Indentation Protocol

Math:

The following math turns the data collected from the indentation machine into the Elastic Modulus in KPa (Kilopascals) using the following formula.

Where in:

*F*= Force (Newton)

*E*= Elastic modulous (Pa)

*V*= positions ratio (always assumed 0.5 for viscoelastic materials)

*R*= radius (mm converted to M)

*H*=Indentation Depth (mm Converted to M)

Note: if forgotten F24 in excel sheet

Where does nu go? Ask michelle

As we are looking for the elastic modulus and have all the other values we adjust the formulate to isolate *E.*

However, as our materials are viscoelastic, the Elastic Modulus is variable at max force (F0 and Finf) versus final compressed force according to log scale. (Slope of 2) These can be found at the very start and the very end of compression in the data. (D105 and D605 respectively). For basic elastic cmdulous calculation we use F0 but know that it can be variable related to the changing nature of viscoelastic materials

AND SO:

R= 5.5mm > **0.0055M**

H= 0.8mm> **.0008M**

F0= peak force applied> D106 in excel> **0.222N**

*E=*

*E*=99219.7Pa

As this result in is Pascals we then divide by 1000 to convert to Kilopascals and…

***E*= 99.219KPa**

This is a good back of the napkin estimate for Elastic modulus. However, it is not exact. It is not physically possible to truly measure the force at F0 due to the inability to apply force instantaneously There will ALWAYS be some amount of ramp time. Same issue with Finf  as compression cannot truly be measured forever. HOWEVER, from the gathered data by the indentor, a graph can be made of the points and expanded out following the slope to where the theoretical F0 and Finf really lie. This is done via code and tends to be a few percentage points off the calculations from the data directly.

Now that you’ve done this by hand, here is the excel formula. Be sure to adjust Indentor radius and depth accordingly. Enjoy.

F0 = Excell formula: *=(-3\*D106)/(4\*(0.0055^0.5)\*(0.0008^1.5))*

or

Finf = Excell formula: *=(-3\*D605)/(4\*(0.0055^0.5)\*(0.0008^1.5))*