Injection Molding Tolerance Impact on Freeform Parking Lot Lens Performance

Ryan Kelley

OSA – Optical Fabrication and Testing
July 13 2017 3-3:15PM
FTh3B.4

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about me

Ryan Kelley

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the application – parking lot lighting

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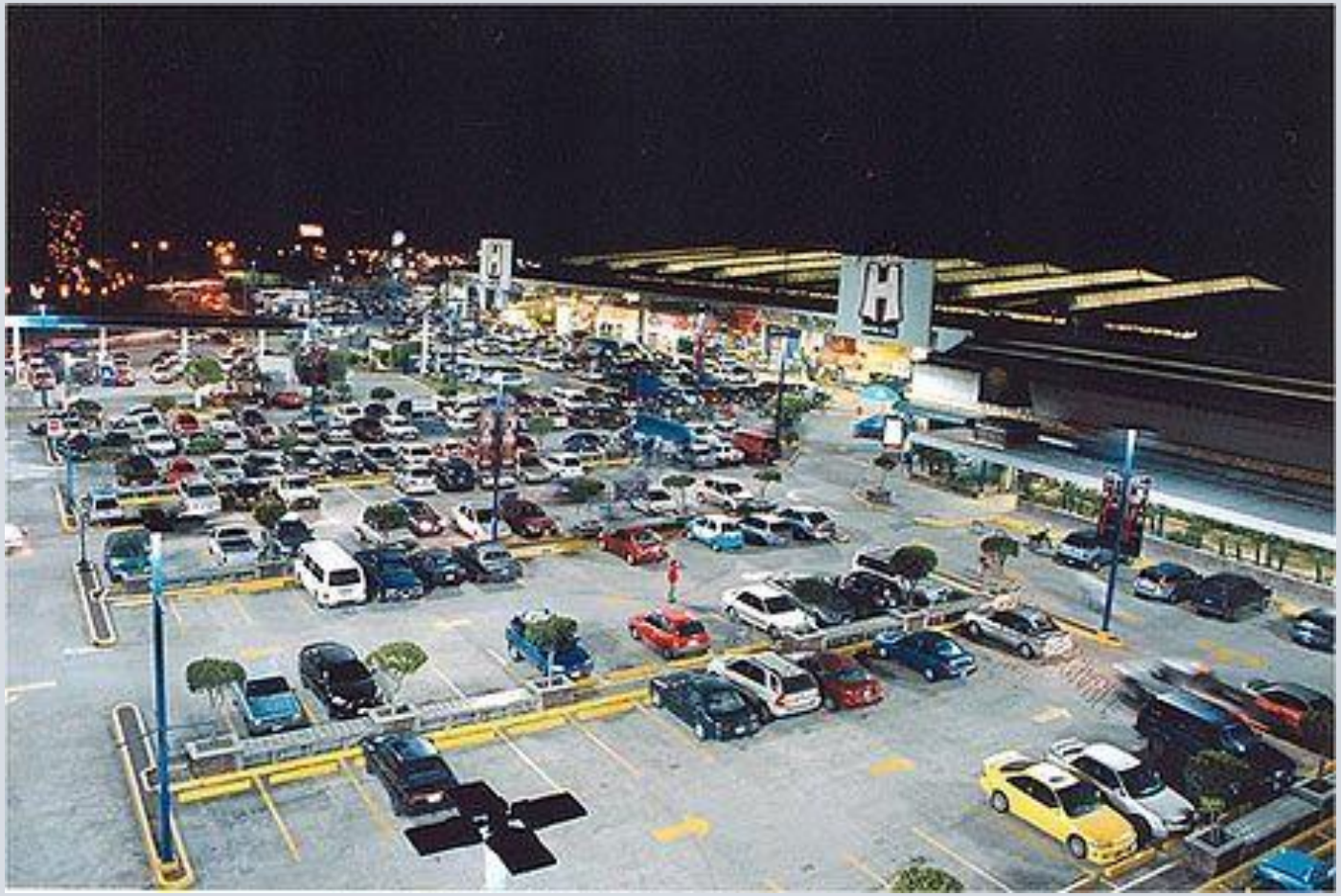
the application – parking lot lighting



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the application – parking lot lighting

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the product

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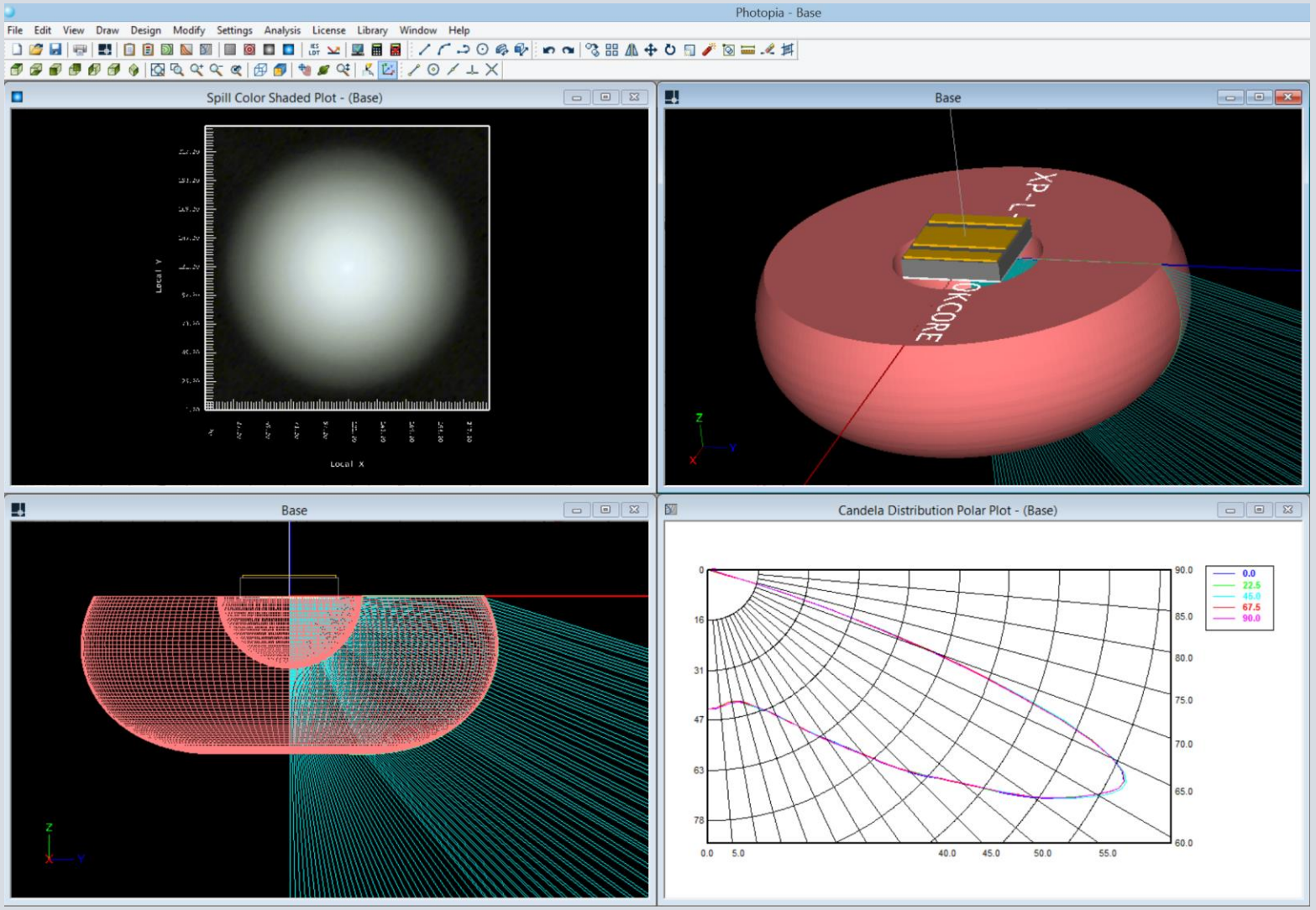
the design – freeform parking lot lens



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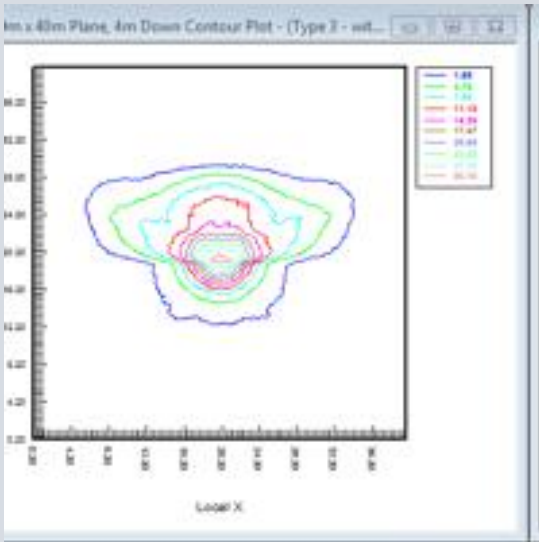
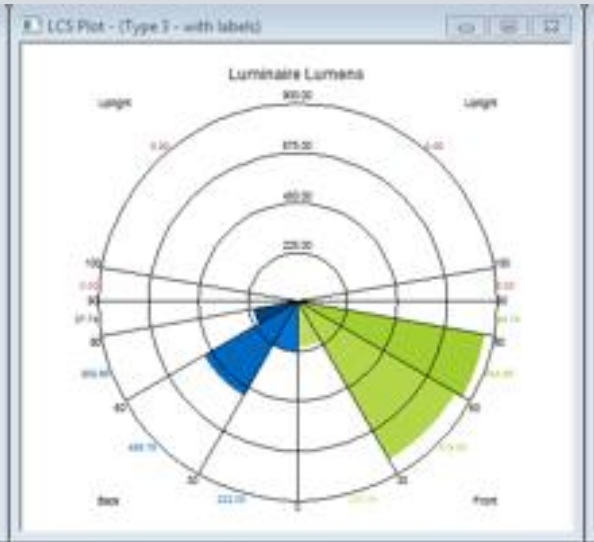
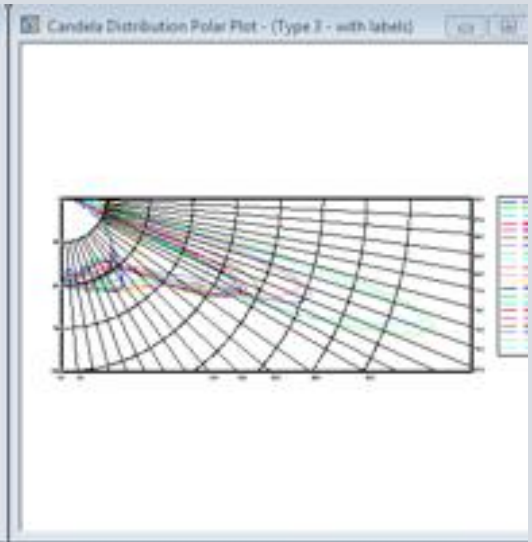
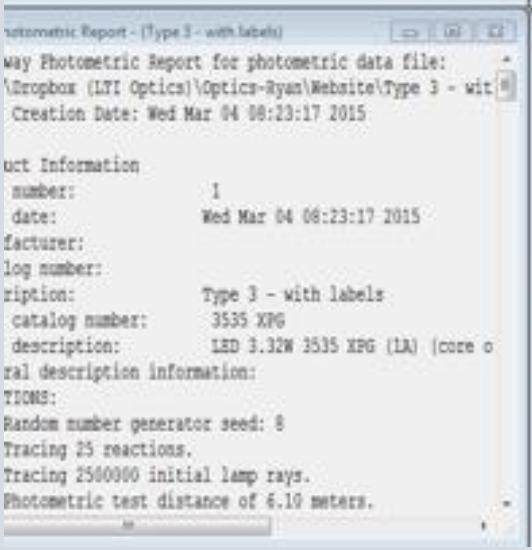
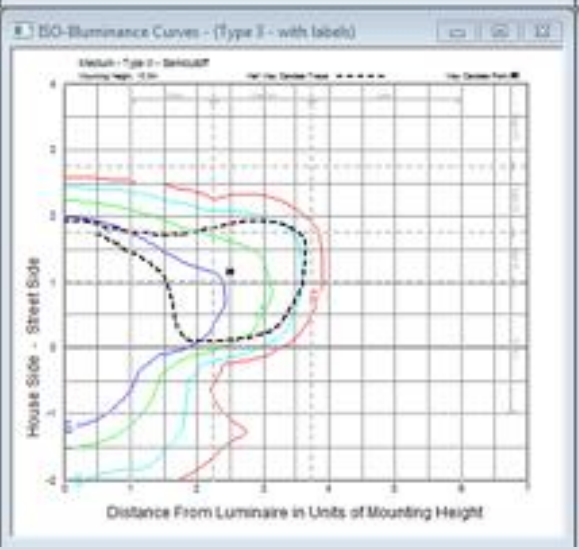
another design – freeform roadway lens

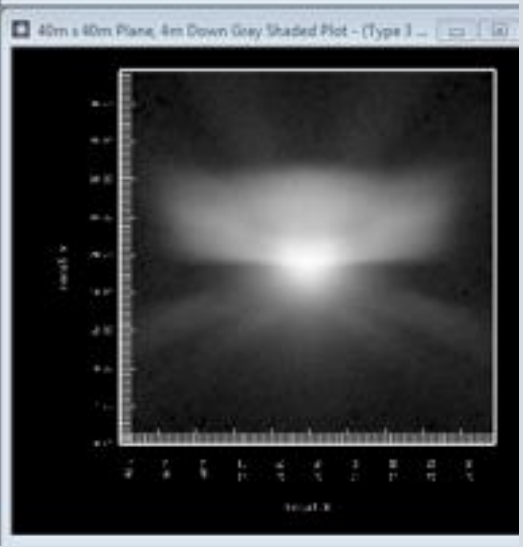












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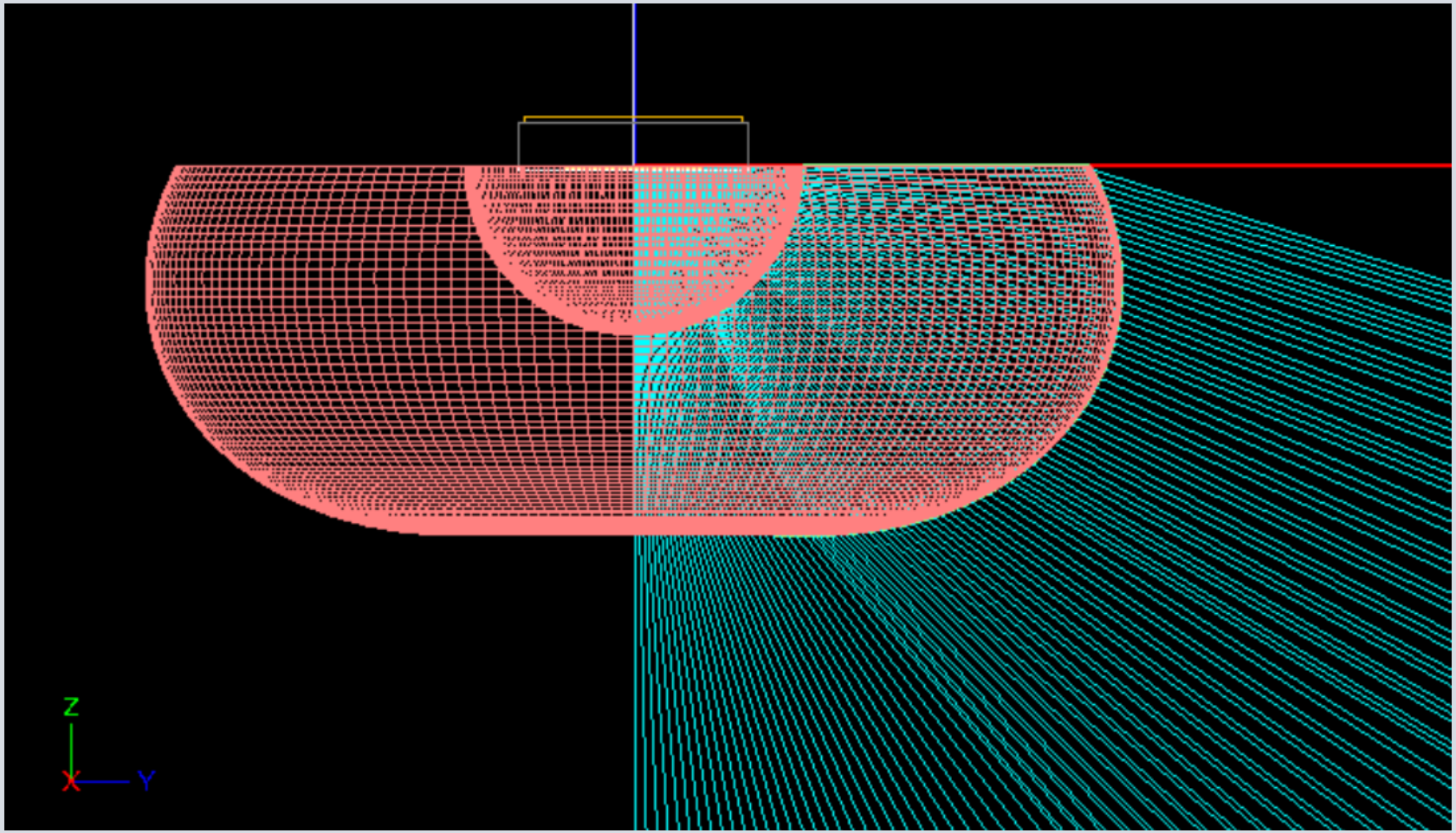
the lens profile



