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Measuring accuracy in the field

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Measuring with the Dual-Measure Tooke® Gage

Measurement with a Tooke Gage is a function of
 the cutting tip and NOT of the microscope.

This information applies to measurements viewed through the Dual-Measure Tooke® Gage scopes.

The precision-ground tungsten-carbide cutting tip incises an angled face into the coating down to the substrate. The V-groove incised by the cutting tip is observed vertically through the Tooke Gage illuminated microscope. The *coating thickness* is calculated based on the *distance (visually) measured through the scope across the cut width*. Essentially, you're measuring one arm (side) of an right-angle triangle.

The observed horizontal projection of the film in the incision wall is related to the film thickness by the equation:

Example: $A = A' \tan \theta$

The 1× tip cuts a 45° incision (creating an equilateral triangle), where

A (the *coating thickness*) = A' (the *measured cut width* seen through the scope).

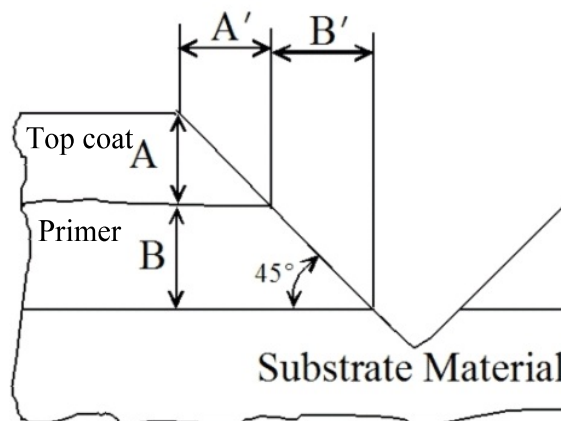
Thus, the ratio for the 1× tip is **1 : 1**, as shown at right:

Thus (using the 1x tip): $A : A' = 1 : 1$

At a 45° groove angle: $\tan \theta = 1$

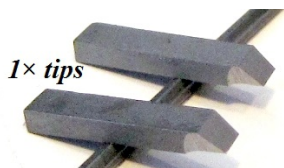
And, so (using the 1× tip): $A = A'$

*Visualization of an incision made
 using a 1× (45°) cutting tip*



The 1× tip cutting face of 45° has a ratio of **1 : 1** (*measured cut A' : calculated coating thickness A*) thus: $A = A'$ ("what you see is what you measure").

The 10× tip with its cutting face of 5° 42' has a ratio of **1 : 0.1** (so the ratio is: *measured cut A' : calculated coating thickness A*) so, $A = 1/10$ th of A'.

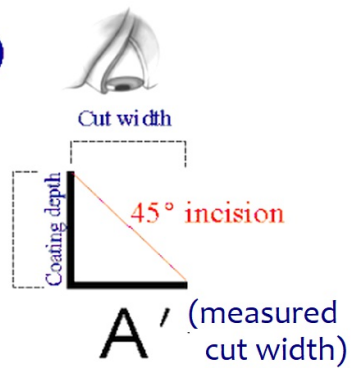


1× tip

$A = A'$

(calculated coating thickness)

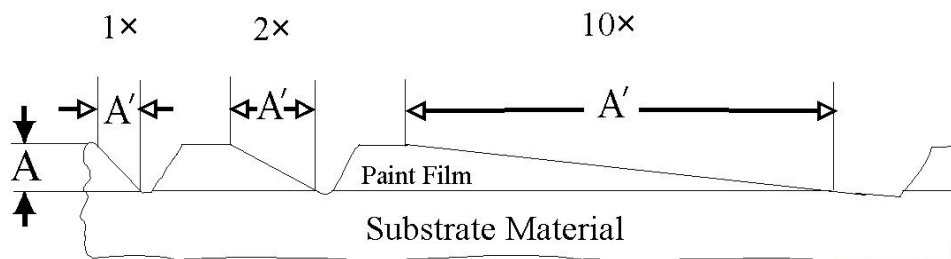
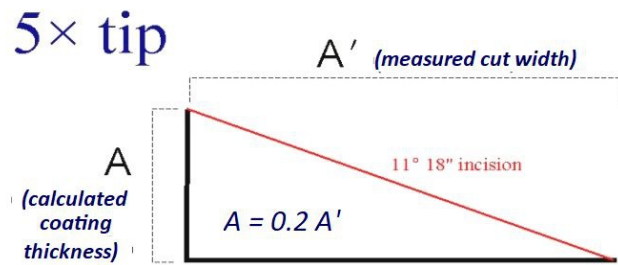
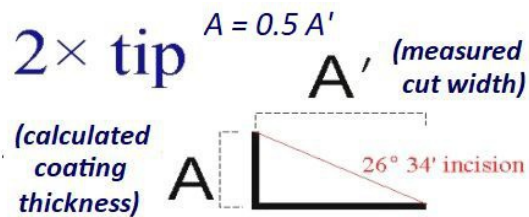
A



A' (measured cut width)

The math and measurements in this paper applies to the Dual-Measure scope, with 20μm / hashmark space. If you're using the **universal scope** (with 50μm / hashmark space), please see the linked paper for correct calculations.

