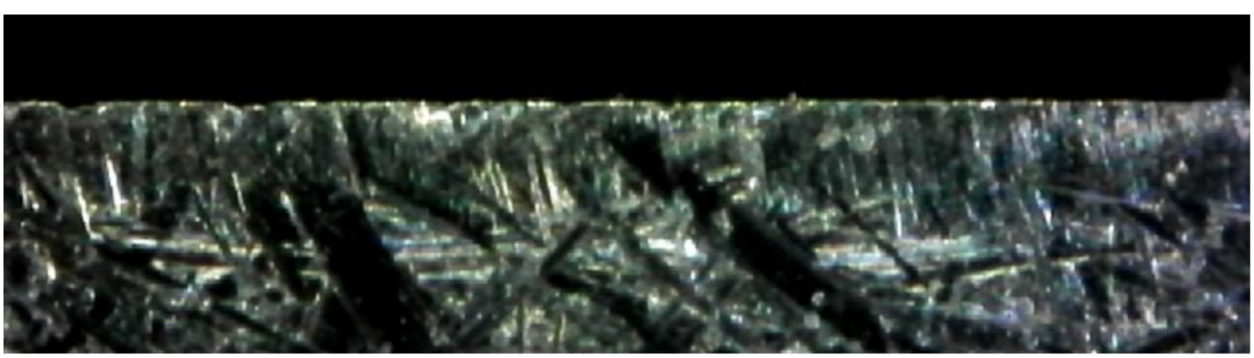
BURRS - Burrs are good things and not bad. Lacking instrumentation for the task, burr creation will likely be your best indicator that the grinding process is complete. Coarser abrasives leave big burrs and finer abrasives leave small burrs. Once any burr is created though, it must be removed completely. The presence of even the most miniscule of burrs are easily detectable by your edge tester. The burr is usually just a roll of very thin metal that has been pushed to one side of the edge after grinding operations are complete. A burr presence will usually manifest itself as a widening of the edge apex resulting in higher BESS scores. The burr is attached to the very apex of the cutting edge and may be contiguous or semi-contiguous. The following is a picture of a burr created by an electric "sharpener". Sharpener is in quotation marks for a reason but we'll keep those opinions to ourselves. Keep in mind while looking at this picture that the burr is rolled toward you in this perspective so, effectively, you are looking at the broad "rolled edge" of the burr.



The crisscross grind marks on the edge were left by the spinning wheels of the "sharpener". Don't be distracted by the "junk" sticking up above the edge. It's mostly just loosely attached shards. We show you this picture only because ineffective and incomplete burr removal can be a source of variation in edge measurements. This edge measured from 545 to 750 as pictured. In the same picture immediately below let's focus in on points A, B, C, and D.



The picture above is pure photographic luck because it shows us many things that are very difficult to capture. At "A" we can see where the rolled burr has been partially detached from the edge both in sliver and complete form. At point "B" we can see some of the metal shard still attached to the partially detached rolled burr edge. At "C" we see the beginning of the detachment point. "D" is very likely a point where the burr was torn completely away by the grinding wheels. On those portions of the edge where the burr was torn away it is very likely that the edge will never be nearly as sharp as the edge portions where proper burr removal techniques will be employed. In the picture below we see this same edge after burr removal using a SHARP PAD. This edge measured 240 to 285 after deburring.



The specific edge information imparted by your instrument to you can be very useful in determining what abrasives and techniques are worthwhile to your sharpening process and which are not. Most importantly though, learn to trust your instrument and the basis for that trust is better explained in the following section . You will undoubtedly encounter many "head scratching" moments in the process of measuring edges but through diligence and experimentation you will likely discover the source of and the reason for any unexpected results.

Rolled Edges - Please read the last section in this document and you will understand why rolled edges play a large role in knife edge maintenance. Even the most modest of rolled edges can easily create 50 or 60 point differentials and severely rolled edges 300 points or more. Sharpen a knife in the evening and by morning it could easily measure 30 points higher as the edge tries to get back to where it thinks it belongs (metal memory). All these things are easily detectable with your edge tester and when you strop the edge straight again, your edge tester will indicate that it is straight.