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driving factors for tolerance

- commodity product – low cost

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driving factors for tolerance

commodity product – low cost

injection molded – PMMA or PC

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driving factors for tolerance

commodity product – low cost

injection molded – PMMA or PC

standard tolerances +/- 0.006”
(.152 mm)
(152 microns)

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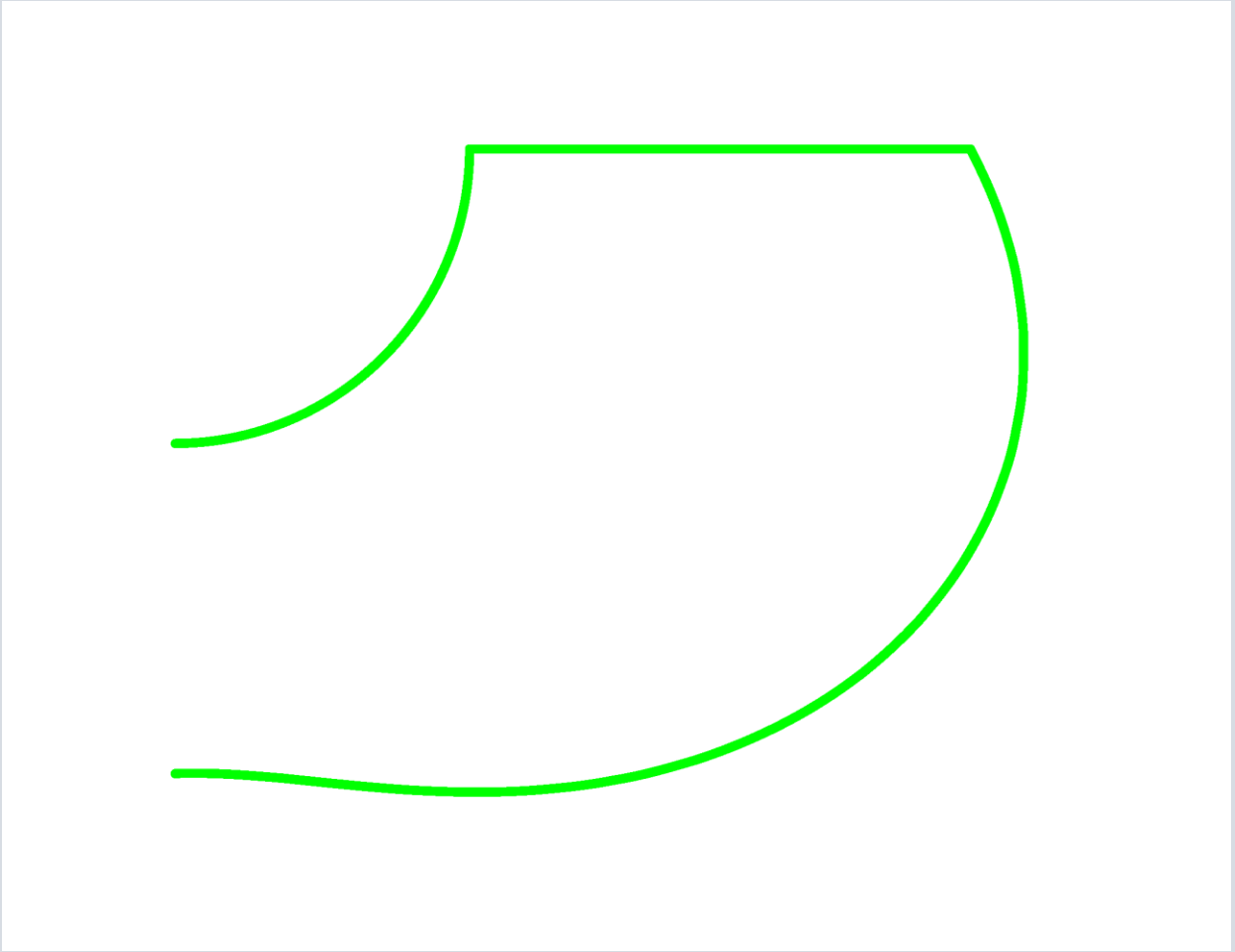
design profile



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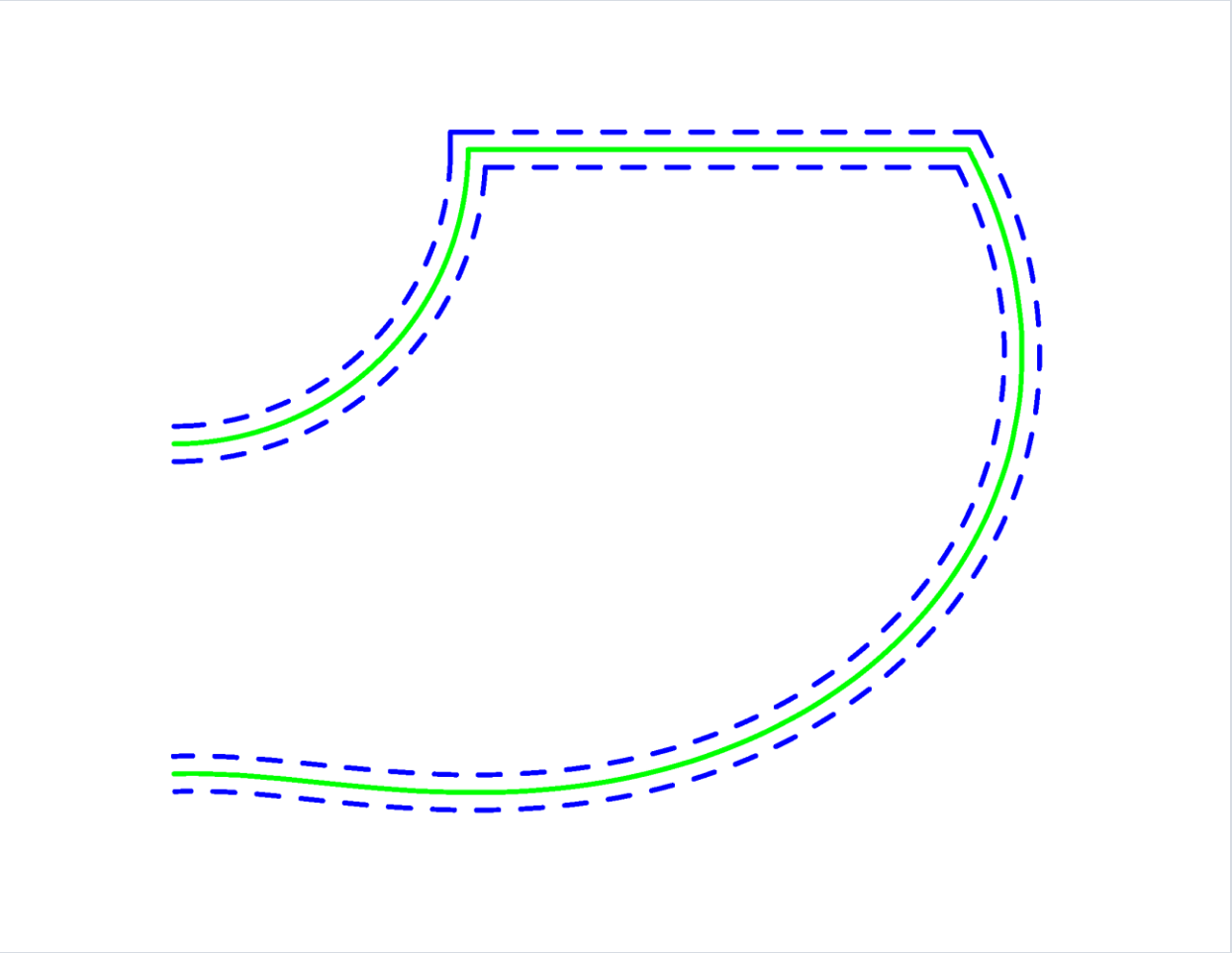
tolerance range



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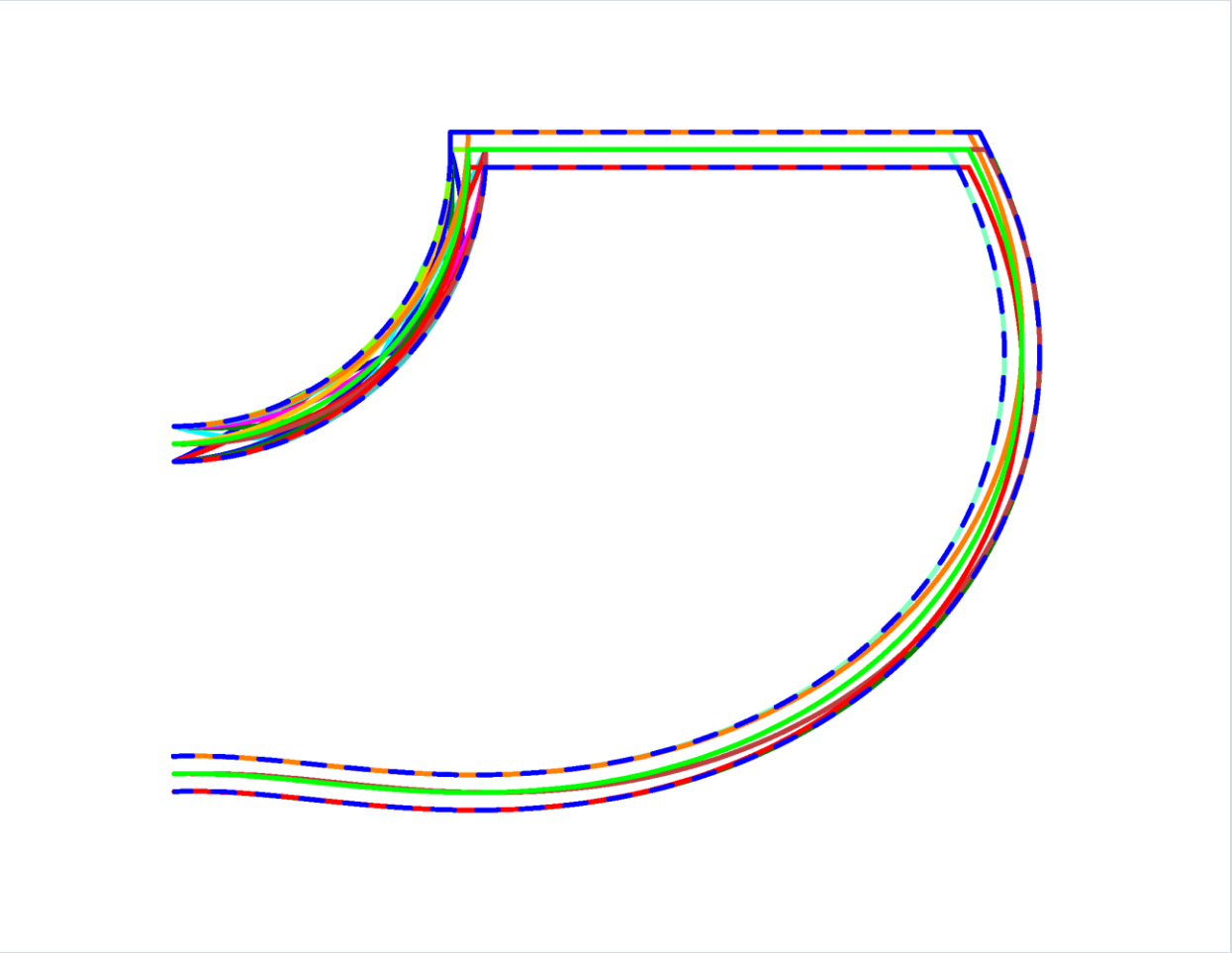
potential variations



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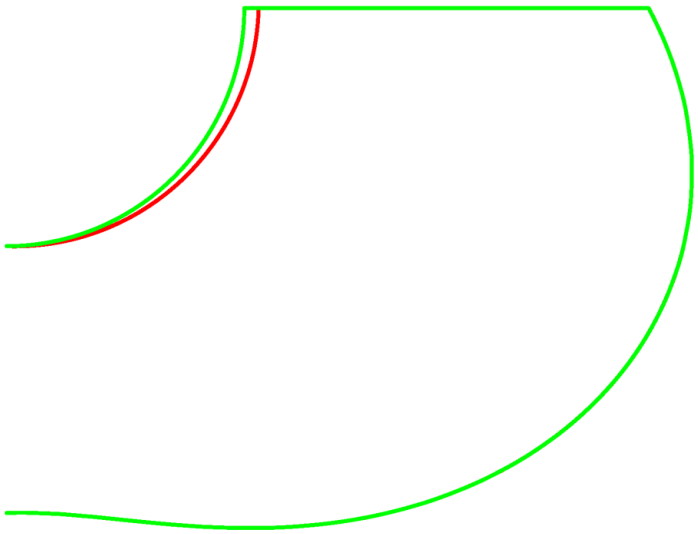
likely variations?