<http://www.micro-metrics.com/TechData/OG204-TDS.pdf>



The new Dual-Measure microscope reticle is marked with both mils and microns.

(Cut width) measurement per hashmark space

	1× tip	2× tip	5× tip	10× tip	
Top scale: mils*	1	0.5	0.2	0.1	Top scale: mils*
Bottom scale: microns**	20	10	4	2	Bottom scale: microns**
Converted: millimeters	0.02	0.01	0.004	0.002	Converted: millimeters

*1 mil = 1 "thou" = 0.001" = one thousandth of an inch

**micron = micrometer = μm

Maximum coating thickness

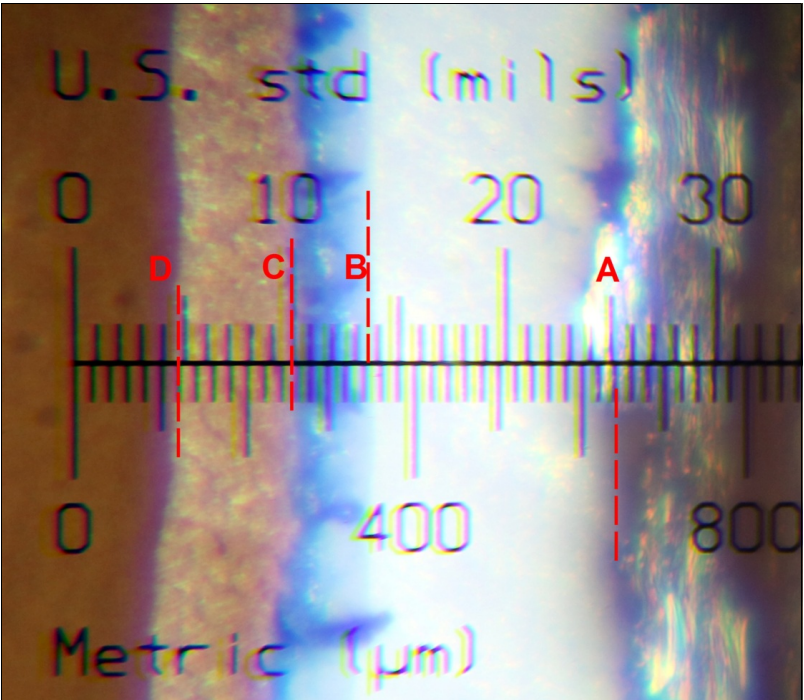
(Dual-Measure reticle width overall = 100mil and 2 540 μm)

Cutting tip designation	Maximum coating thickness in:		Precision of thickness determinations in:	
	English	Metric	English	Metric
	mils	microns (μm)	mils	microns (μm)
1×	100	2 540	±0.25	± 5
2×	50	1 270	±0.13	± 2.5
5×	20	508	±0.05	± 1
10×	10	254	±0.025	± 0.5

A measuring demonstration

The “zero-line” of the Dual-Measure reticle at right is **not** lined up with the edge of a coating (nor does it need to be, as any hashmark will do). The zero-line is off onto the brown top-coat, well beyond the edge of the incision.

- Line A is on the right edge of the (white-appearing) substrate. (The incision **into** the substrate, on the right past A, reflects silver in the photo.)
- Line B marks the bottom of the blue primer coating. Begin measuring (leftward) at Line B.
- Line C is the top of the primer and the bottom of a brown top coat.
- Line D is the end of the incision at the top coat.



If needed, the top of the top-coat can be made easier to see using the black marker provided with the Tooke Gage. In this photo, the darker brown of the top is easy enough to differentiate from the lighter tan of the interior of the top coat.

Thus, in the demonstration photo above, the thickness measured for each different tip face-angle will be:

Above the line on the Dual-Measure or the old-style scope (U.S. standard-units: 1 mil per hash)					
<i>Coating</i>	<i>1mil /hashmark space</i>	<i>1× tip, mils</i>	<i>2× tip, mils</i>	<i>5× tip, mils</i>	<i>10× tip, mils</i>
<i>A-to-B</i> substrate top (do NOT measure)	11.25 hashmark spaces	11.25	5.6	2.25	1.1
<i>B-to-C</i> Blue primer	3.75 hashmark spaces	3.75	1.9	0.75	0.4
<i>C-to-D</i> Tan top-coat	5 hashmark spaces	5	2.5	1	0.5