Wire Edges - You can disagree if you like but our feeling is that wire edges are likely nothing more than rolled burr edges that have been straightened up. Push a wire edge over to one side or the other of the edge and you have a rolled burr edge. The mechanical design of ceramic roller style pull thru sharpeners lend themselves to the production of wire edges. We have tested the output of this style of sharpener many times. If it's done just right, eye-popping BESS scores can be the result (120/130). Chop one carrot though and the test score goes to 750. This is because the tall, flimsy piece of metal that once comprised the "edge" has been folded over by the carrot. Of course other sharpening techniques produce wire edges as well. Wire edges are only worthy of mention here because you may measure just such a precipitous increase as well some day. If you do, a wire edge may have been the culprit.

The Science Behind Edge On Up Instrumentation and BESS Test Media

As we said earlier in this document we are often asked "how does this work?" and our short answer is "how could it not work?". While it isn't rocket science it is basic physics. Here is the long answer but it really couldn't be more succinct.

$$S = \frac{F}{A}$$

Stress (S) is the physical effect produced once we begin to cut. Force (F) is the degree to which we bear down on the cutting instrument and Area (A), in this example anyway, represents the relative thinness (sharpness) of our cutting edge. Now we don't really mean to belabor this explanation but in a nutshell; when it comes to cutting something - The amount of Force (F) exerted, the width (A) of our cutting edge and the characteristics of the material (M) to be cut are the primary variables we concern ourselves with. If we know any two of these variables we can then solve for the third.

In our video tutorials you will often see variations of two examples of this problem solving. Of course we always know (M) because it's our BESS test media so in the case of a knife of unknown sharpness we solve for (A). When measuring DE razor blades though we often solve for (F) because we think, with some assuredness, that we already know (A). Then when we dull that razor blade edge an unknown amount we are back to solving for (A).

So what is actually happening when we sever something? At a single point, we are simply dividing and separating the electrical/chemical bonds that hold the object's molecular structure together. When we are finished with our cut we have effectively taken a very tight knit community of molecules and divided them into two, albeit smaller, very tight knit communities. So how hard did we have to work at accomplishing this exercise in divide and conquer? That depends on three factors: the density of the molecules , the strength of the electrical bonds that held them together, and the area (sharpness) of our cutting edge. If our edge was sharp (thin), we had fewer molecules to push and shove around so our task was made easier.

So now what, assuming we would like to invest as little labor as possible into our molecule separating activities as possible, can we do with this knowledge? Let's first borrow from and then build on our equation and see if we can derive some practical benefit from it. Most materials that we cut, likely, have well defined characteristics but those characteristics are unknown to us. They may be thick or thin, rigid or flimsy, dense or soft. Simply too many variables to keep track of. Using our equation, we can calculate the degree of Stress placed on them at any given time but we cannot predict in advance how much Stress (Force) will be required to separate our material into two pieces. We just don't have enough information about the material to make a valid prediction. But what could we do if we created a test material that did have well defined, environmentally stable and reproducible molecular characteristics? Now we have some possibilities.

Let's call this case #1. We could take an edge of known Area (sharpness) and accurately predict how much Force would be required to sever the test material we developed *or Case #2,* we could measure the amount of force required to sever our test material and then make accurate assumptions concerning the Area (radius or width) of the edge. Now that sounds like something that someone interested in sharpening an edge could find useful. In Case #1 we validate the accuracy of the instrument and then in Case #2 we use that same instrument to measure the Area (sharpness) of an unknown edge. Of course this is where BESS Test Media enters our picture.

In fact though, almost any material with minimally suitable physical characteristics would demonstrate the fundamental principles of our physics equation. Sewing thread, dental floss, or kite string. All would take less or more force to separate dependent on the thinness of the cutting edge.

Of course these materials fall well short of our needs in many areas but particularly in one area; they do not provide us with the basis for a universal standard. A standard that can be relied upon and used only for our individual benefit or shared with anyone in the world. The ability to accurately describe, compare and log sharpness data numerically is a wonderful thing whether it means simply to jot it down on a yellow legal pad in your sharpening room or by specifying it in a request for quotation at work.

