

## Measuring with the Tooke Gage

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

This information applies to measurements made using the current (metric-unit) “universal” scope; to the old-style English or metric scopes (with the green anodized barrel); and will apply to the new enhanced custom dual-measuring English / metric scopes when they become available. (Watch the [Micro-Metrics blog](#) for updates!)

The Tooke Gage 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*. (Essentially, you incise the hypotenuse of a triangle to calculate the opposite side = the coating thickness).

### Maximum coating thickness for the cutting tips

Cutting tip designation	Maximum coating thickness in:		Precision of thickness determinations in:	
	English	Metric	English	Metric
	mils	microns ( $\mu\text{m}$ )	mils	microns ( $\mu\text{m}$ )
1×	100	2 500	±0.25	± 5
2×	20	500	±0.13	± 2.5
5×	6	150	±0.05	± 1
10×	3	75	±0.025	± 0.5

(Reminder: The current universal scope is **marked in metric units, conversion is necessary for English units.**)

The observed horizontal projection of the film in the groove wall is related to the film thickness by the equation:  $A = A' \tan \theta$

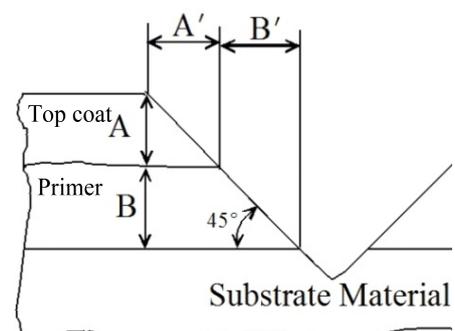
**Example:** The 1× tip cuts a 45° incision (which make an equilateral triangle), where A (the *coating thickness*) = A' (the *distance measured through the scope across the cut*); therefore, the ratio for the 1× tip is 1 : 1, as shown, right:

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 using a 1× (45°) cutting tip*



**Universal scope, multiplier per smallest hashmark space by cutting tip face**

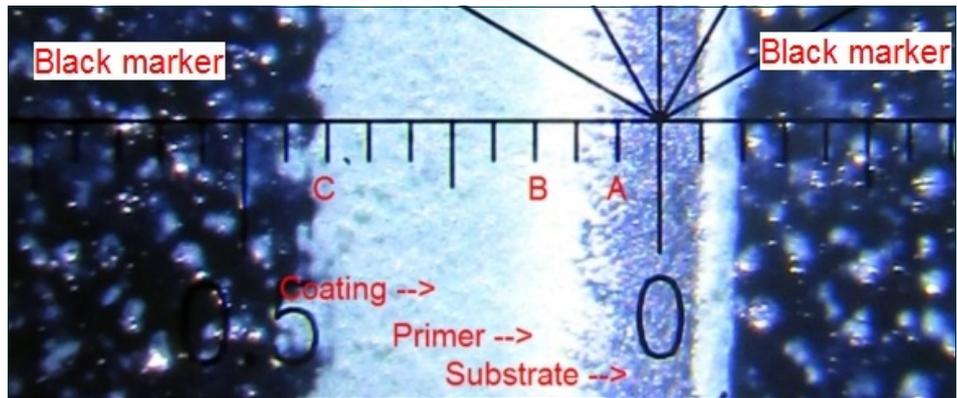
	1×		2×		5×		10×		
Mils*	2	(1.97)	1	(0.984)	0.4	(0.394)	0.2	(0.197)	Mils
Microns**	50	(50.0)	25	(25.0)	10	(10.0)	5	(5.0)	Microns
Millimeters	0.05	(0.050)	0.025	(0.025)	0.010	(0.010)	0.005	(0.005)	Millimeters

\*1 mil = 1 "thou" = 0.001" = one thousandth of an inch      \*\*micron = micrometer = μm

**(Measurement is a function of the cutting tip and NOT of the microscope.)**

**A measuring demonstration**

The "zero-line" of the reticle is shown **not** lined up with the edge of a coating (nor does it need to be, as any hashmark will do). The zero-line is approximately centered in the substrate (silver-gray color). A cutting tip was used to draw the incision through the black marked line.