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what are the likely variations?
(part 1)
uniform shrink & position

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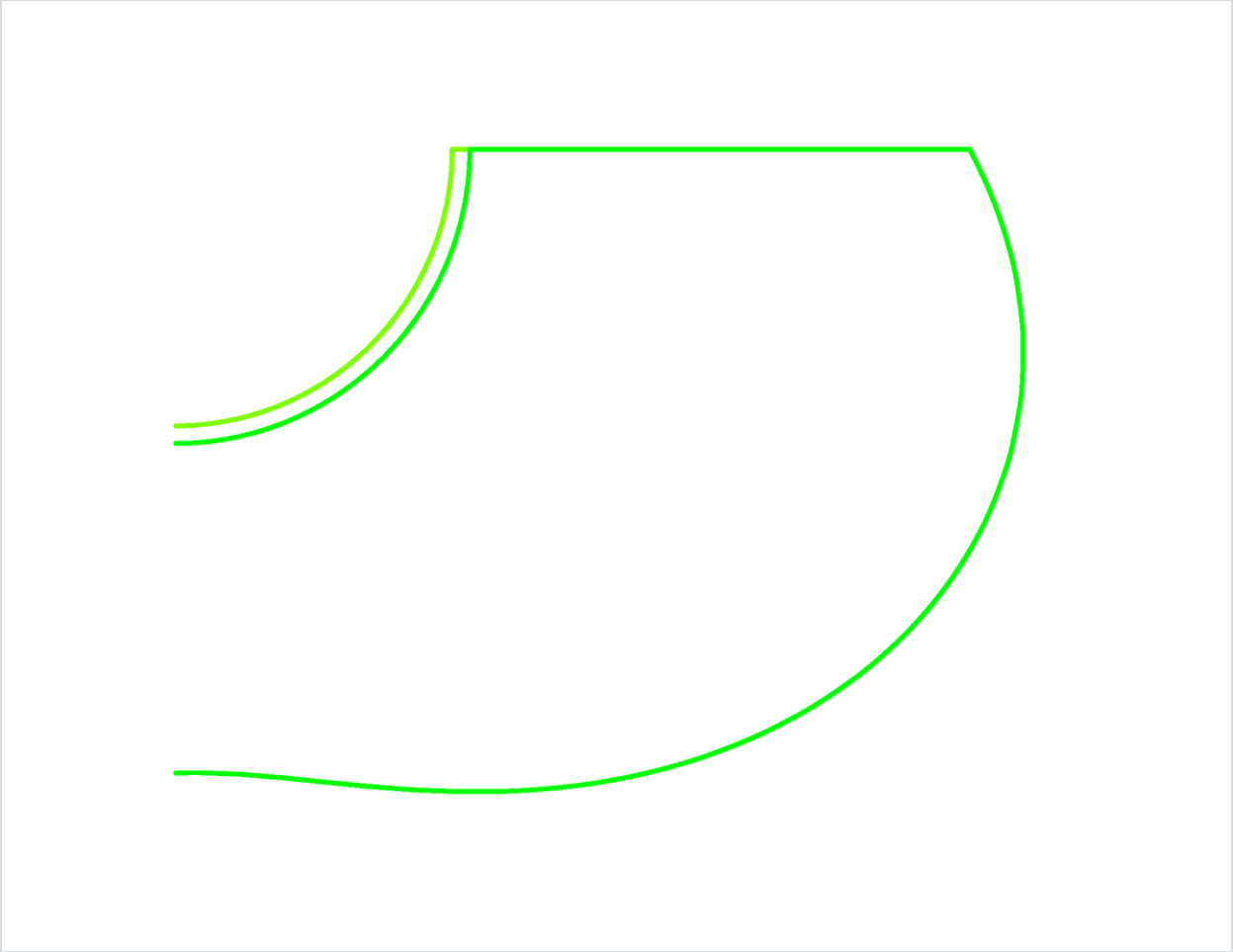
position tolerance



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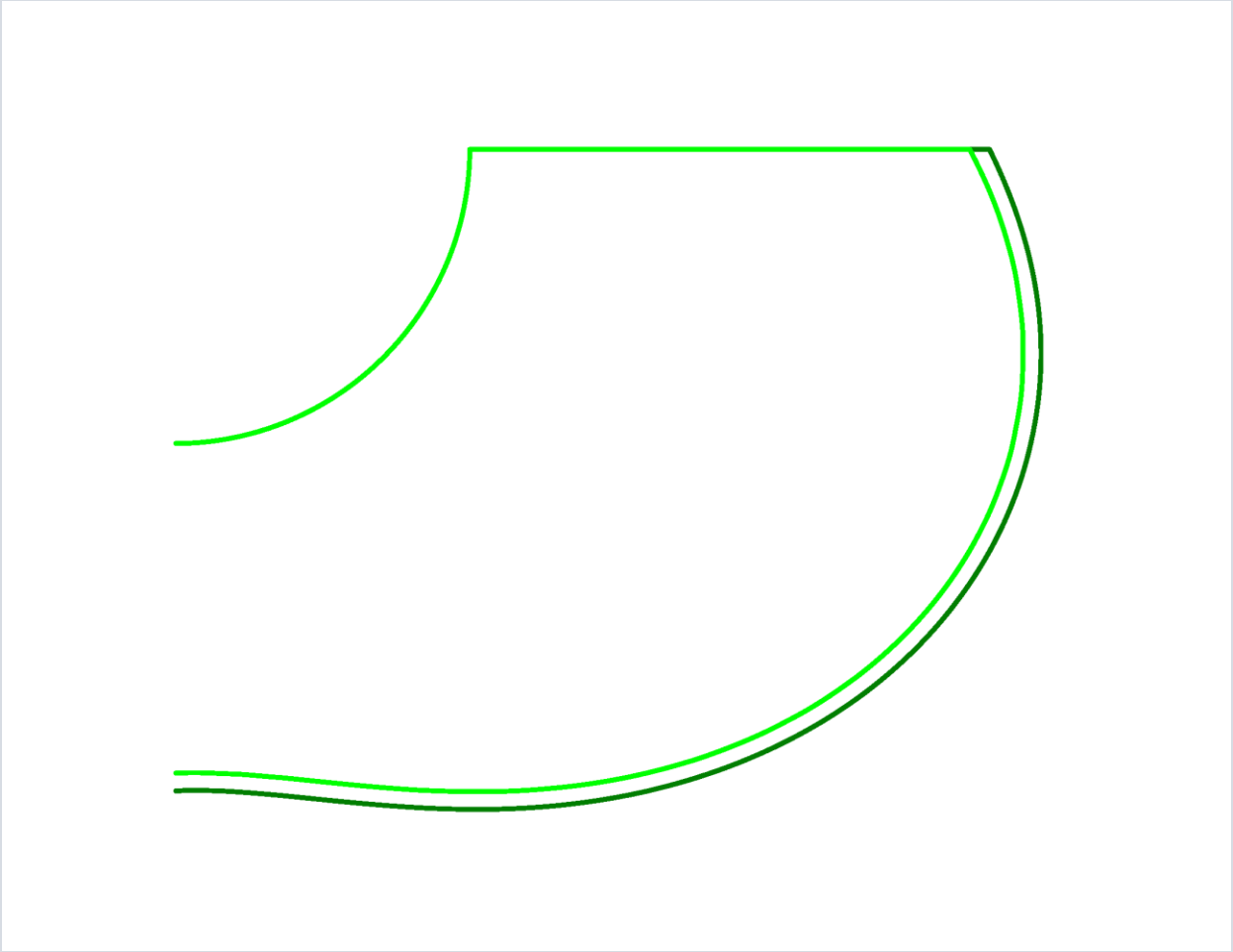
position tolerance



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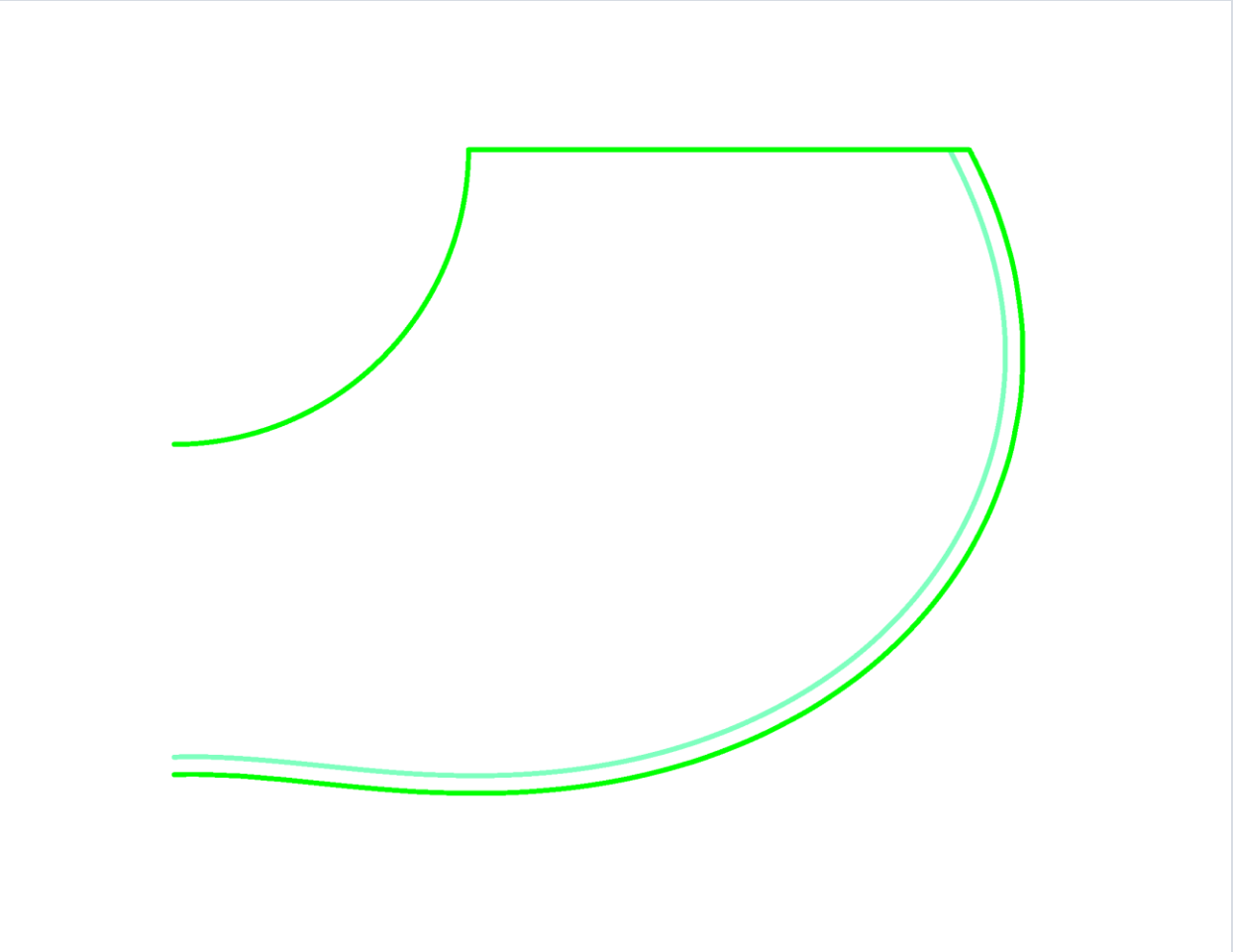
position tolerance



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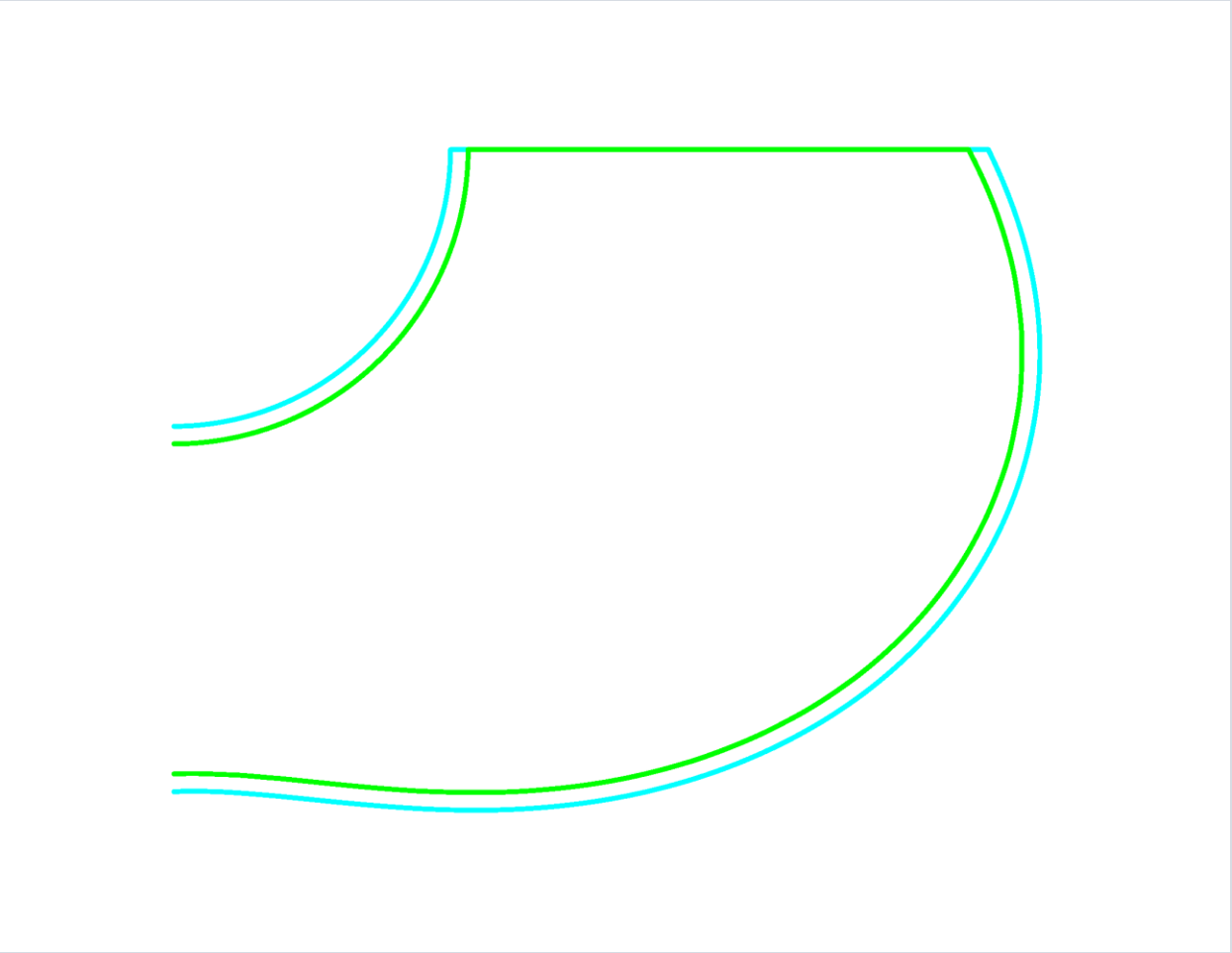
position tolerance



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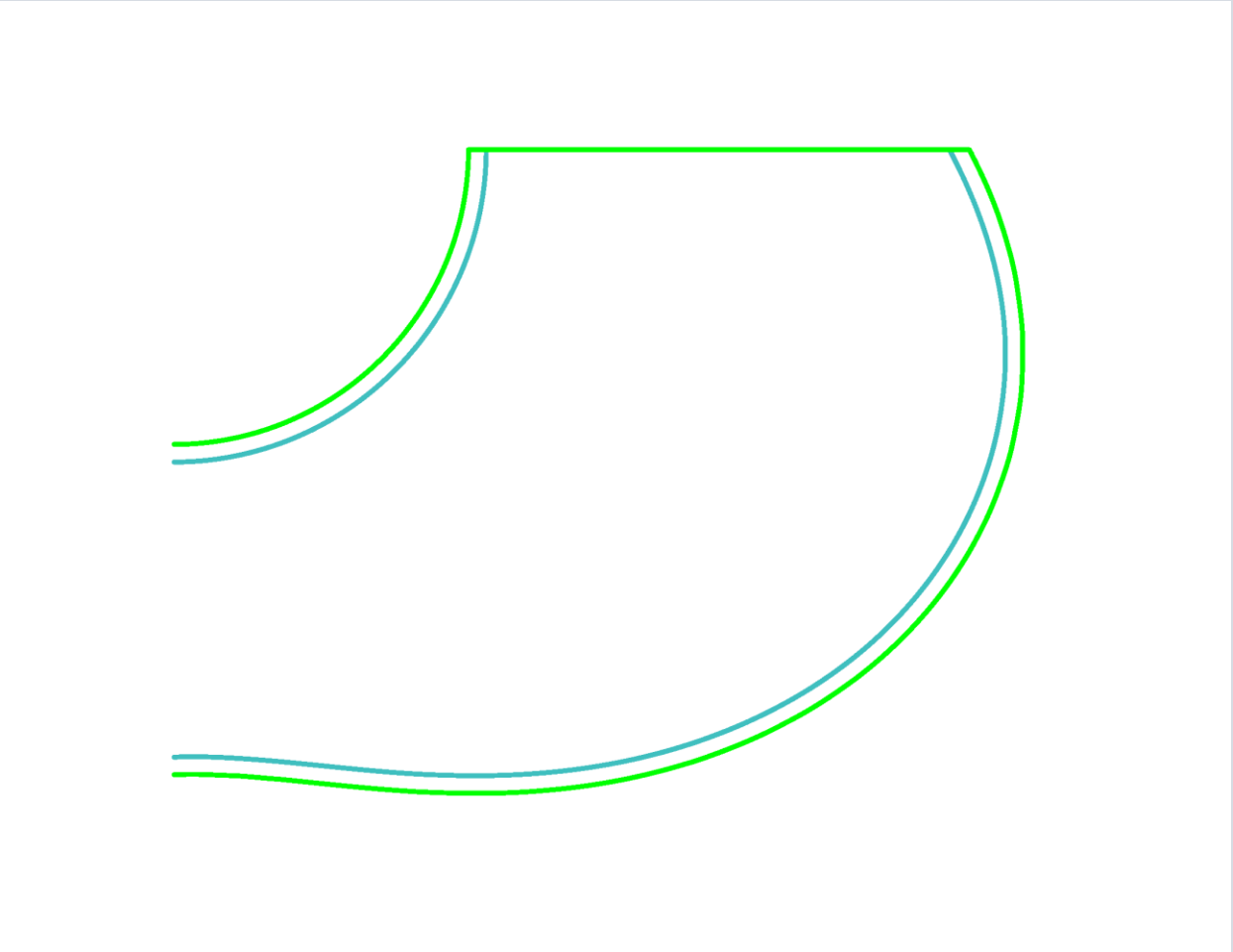
position tolerance



