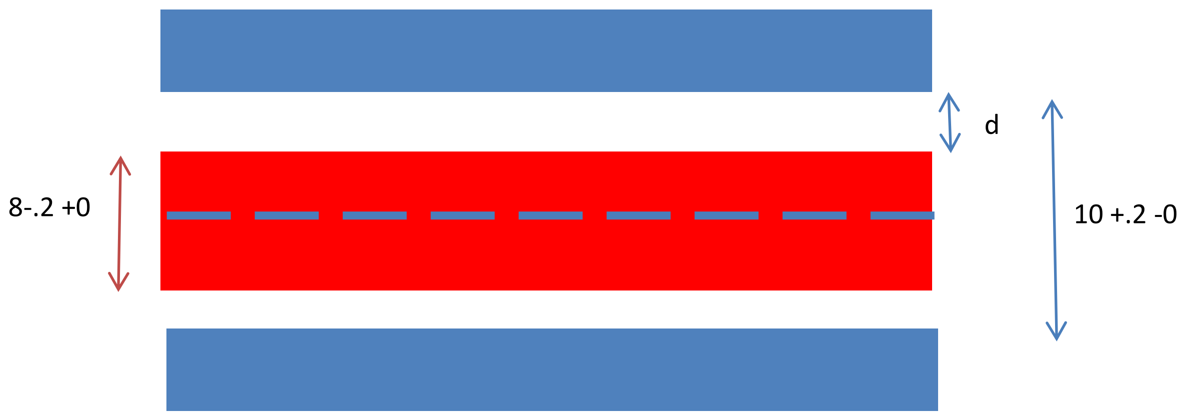
Radial stackups – concentric components

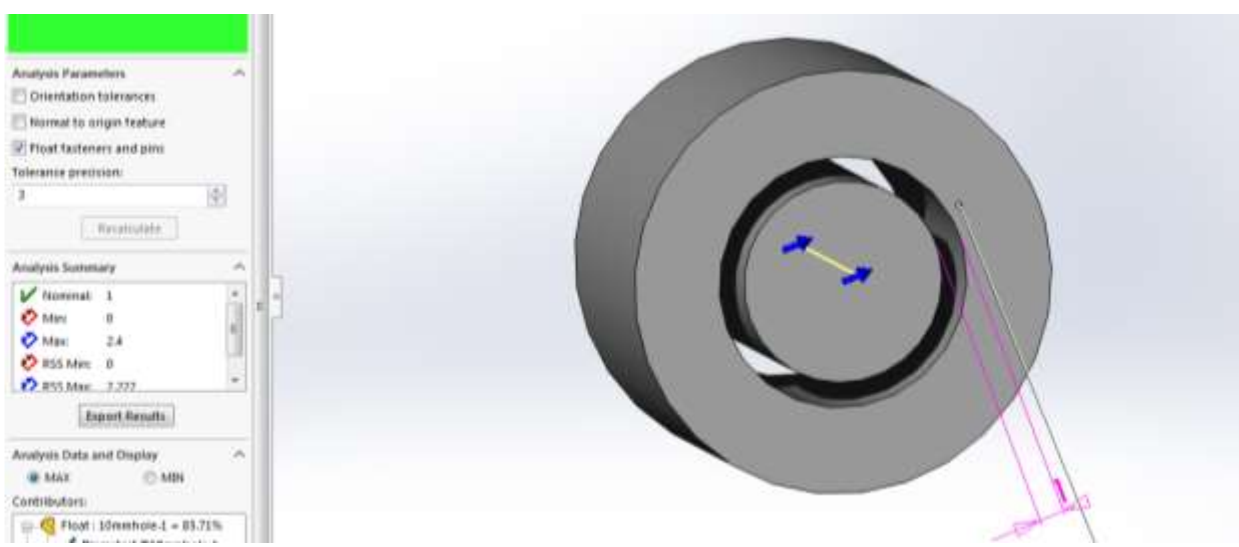
Example:

Two concentric components, an 8mm diameter shaft with +0, -.2 tolerance, fitting into a 10mm diameter hole with tolerance +.2, -0. I'm trying to find a way to accurately do a stackup that finds the minimum and maximum value of d.