- Line A is on the edge between the substrate and the primer-coat (the white line to the left of the zero-line): begin your measurement there.
- Line B marks the top of the primer coating/beginning of the (light blue) top coat.
- Line C is the end of the incision at the top coat, made easier to see by using the black marker provided with the Tooke Gage.

So, in the photo above, and using each type of microscope, the thickness measured for each tip will be (see page 3 to understand the multiplication factor used to determine these measurements):

*Through the universal (metric-marked) scope: the thickness calculated for each tip is:*

Coating	0.05mm (50 μm) /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	100 μm	50 μm	20μm	10 μm
Blue topcoat	5 hashmark spaces	250 μm	125 μm	50 μm	25 μm

*Through the enhanced or old-style (English-marked) scope: the thickness calculated for each tip equals:*

Coating	1mil /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	2 mils	1 mil	0.4 mils	0.2 mil
Blue topcoat	5 hashmark spaces	5 mils	2.5 mils	1.0 mil	0.5 mil

*Through the enhanced or old-style (metric-marked) scope: the thickness calculated for each tip equals:*

Coating	0.02mm (20 μm) /hashmark space	1× tip	2× tip	5× tip	10× tip
White primer	2 hashmark spaces	40 μm	20 μm	4 μm	2 μm
Blue topcoat	5 hashmark spaces	100 μm	50 μm	20 μm	10 μm

**Example**

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

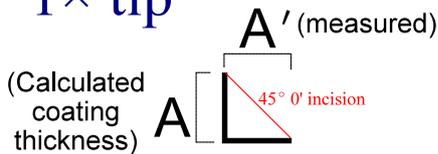
The 10× tip with its cutting face of 5° 42' has a ratio of 1 : 0.1 (measured cut A' : calculated coating thickness A) so, A = 1/10th of A'

Reminder: measurement is a **function of the cutting tip** and not of the microscope reticle.

**Cutting tip ratio - A : A'**

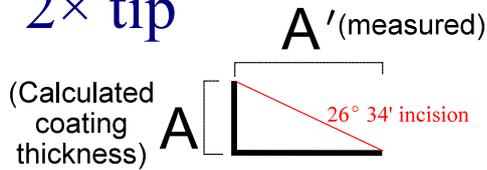
Tip	Face angle	Ratio
1×	45° 0'	A : A' = 1 : 1
2×	26° 34'	A : A' = 1 : 0.5
5×	11° 18'	A : A' = 1 : 0.2
10×	5° 42'	A : A' = 1 : 0.1