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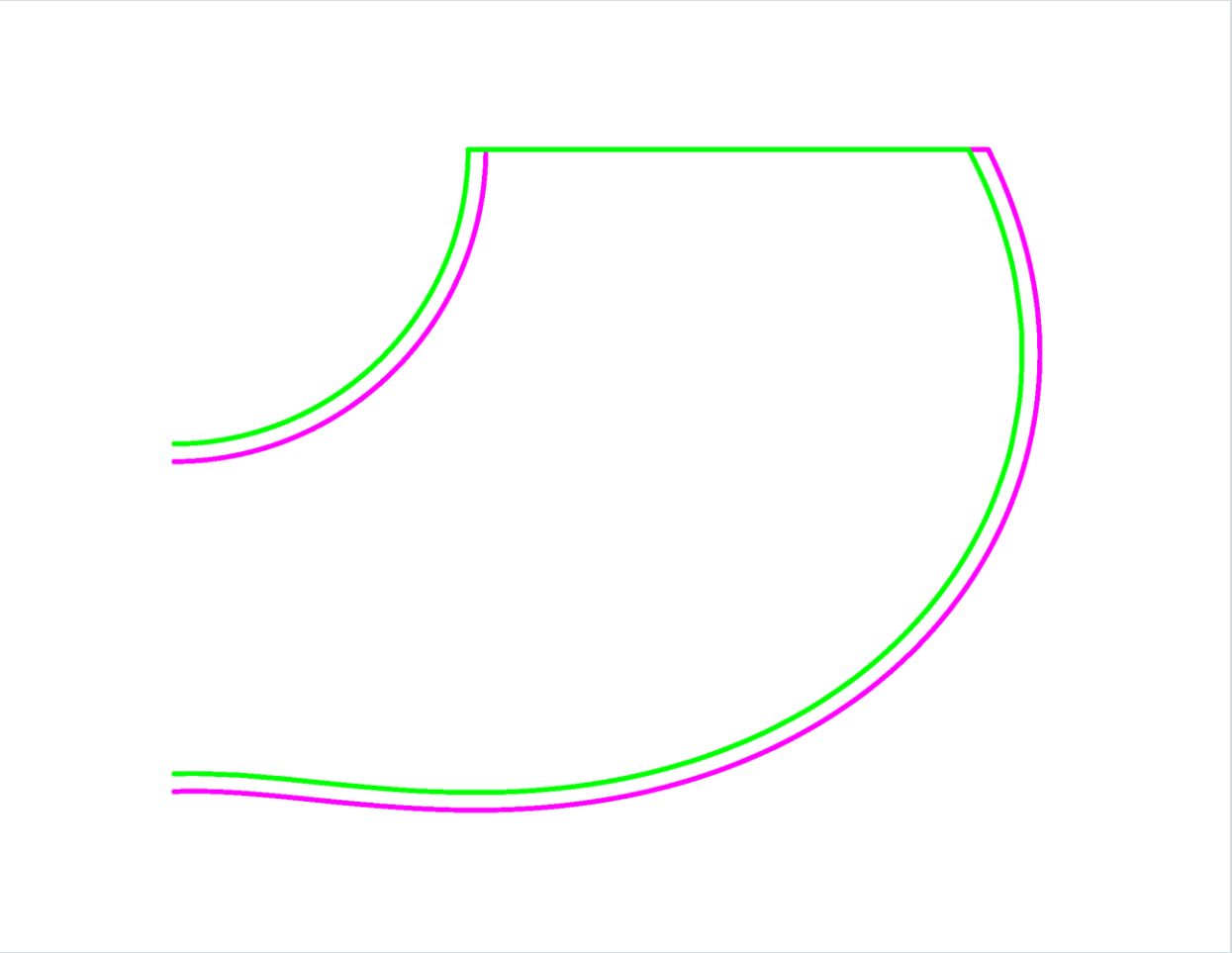
position tolerance



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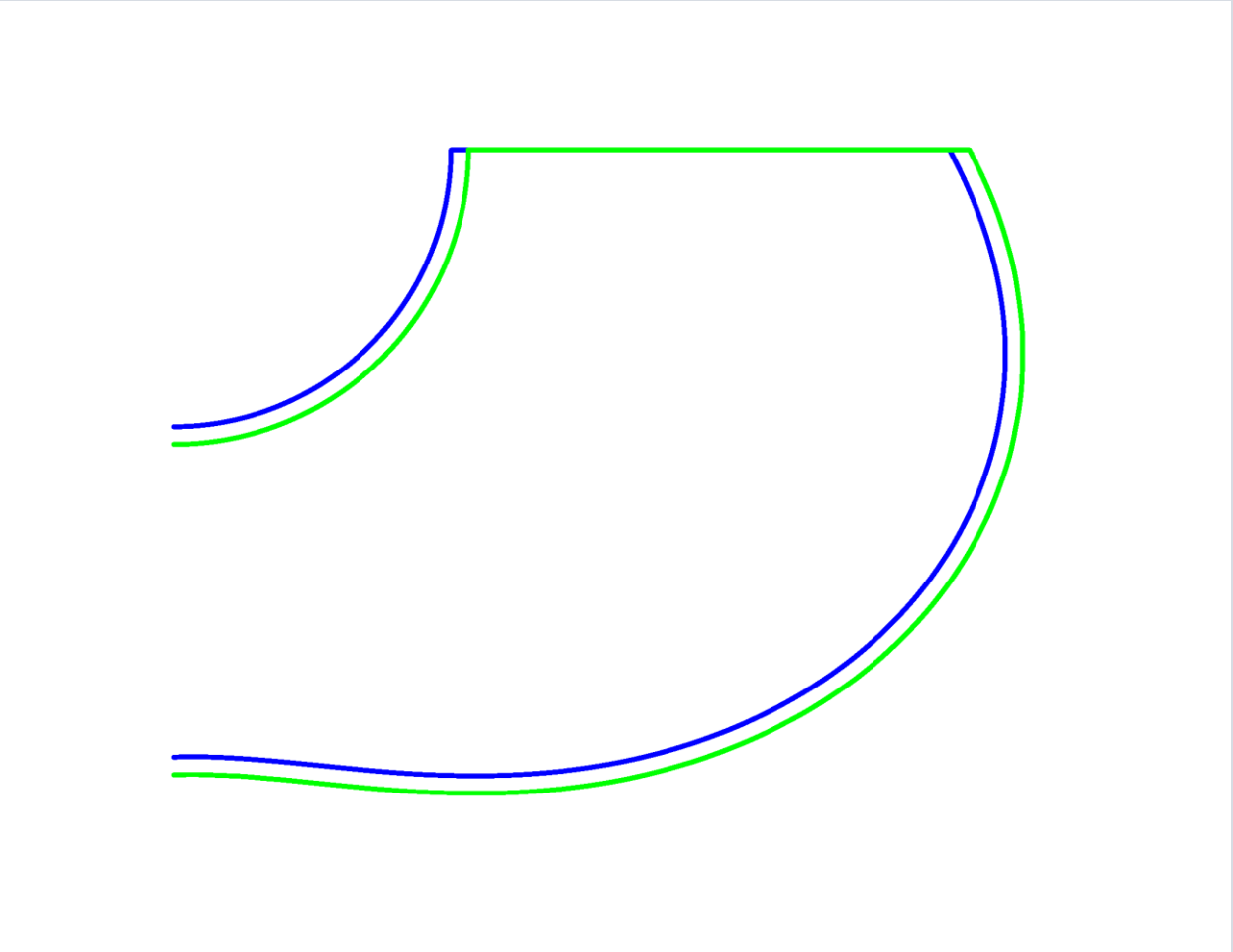
position tolerance



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what are the likely variations?
(part 2)
gradient shrink - sag

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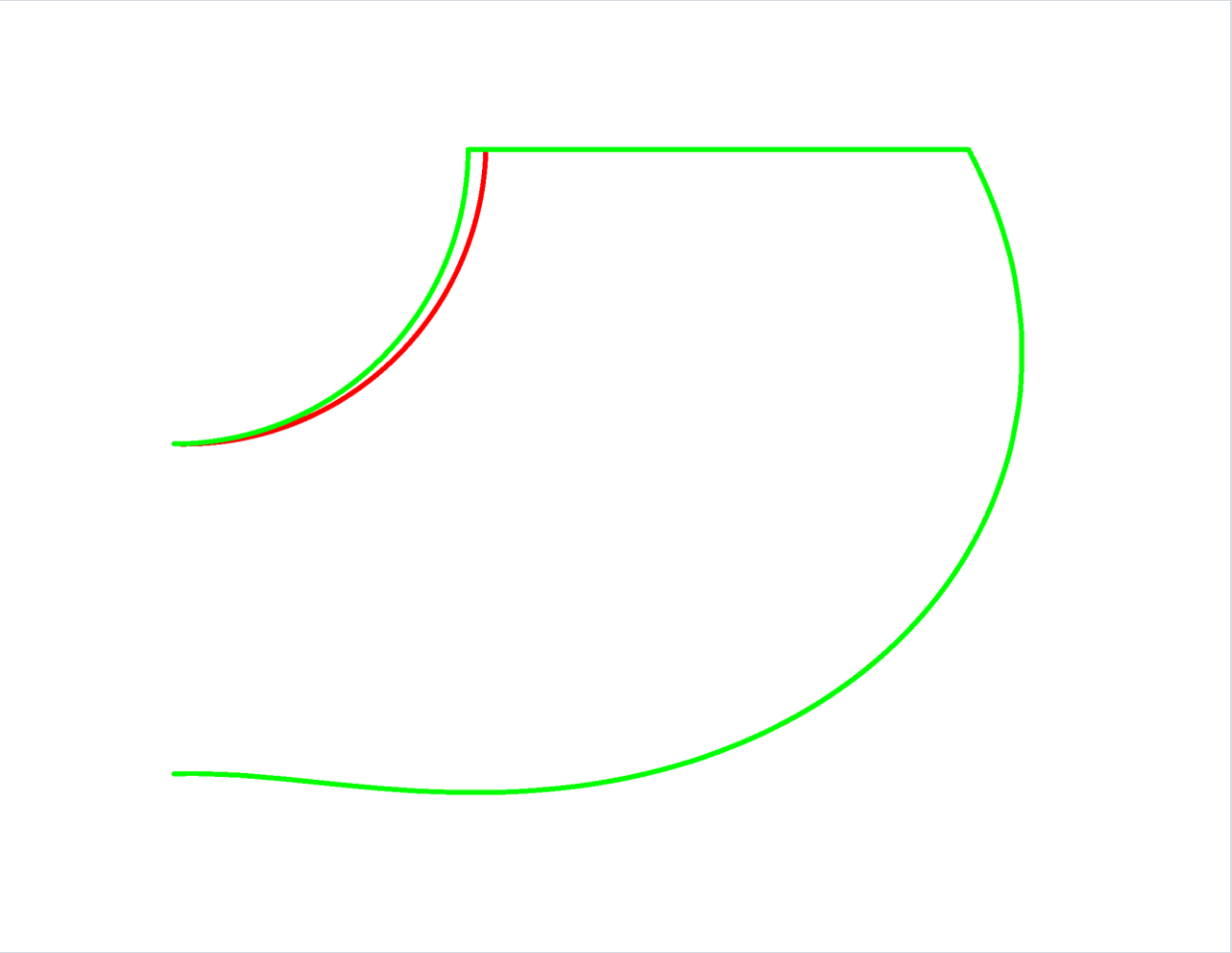
gradient shrink



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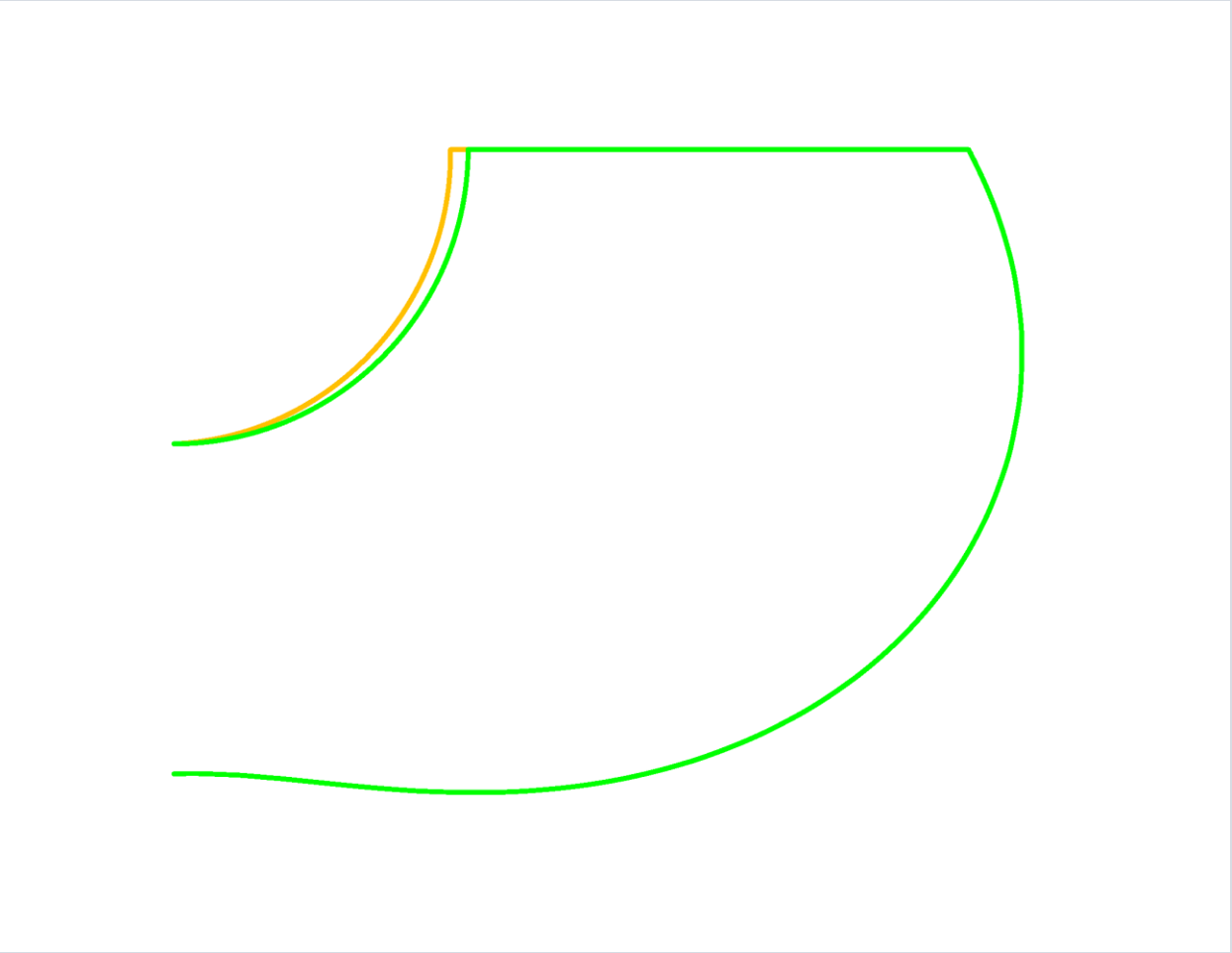
gradient shrink