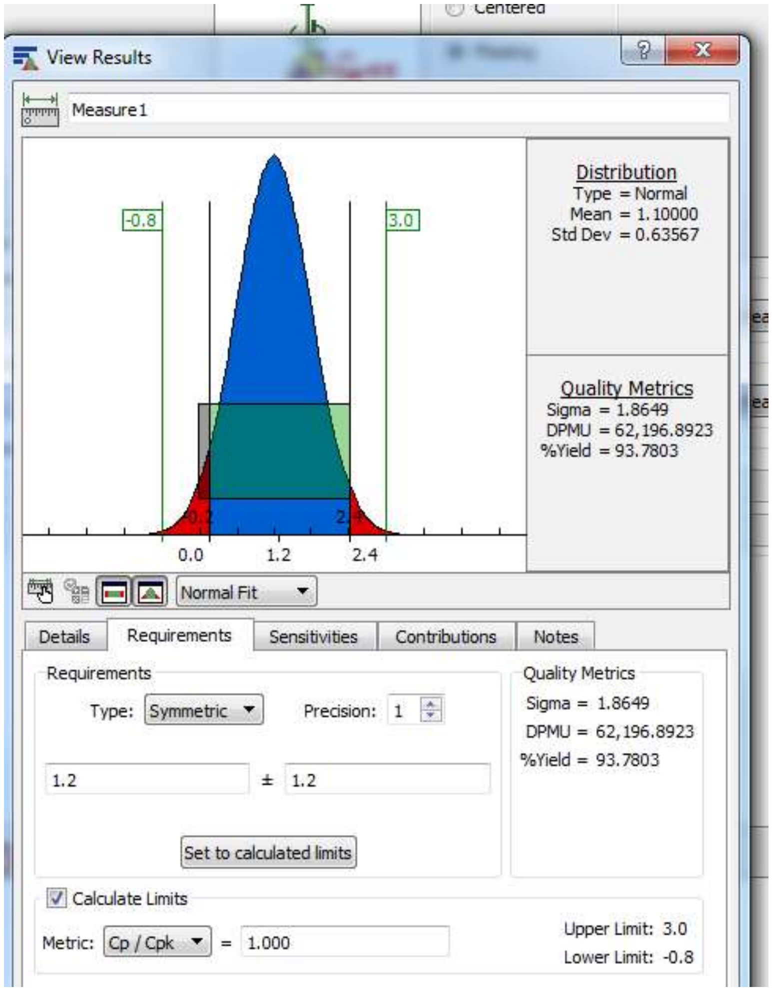


The correct result of this stackup should be that the distance can be anywhere from 0 to 2.4, depending on the diameter of each part and where the inner part is shifted with respect to the first part. The mean value for the gap should be 1.1, which is the gap if the two components are made to center tolerance and have the same center axis.

Solidworks tolanalyst calculates this correctly when using the "float fasteners and pins" option.



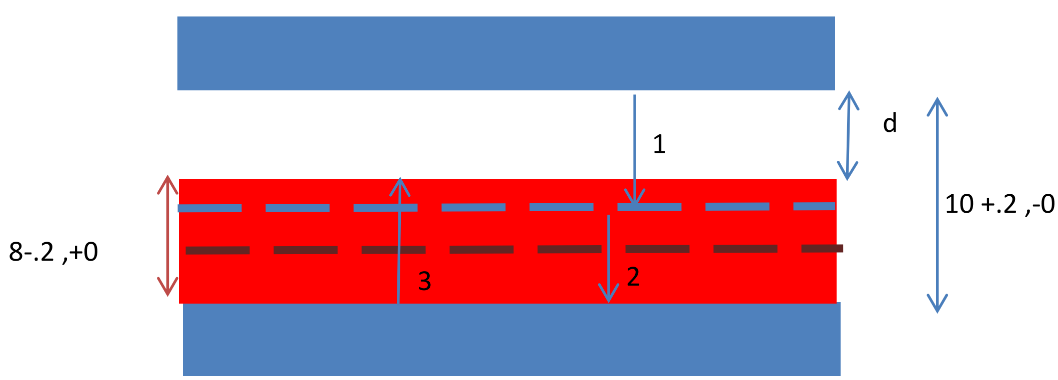
However, Sigmetrix CETOL calculates the worst case min and max gap to be -.2 to 2.4 respectively.



A gap of -.2 seems to indicate that interference is possible, depending on the diameters of each component. Of course, this is not possible as the 8mm shaft is always smaller than the 10mm mating diameter. I've doublechecked my CETOL setup numerous times and believe I am setting up the problem correctly. How can a commercial package like CETOL provide a wrong answer for the minimum gap. calculating possible interference is very important for the products I am working on.

Worst case stackup method

Shifting components to their extreme ends to give maximum (or minimum) value of gap and performing stackup gives accurate values of min and max clearance if the components are shifted to their extreme ends.