**1× tip**



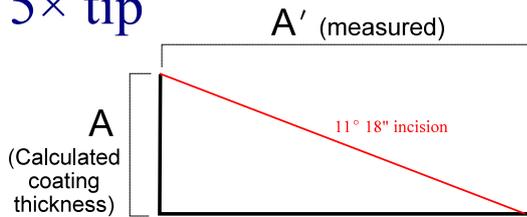
$A = A'$

**2× tip**



$A = (0.5)A'$

**5× tip**

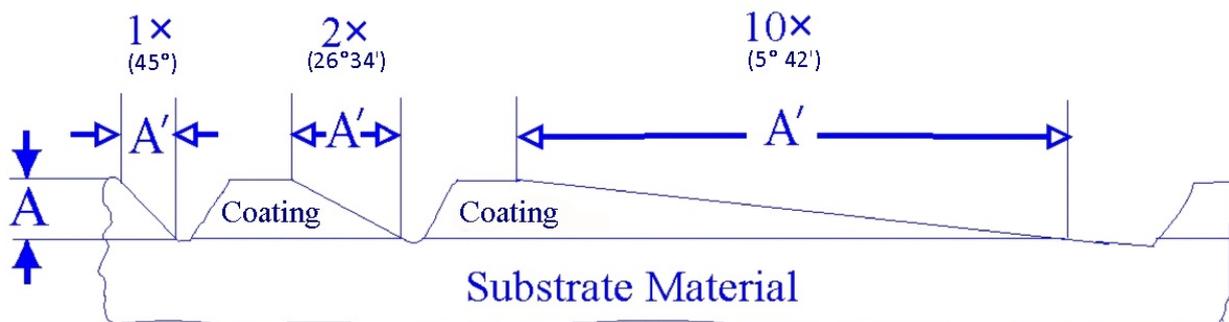


$A = (0.2)A'$

**10× tip**



$A = (0.1) A'$



## Validation and calibration:

Note: Every microscope is validated before sale against a certified gage block traceable to the U.S. National Institute of Standards & Technology (NIST). An OEM calibration certificate can be ordered with a new gauge, or your gauge can be sent in for calibration. Please call or email Micro-Metrics for pricing.

## Considerations when measuring

Several cautions are called for in this type of estimation.

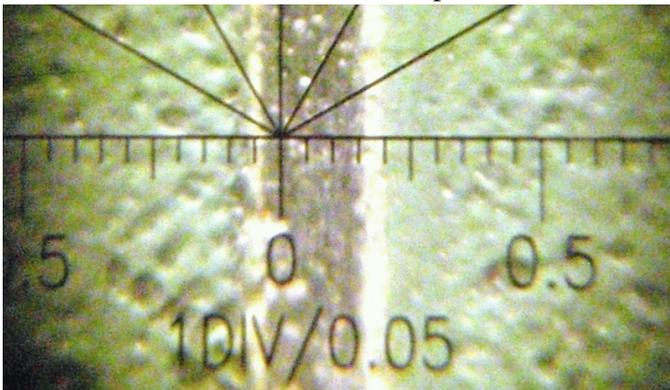
- Different operators may chose a different visual “approximation of half-way between” two hashmarks.
- Operators should measure several different spots in a coating and average the measurements to ensure the measurement was not taken in a thicker-than-normal or thinner-than-normal spot in the coating.
- Because the reticle scale markings 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.

## About the new enhanced scopes:

Please note that Micro-Metrics is working on a new (custom-made) enhanced microscope with a finer reticle than the “universal” one. It will also be dual-measuring: English and metric. (Photo through the prototype scope, below right.) See here for updates: <http://micro-metrics.com/blog>. There will be a swap program offered once the new scopes are in production.

One important difference (and one of the major reasons for the custom scopes) is the ‘universal’ scope has 50 microns between hashmark lines; the new enhanced scopes will have 20 microns.

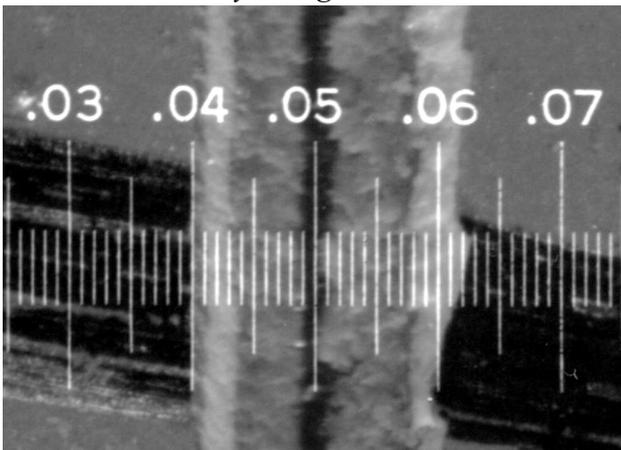
*Current “universal” scope reticle*



*New enhanced dual-measuring reticle (prototype version; not yet available)*



*Old-style English reticle*



*Old-style metric reticle*