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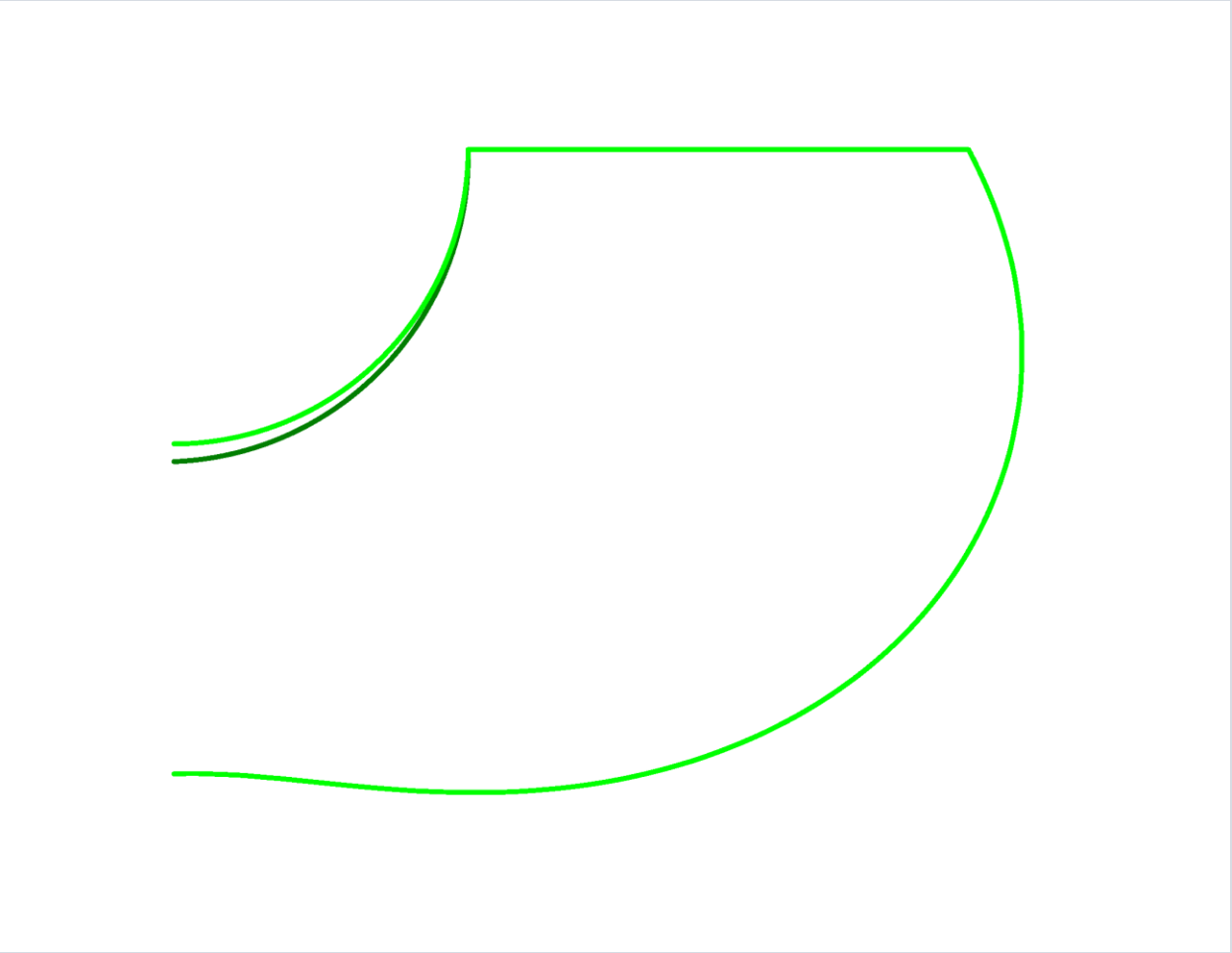
gradient shrink



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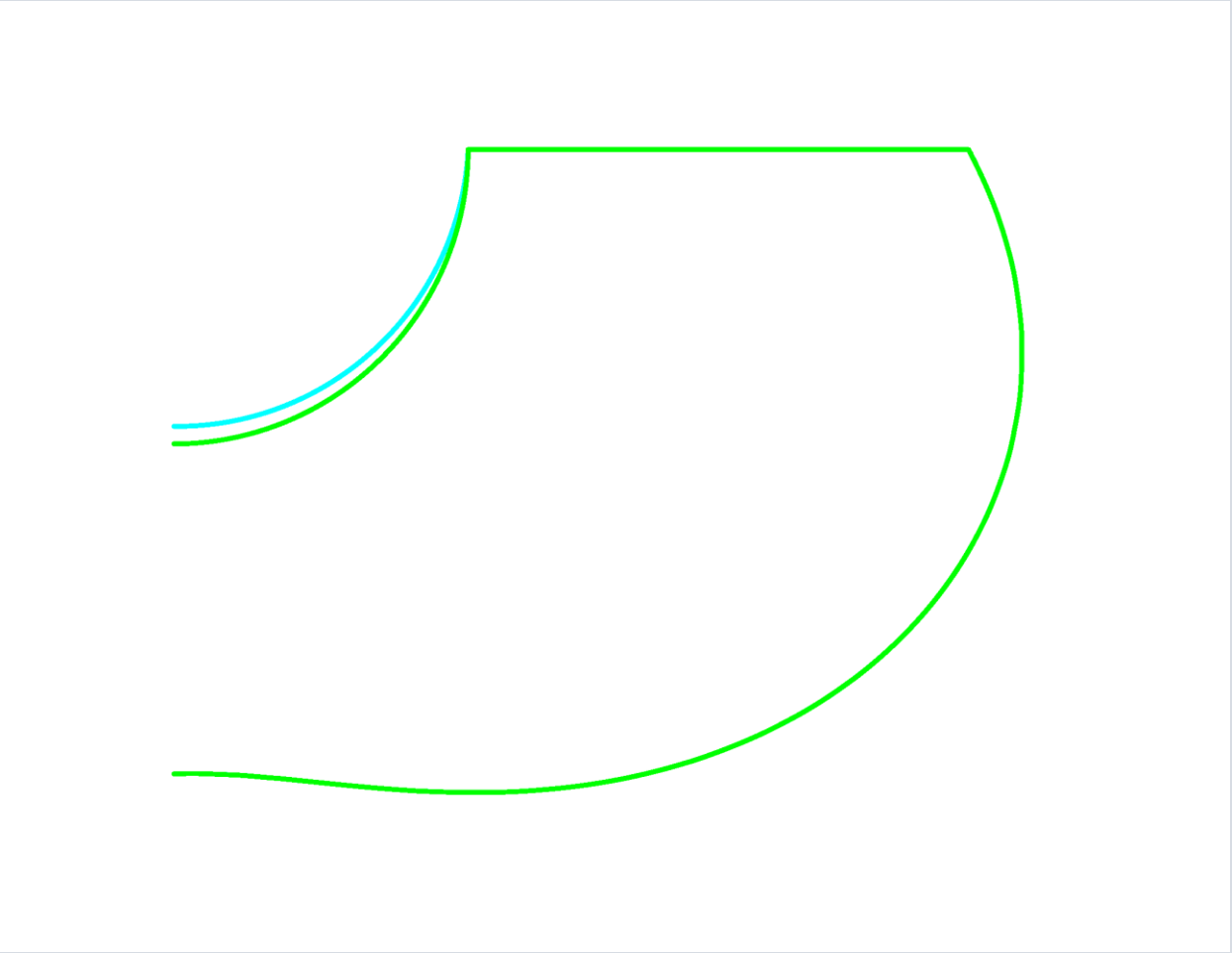
gradient shrink



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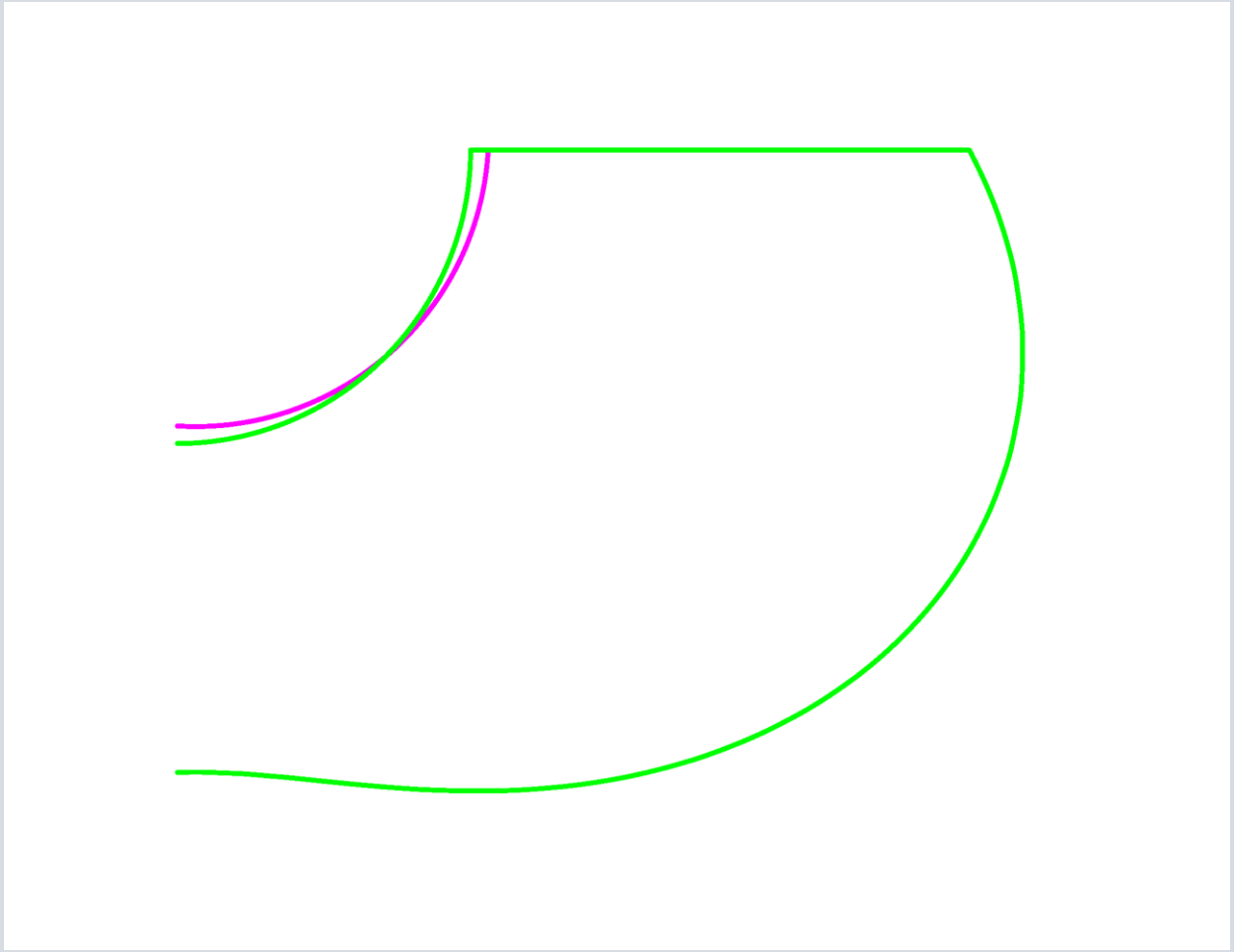
gradient shrink



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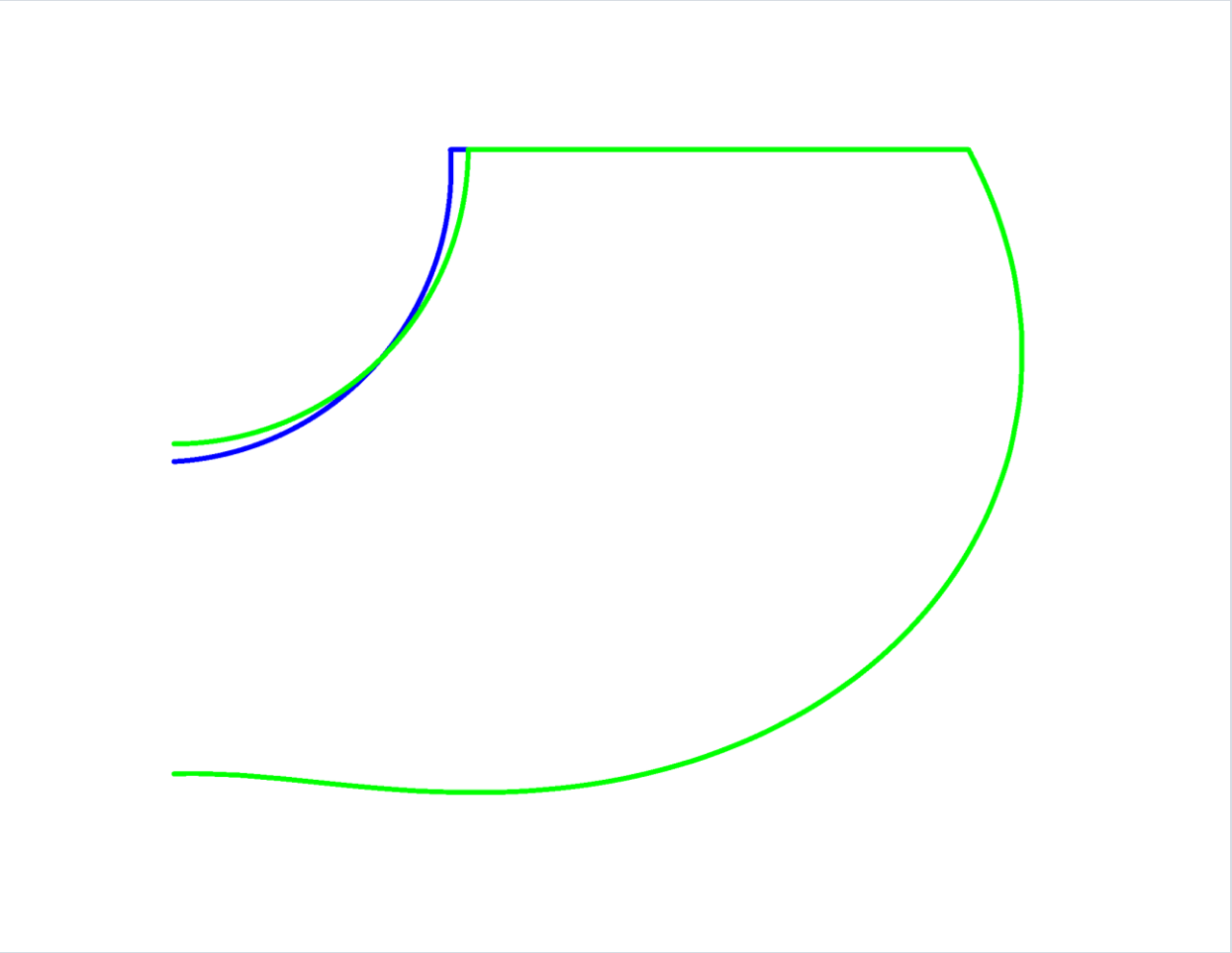
gradient shrink



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what are the likely variations?
(part 3)
non-uniform shrink - waviness