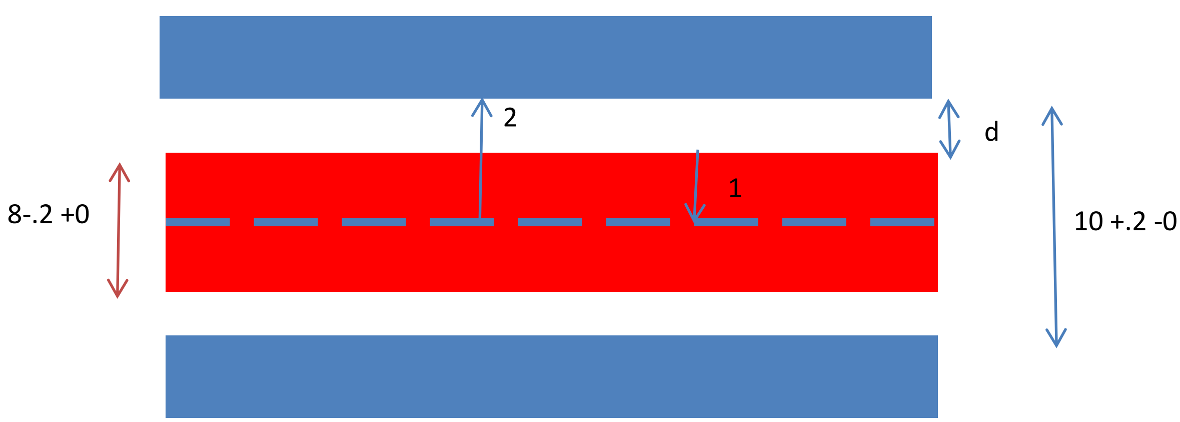


	DIM		TOL
1	+5.05000	+/-	.05000
2	+5.05000	+/-	.05000
3	-7.9		0.1
4			
5			
6			
	+2.20000		**+.20000**
	MIN	2.000	
	MAX	2.400	

However we know that the inner component can shift such that the minimum d is zero. I'd like to be able to make a stackup table for concentric components which accurately shows the min and max values of the gap, and using the worst case method (shifting all concentric components to their extreme ends and then doing a stackup loop analysis) provides an innacurate value of the min gap.

To accomplish this, I tried to do the stackup loop analysis assuming that the two components are coaxial.

RSS analysis (Assumes components are centered first)



Producing a table:

	DIM		TOL
1	-3.95000		.05000
2	+5.05000	+/-	.05000
3			
4			
5			
6			
	+1.10000		**+.10000**
	MIN	1.000	
	MAX	1.200	

Of course, this is not right because it does not account for the possible shifting of the inner component. In situations like these it makes sense to consult textbooks, I've been referring to Mechanical Tolerance Stackup and Analysis by Bryan R Fischer. There are not any examples in the book similar to the one I have, but I did notice that there is a section on assembly shift, which recommends adding a +- shifting tolerance onto the stackup table to account for assembly shift between components. The assembly shift is the amount that the center axes of each part can shift with respect to eachother.

+/- Assembly shift = (LMC hole – LMC shaft)/2

However these examples are all done within the context of bolted assemblies, and are not used to find the gap between two concentric components.

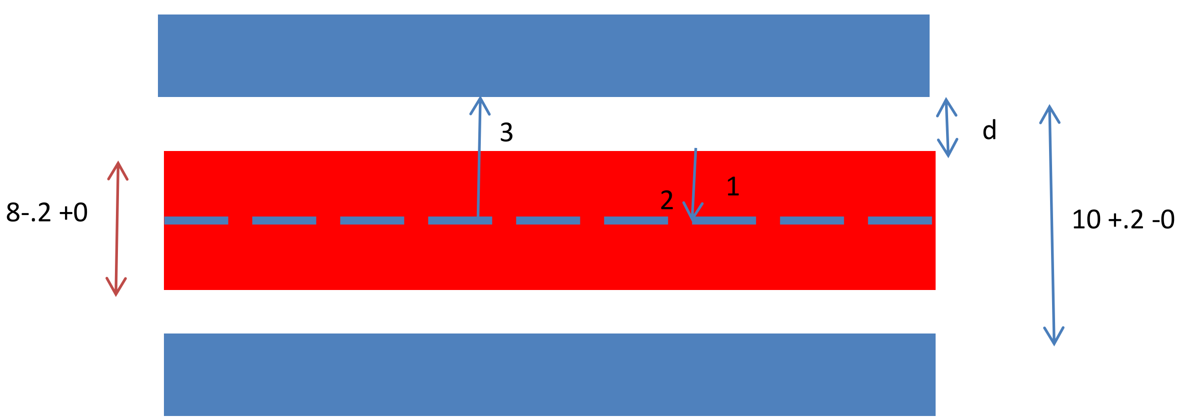
However the assembly shift formula can be used to find the distance that the two center axes can shift away from eachother.

For our example:

+/- Assembly shift = (LMC hole – LMC shaft)/2

=(10.2-7.8)/2 = +/- 1.2

So then I thought that the assembly shift must be added as a line onto the stackup table. However this results in an innacurate value for the minimum gap.



	DIM		TOL
1	-3.95000		.05000
2			1.2
3	+5.05000	+/-	.05000
	+1.10000		**+1.30000**
	MIN	-0.200	
	MAX	2.400	

This seems to be how CETOL is calculating the max and min gap. Of course that minimum gap is not possible.

So, what's the right way to do this? I would like to resolve this so that I can produce a stackup with multiple concentric components, each with their own gap and possible assembly shift, to confirm that when all of the components are assembled, there is no possible interference.