Below the line on the Dual-Measure or the old-style scope (metric units: 20 µm per hash)					
<i>Coating</i>	<i>20 µm /hashmark space</i>	<i>1× tip, µm</i>	<i>2× tip, µm</i>	<i>5× tip, µm</i>	<i>10× tip, µm</i>
<i>A-to-B</i> substrate top (do NOT measure)	15 hashmark spaces	300	150	60	30
<i>B-to-C</i> Blue primer	4 hashmark spaces	80	40	16	8
<i>C-to-D</i> Tan top-coat	7 hashmark spaces	140	70	28	14

Precision and calibration:

Note: Every microscope is validated before sale against a certified gauge blocks traceable to the National Institute of Standards & Technology (NIST). An OEM calibration certificate can be ordered (for cost) with your new gauge or your gauge can be sent in for calibration and certification. Call or email for details.

Considerations when measuring

Several cautions are called for when estimating.

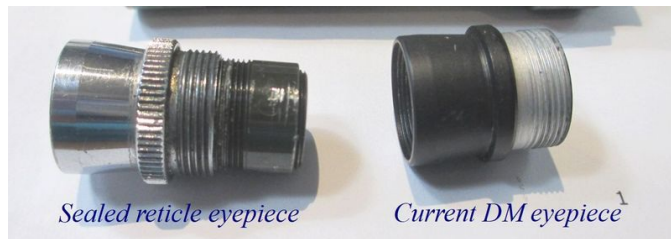
- Different operators may choose differently when picking “approximately half-way between” two hashmarks.
- Operators should measure several different spots in a coating and average the measurements to ensure the measurement was not taken in a thicker-than-normal or thinner-than-normal spot in the coating.
- Because the reticle scale lines themselves represent a perceptible width, when very thin films are measured, the operator should adopt a convention of measuring from and to the matching left or right edge of the actual lines on the reticle.

Four classes of reticle; two classes of microscope (sorry: time and change march on!)

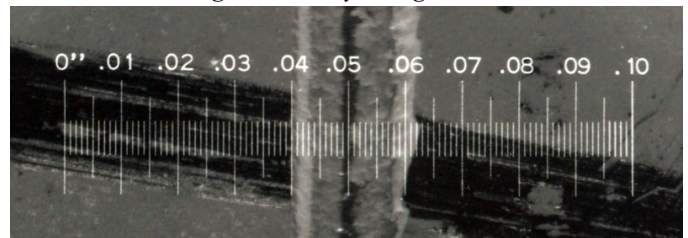
There are now four versions of Tooke Gage scopes out in the world. Two original, old-style, green-anodized barrel scope with: an English scale (mils) or a metric scale (μm) reticle inside. The oldest scales match the scales on the new Dual-Measure scope. (For the fourth version, see universal scope below.)

Old-style English and metric scopes

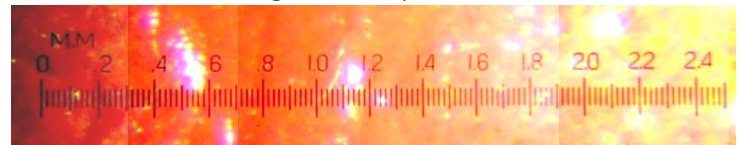
Between the original old-style English and metric unit scopes and the universal scopes, there was a span of a few years where the manufacturer changed the eyepiece design entirely to a sealed unit.



View through the old-style English-unit reticle.



View through the old-style metric reticle.



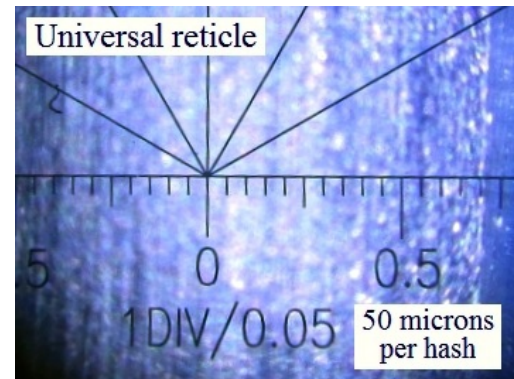
The discontinued “universal” scope

The discontinued “universal” scope measures less fine than either the old style (green-barrel) scope or the new Dual-Measure scope. The smallest scale division (hashmark space) measures 50 microns (nominal 2 mils; actual 1.98 mils). The older metric version and the bottom line on the Dual Measure scope measure 20 microns.

(Note: old-style scopes, and universal scopes can **sometimes** be upgraded to the Dual-Measure scope. Call for information.

Details: www.micro-metrics.com/DMandTRN.htm

This “sealed eyepiece” version cannot have a reticle swap at all because the reticle is inside the eyepiece, not the barrel. It almost always can have a Scope Swap.



New Dual-Measure reticle