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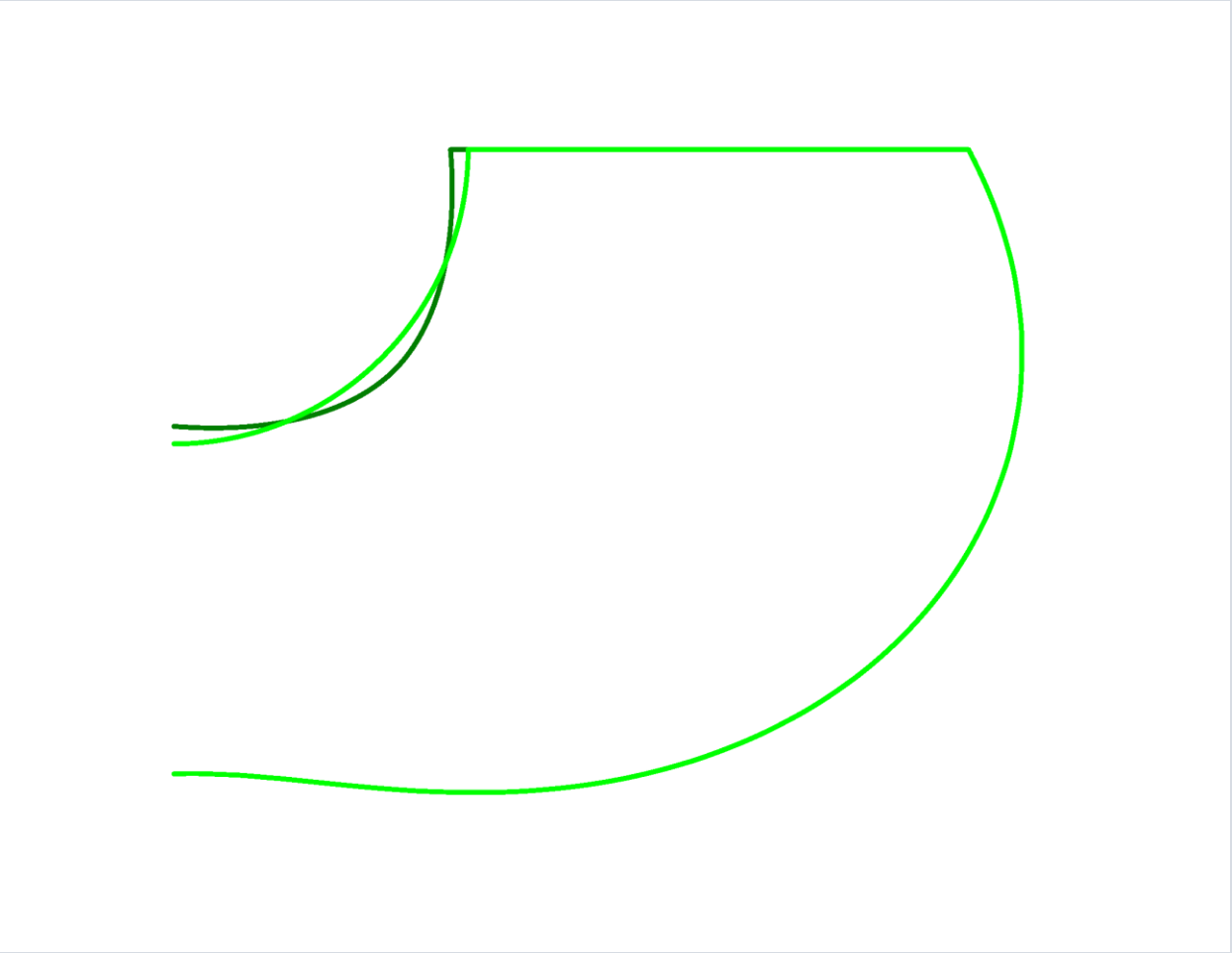
waviness



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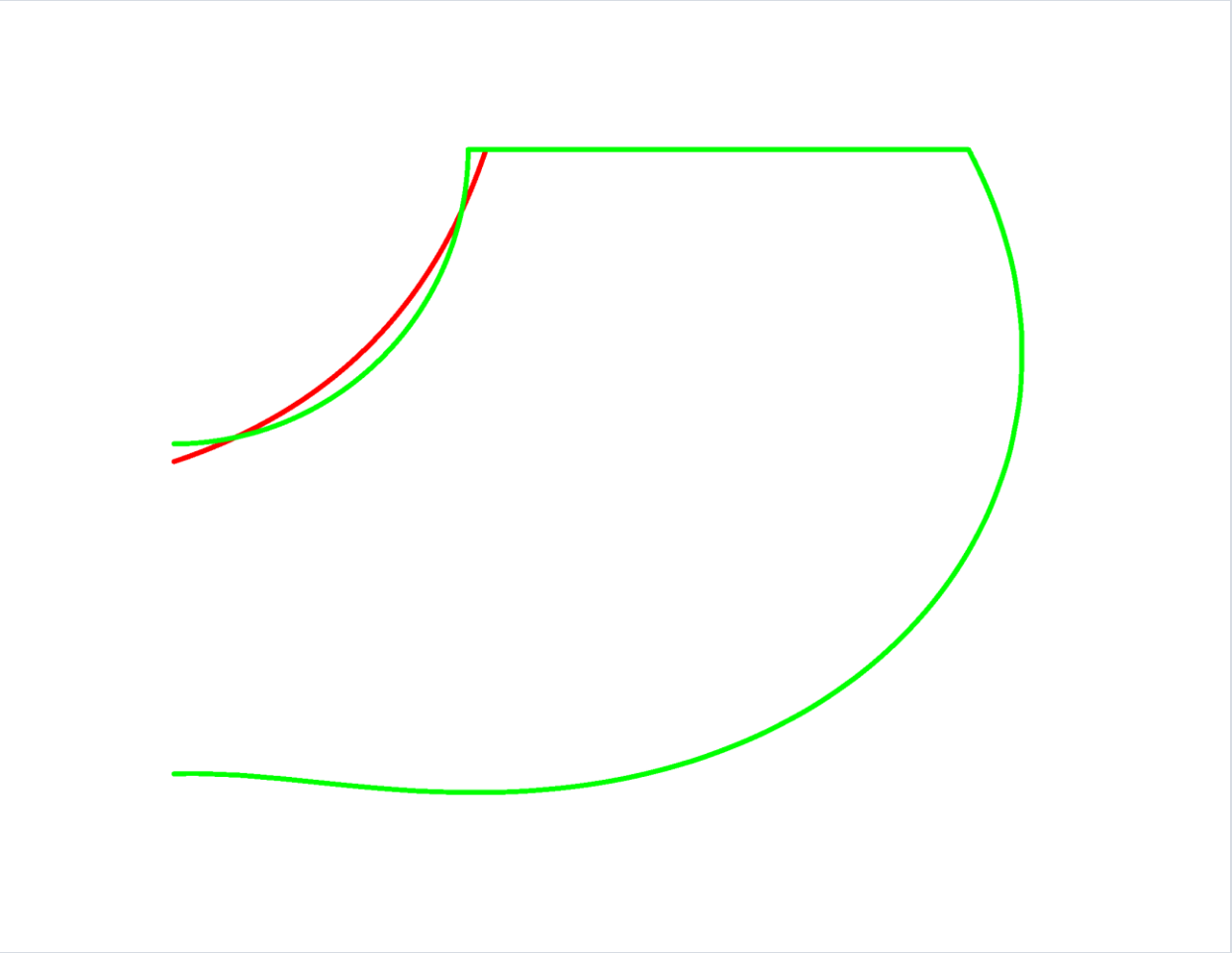
waviness



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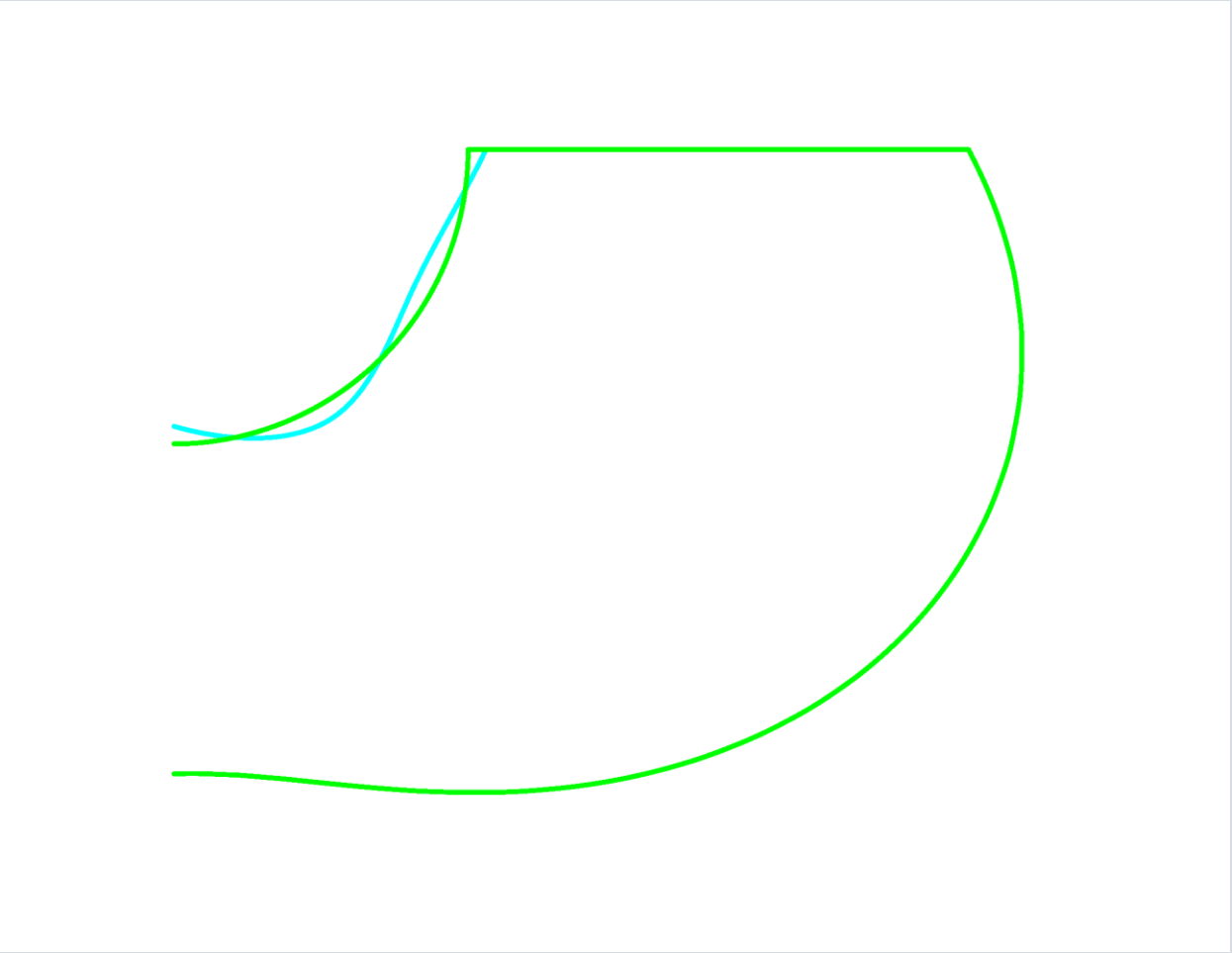
waviness



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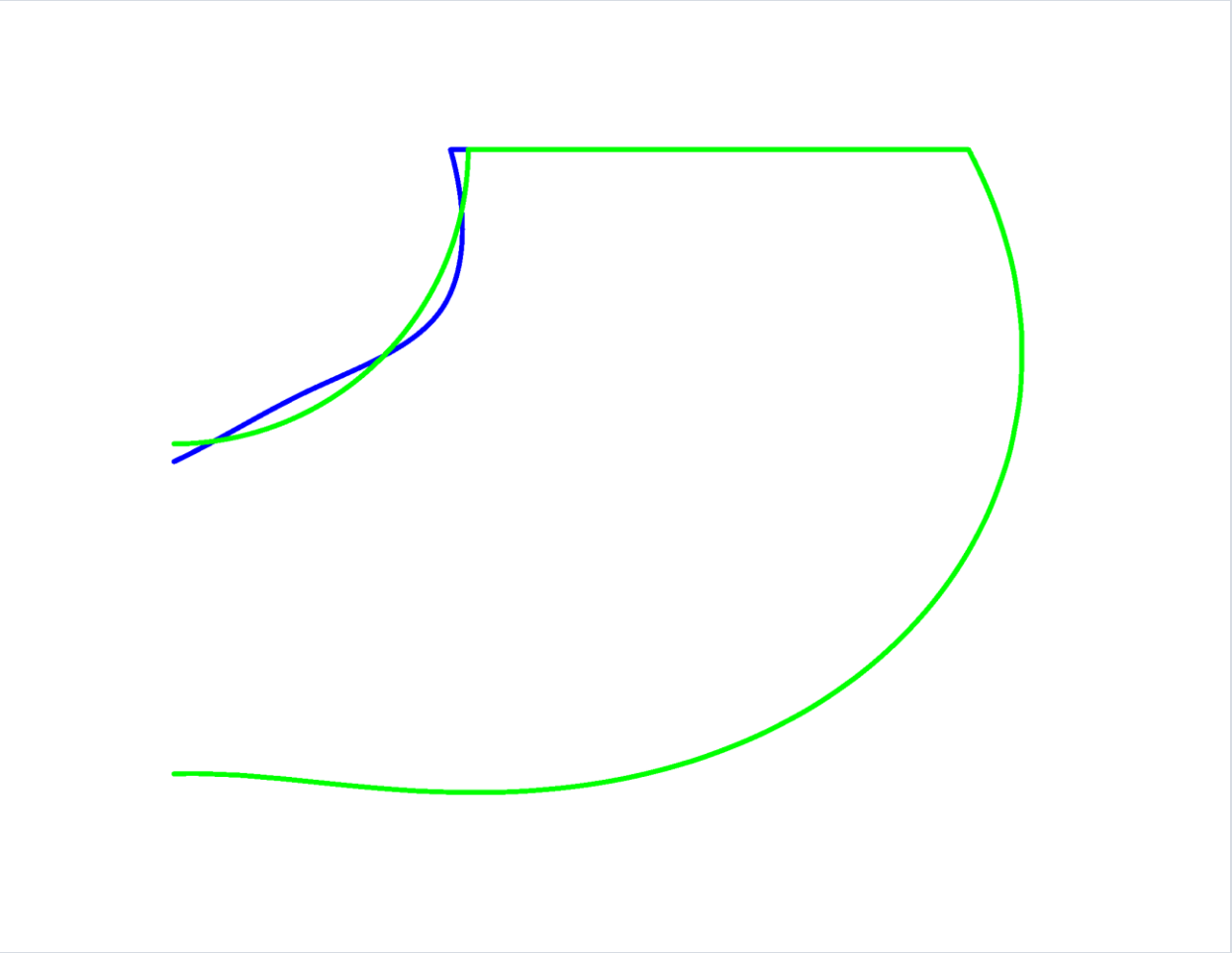
waviness



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what is the impact?

distribution variation
application performance

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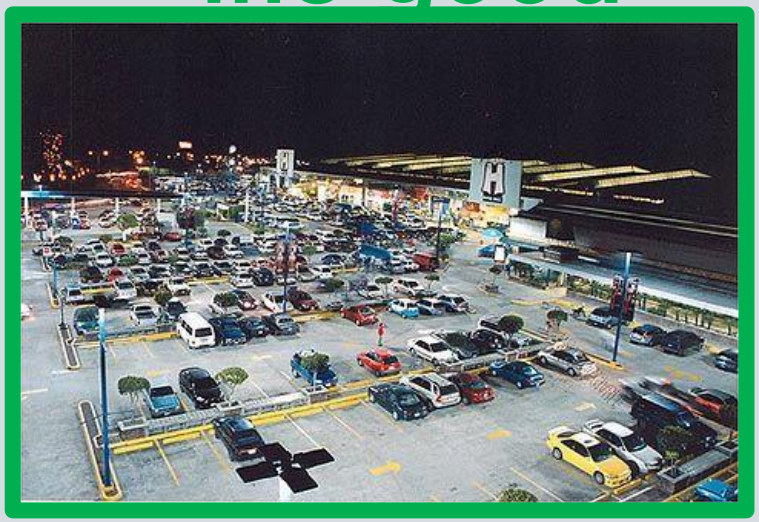
application performance