In Closing - How Thin is Thin?

If you don't already realize it, edge sharpeners are dealing with some pretty thin stuff. Just how thin might surprise you no matter how long you've been sharpening. Knife blade geometry is designed to be a non-factor when using edge sharpness test instrumentation manufactured by Edge On Up in conjunction with BESS test media. We concern ourselves only with the thinness of the edge apex. While we concede that a double-edge razor blade would be a mighty poor tool to use when felling an oak tree we do think that a definition of "sharpness" should include only the thickness or thinness of the edge apex. Having said this we do believe that the geometry of the edge apex itself does call for some discussion although, we hope, very little discussion because it is an exercise in "splitting hairs" for the vast majority of knife sharpeners. At Edge on Up we usually describe the thinness of the edge apex by describing it's radius as opposed to its width and here is why:

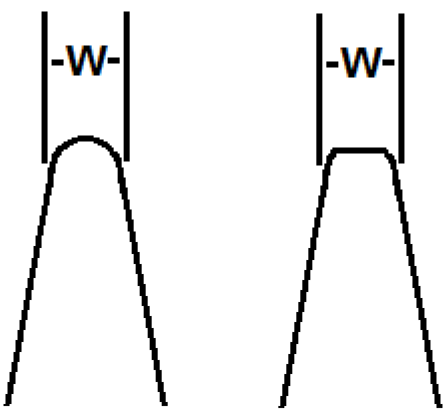


Fig. "A" Fig "B"

Let's assume that we are looking at a cross-section of the apex of a standard DE razor blade at left. In this case "W" or width is going to equal about 100 nanometers (.1 microns). In Fig 1 we have a perfectly formed apex radius so the radius of the apex here is 50nm. In Fig 2 we have an edge apex width of 100nm but as you can see the radius is no longer perfect. We know that the edge represented by Fig "A" will require slightly less force to separate a test media than Fig "B" so we describe Fig "B" as having a slightly larger radius than Fig "A".

BESS test media was developed in a rational sort of way. Every effort was made to give BESS test media relativity to the user and the real world. With that in mind, let's talk about the correlation between BESS scores and apex dimensions. We know that it takes 50 grams of force +/- 5 grams to sever BESS test media when measuring a standard DE razor blade so the relationship, apex radius in nanometers to BESS score, is very close to 1:1. Other tests and measurements conducted up to BESS scores of 300 show this relationship to be essentially linear so with some confidence we can predict approximate apex dimensions using BESS score data. This, of course, comes as no surprise since the equation $S = F/A$ predicts just this result. We must be careful though because theoretical calculations and practice often collide at some point so while this information is useful in helping us to grasp the miniscule world of edges it is not yet absolute from a scientific perspective.

BESS Universal (BESSU) and it's licensee's continue to explore the validity and further refinement of this dimensional relationship through our relationship with the Arizona State University SEM lab but these efforts are very expensive and time consuming. Additionally, further refinement provides little practical value to instrumentation users. It is important for sharpeners to realize that their sharpened edges are composed of almost infinitesimally small thicknesses of metal and for most, that realization will aide them in their edge sharpening and maintenance practices.

A Final Discussion on Edge Apex Dimensions - There is no "steel molecule". Steel can be described as a "solid solution". It is a subtype of chemical mixtures that involve at least two or more molecules in a solid state. These molecules combine to form a single substance "steel". We venture here only because we have "seen asked" and "been asked" some form of the question "how many molecules thick is a sharpened edge?" on many occasions. We applaud the question because the questioner is attempting to gain a better understanding of the dimensions of a sharpened edge. Here's one possible way to equate molecular size to edge apex thickness:

A molecule of water is a very common and well defined entity. Very close to four molecules of water could be fit into a space one nanometer wide. So now you can do the math. If the edge apex of a razor blade is 100nm wide then it could be said that the apex is 400 water molecules wide and, for what it's worth, that's the best molecular example we can come up with.