	Design
Avg	3.1 fc
Max	5.0 fc
Min	1.2 fc
Max/Min	4.2
Avg/Min	2.6

- adequate amounts of light
- good uniformity of light

the good



the bad

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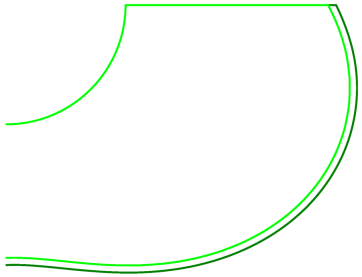
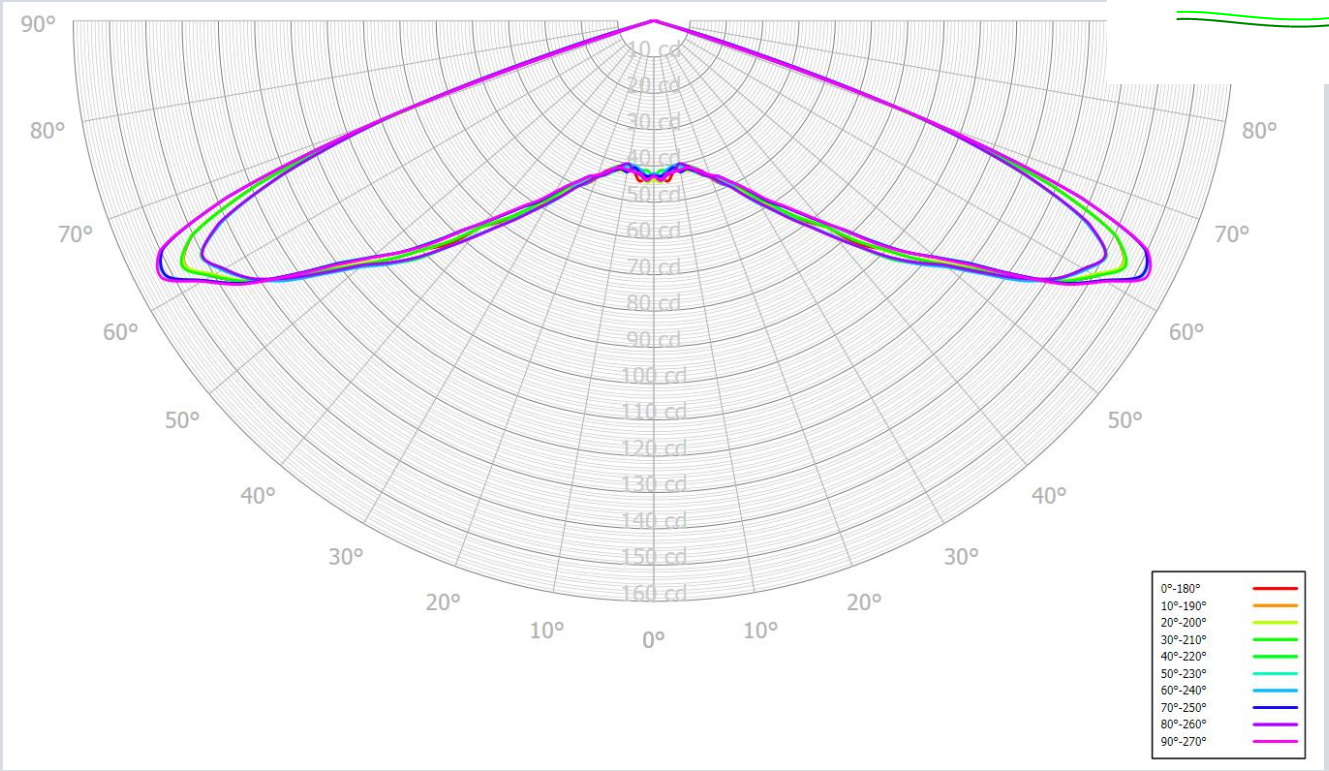
offset surfaces

	Design	Offset Curves							
Avg	3.1 fc	3.0 fc	3.1 fc	3.1 fc	3.0 fc	3.1 fc	3.0 fc	3.0 fc	3.0 fc
Max	5.0 fc	4.9 fc	5.0 fc	4.8 fc	4.9 fc	4.9 fc	4.8 fc	4.9 fc	4.8 fc
Min	1.2 fc	1.2 fc	1.2 fc	1.2 fc	1.2 fc	1.2 fc	1.2 fc	1.2 fc	1.2 fc
Max/Min	4.2	4.1	4.2	4.0	4.1	4.1	4.0	4.1	4.0
Avg/Min	2.6	2.5	2.6	2.6	2.5	2.6	2.5	2.5	2.5





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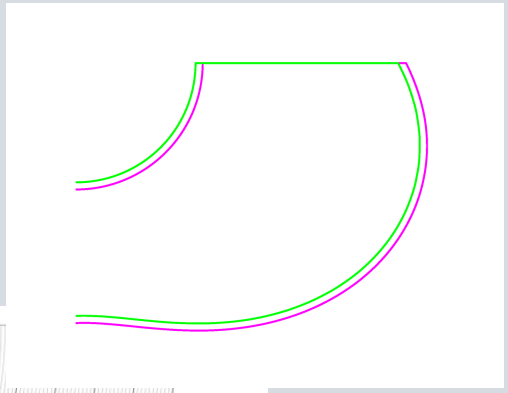
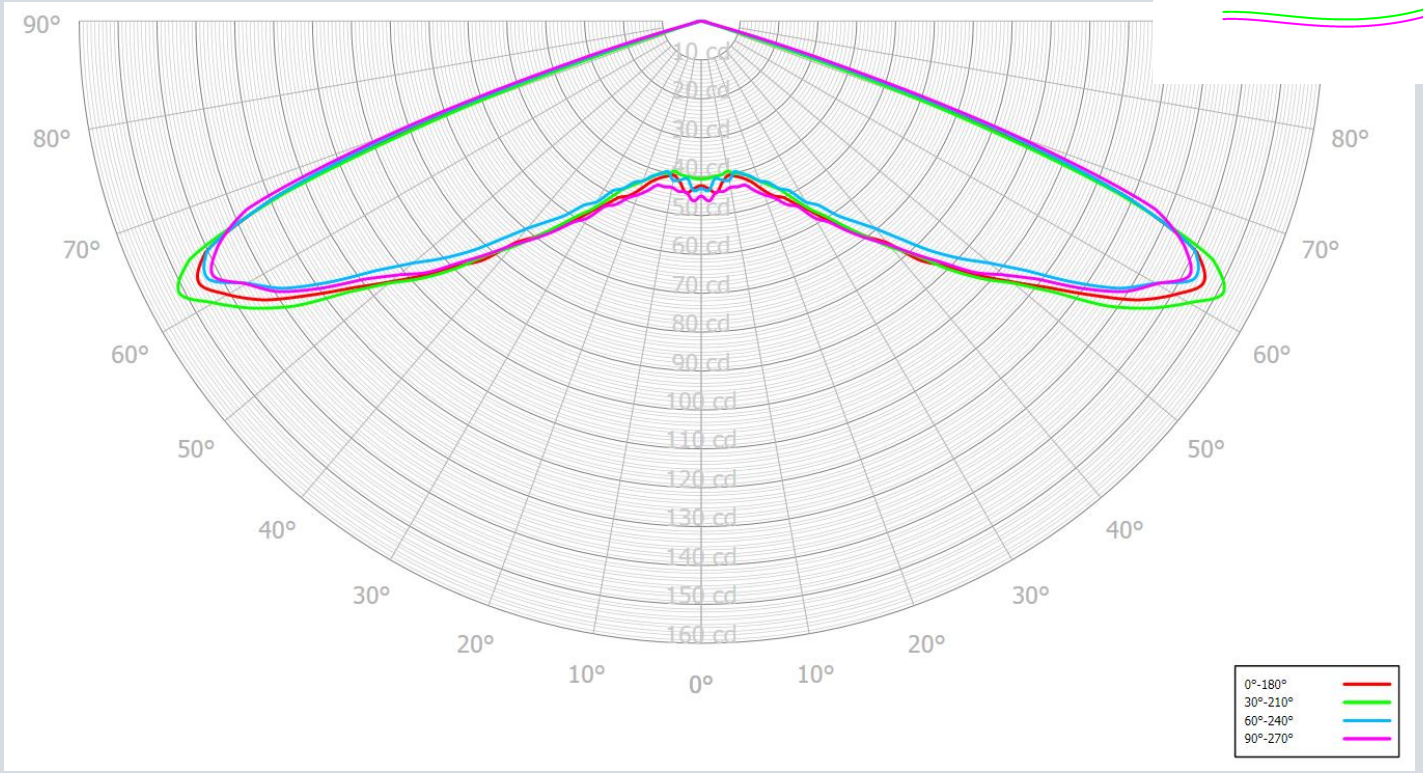
shifted positions

	Design	Position Shift		
Avg	3.1 fc	3.0 fc	3.1 fc	3.1 fc
Max	5.0 fc	4.7 fc	4.8 fc	5.3 fc
Min	1.2 fc	0.9 fc	1.2 fc	1.3 fc
Max/Min	4.2	5.2	4.0	4.1
Avg/Min	2.6	3.3	2.6	2.4





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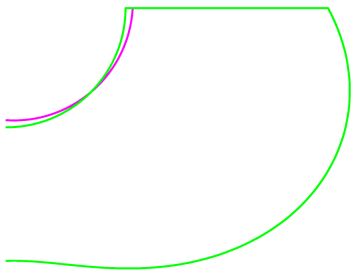
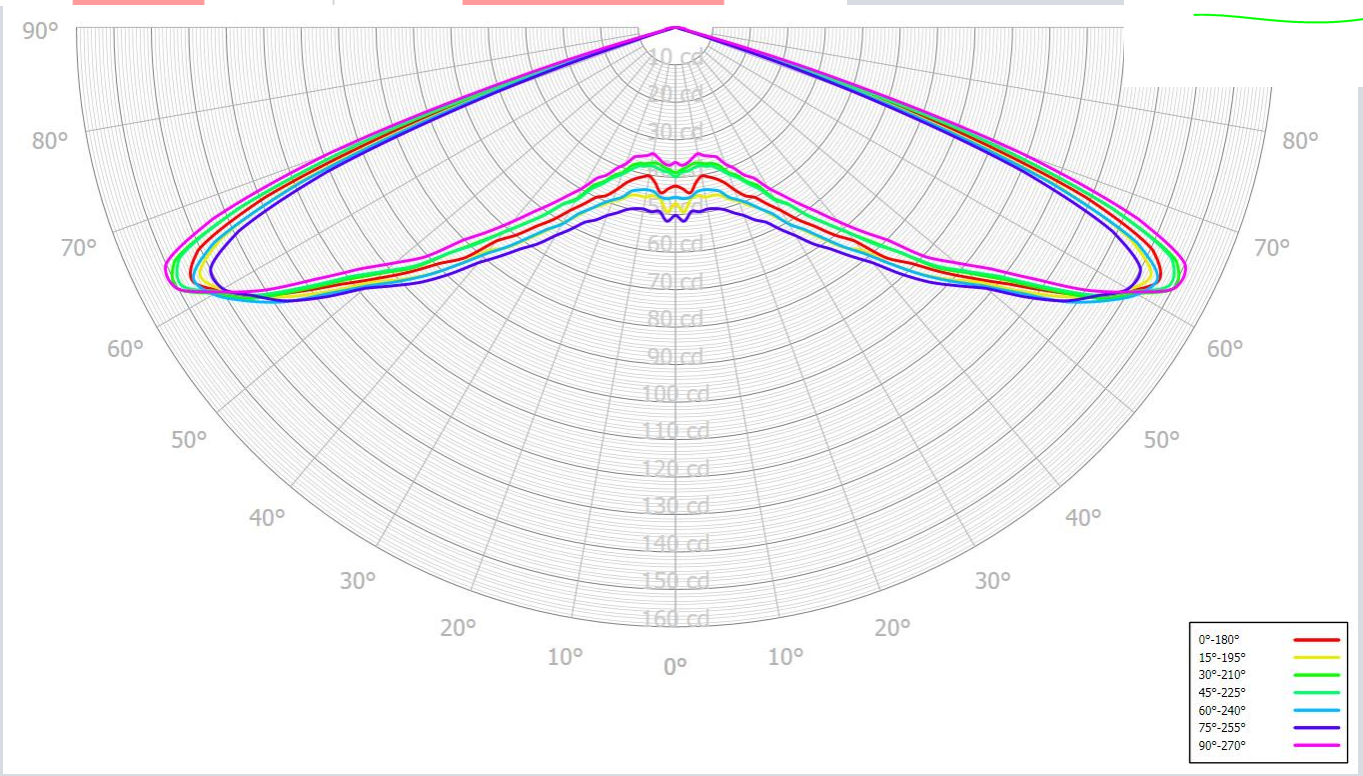
gradient shrink

	Design	One End Clamped Variations				
Avg	3.1 fc	3.1 fc	3.0 fc	3.0 fc	3.1 fc	3.1 fc	3.0 fc
Max	5.0 fc	5.2 fc	4.3 fc	4.4 fc	5.2 fc	5.7 fc	4.1 fc
Min	1.2 fc	1.0 fc	1.3 fc	1.3 fc	0.9 fc	0.8 fc	1.6 fc
Max/Min	4.2	5.2	3.3	3.4	5.8	7.1	2.6
Avg/Min	2.6	3.1	2.3	2.3	3.4	3.9	1.9





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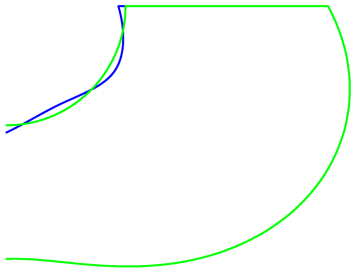
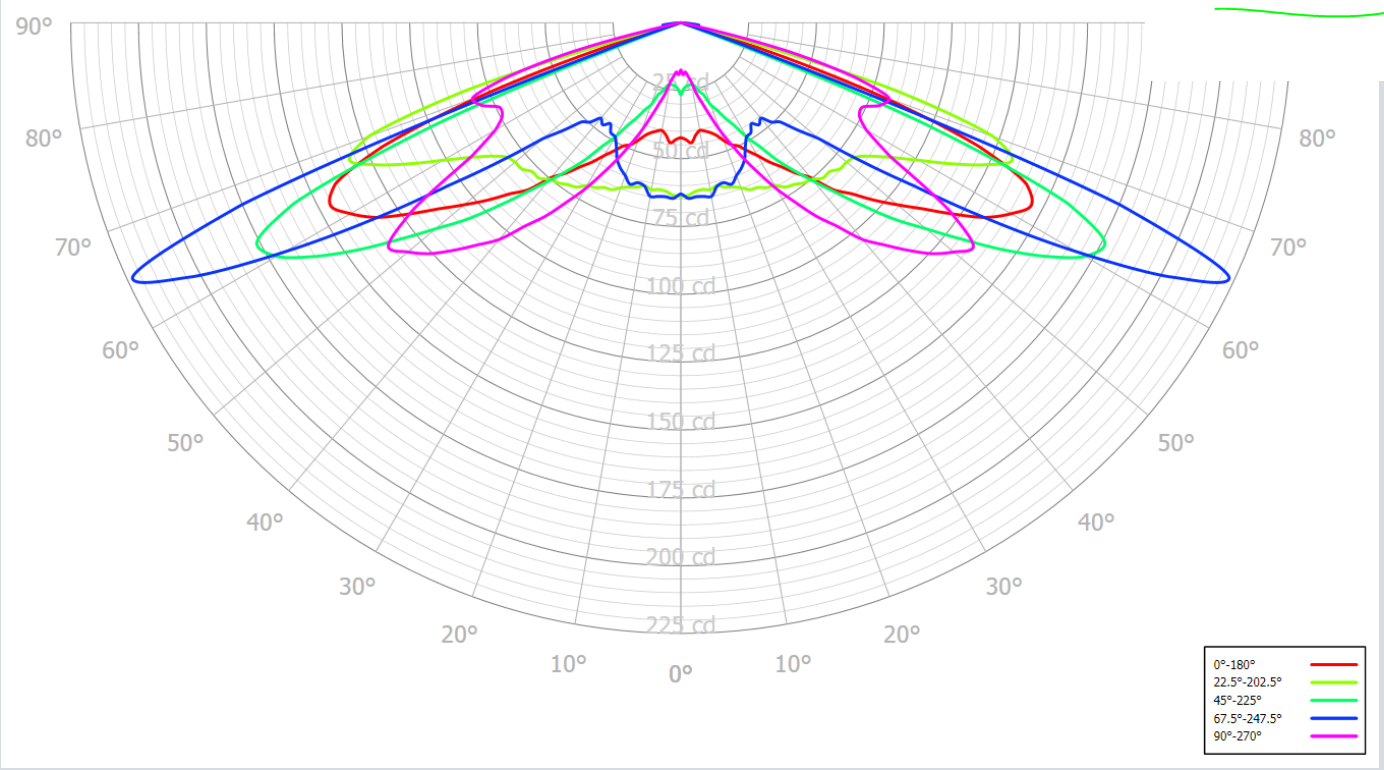
waviness

	Design	Multiple Wave Variations			
Avg	3.1 fc	3.1 fc	3.0 fc	3.0 fc	3.0 fc
Max	5.0 fc	7.2 fc	4.0 fc	7.4 fc	5.9 fc
Min	1.2 fc	2.1 fc	0.1 fc	0.4 fc	1.4 fc
Max/Min	4.2	3.4	40.0	18.5	4.2
Avg/Min	2.6	1.5	30.0	7.5	2.1





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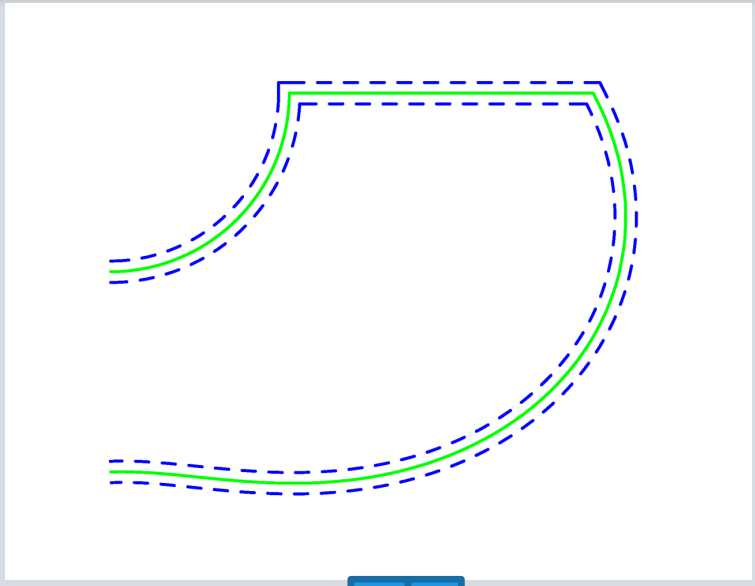
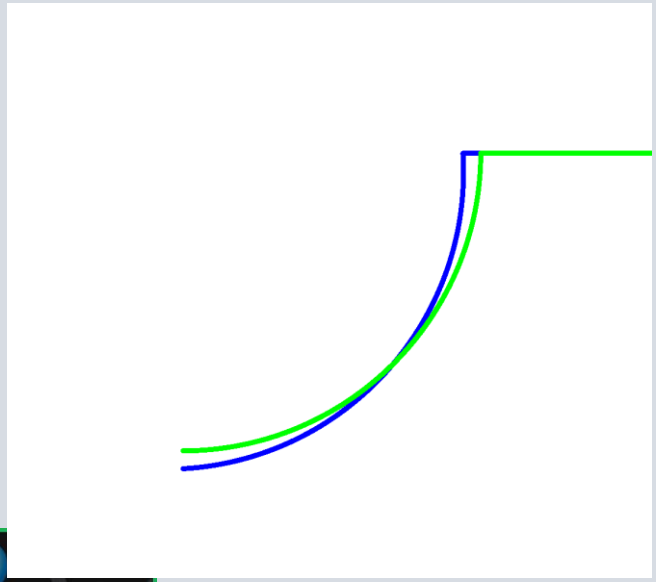
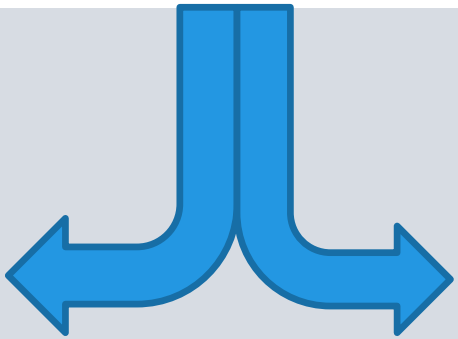
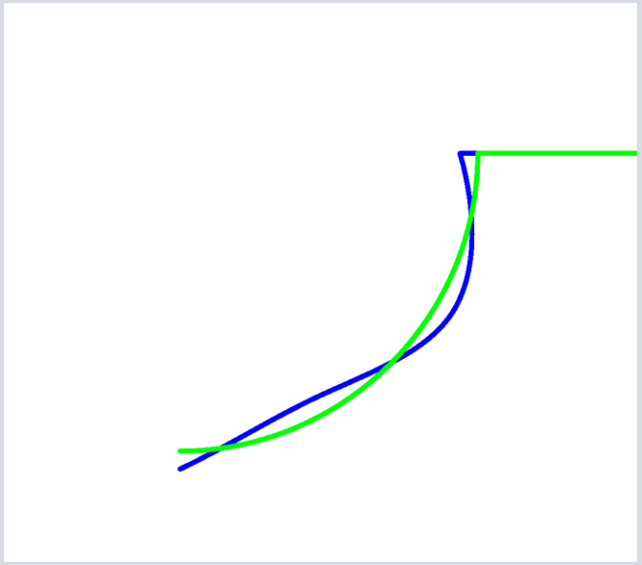
what's the point?

same tolerance – wildly different results









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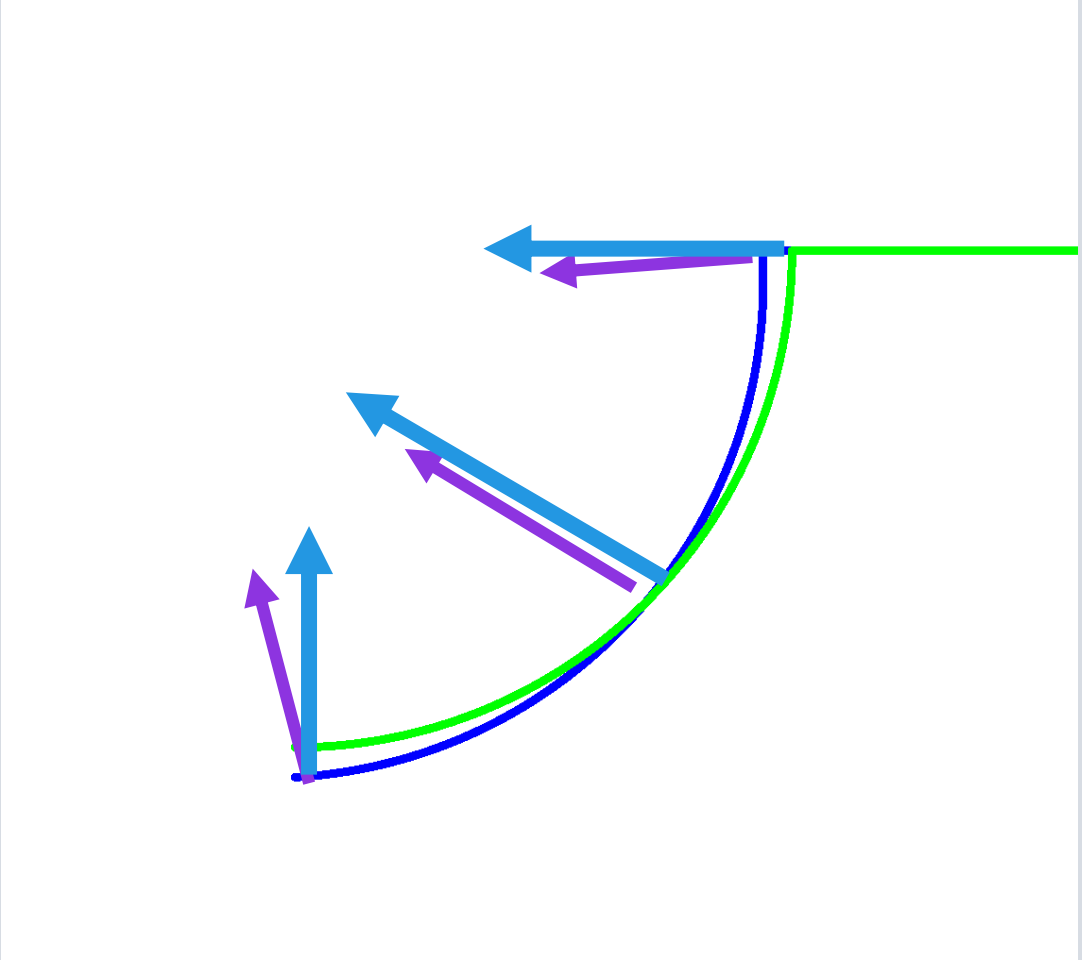
minimally variable surface normals



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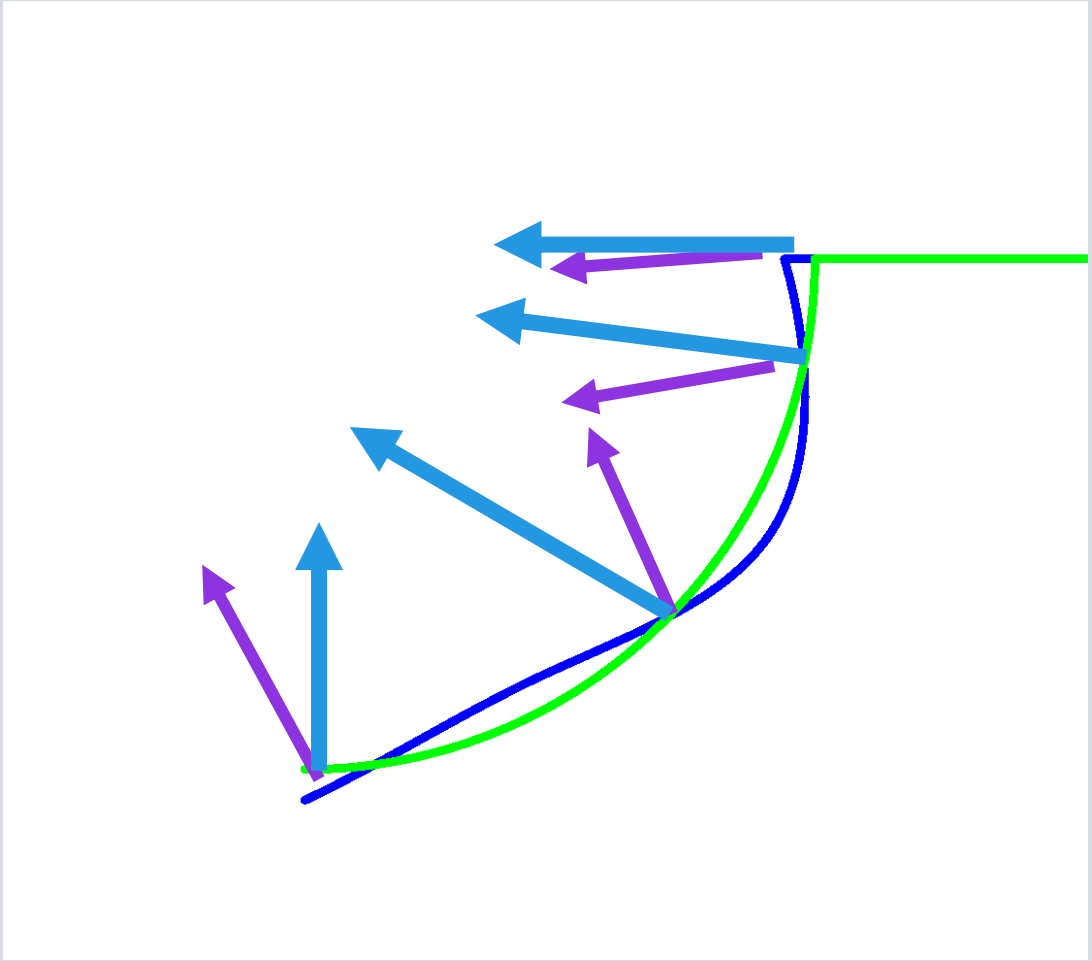
highly variable surface normals



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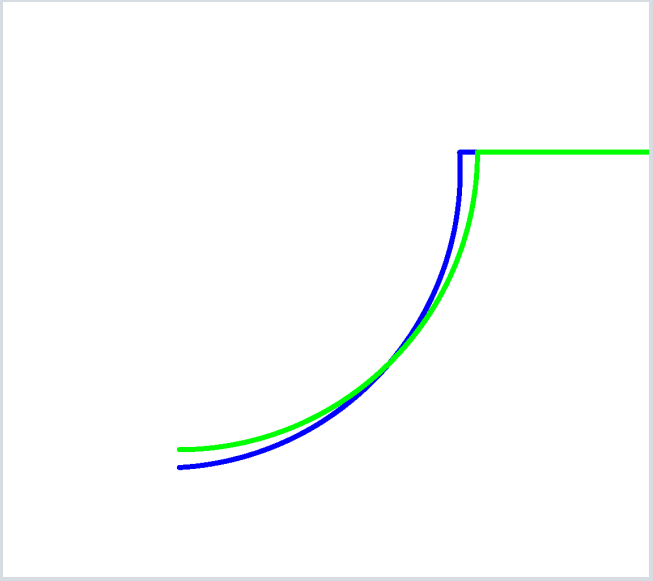
so….

when a molder asks if +/- 0.006” is acceptable, the answer is **hard**

(and usually mine is “it depends”)

am I going to get this:



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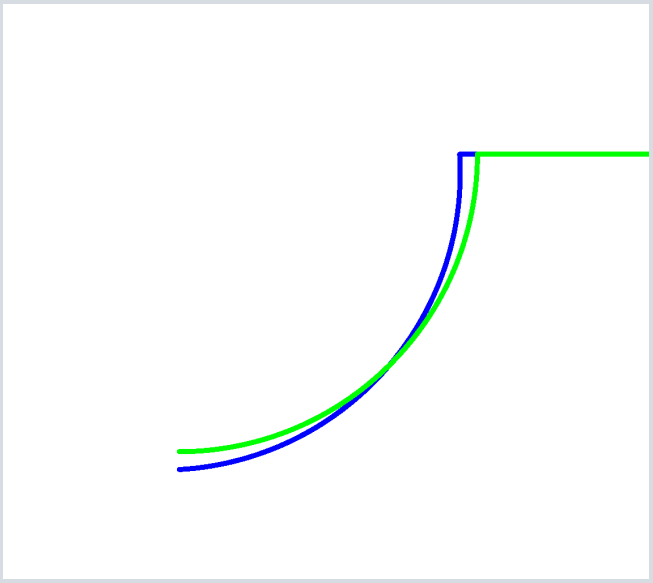
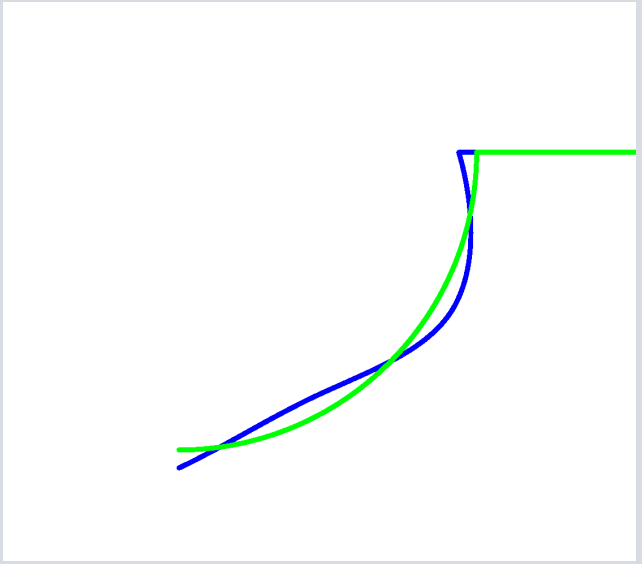
am I going to get this:



or this:



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all I really want is to specify +/- tolerance

+ *and* +

surface normal deviation (slope error)

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Thanks!

Questions?

ryan@ltioptics.com

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