GD&T

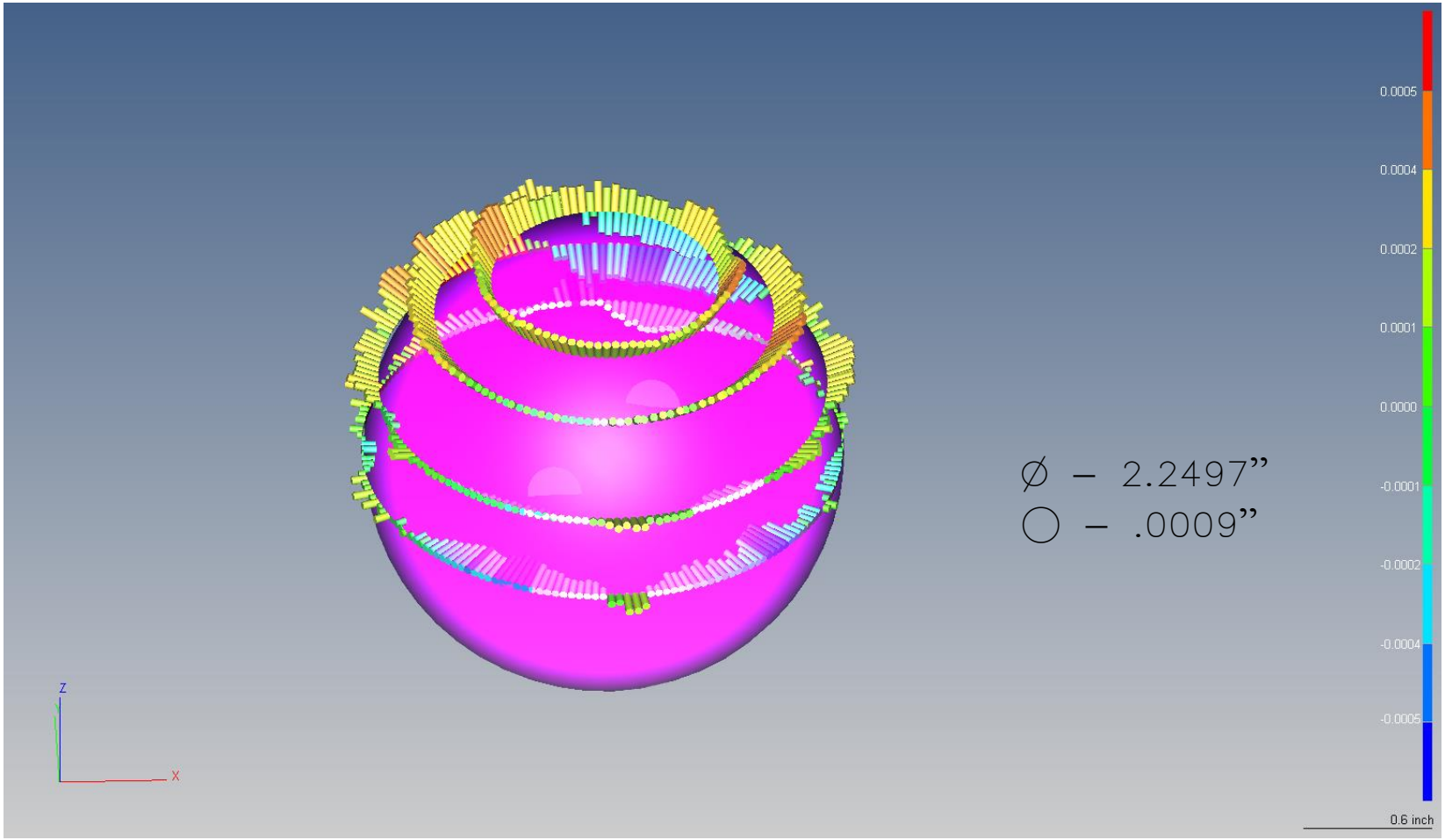
Review

- Orthographic Projection
- Dimensioning

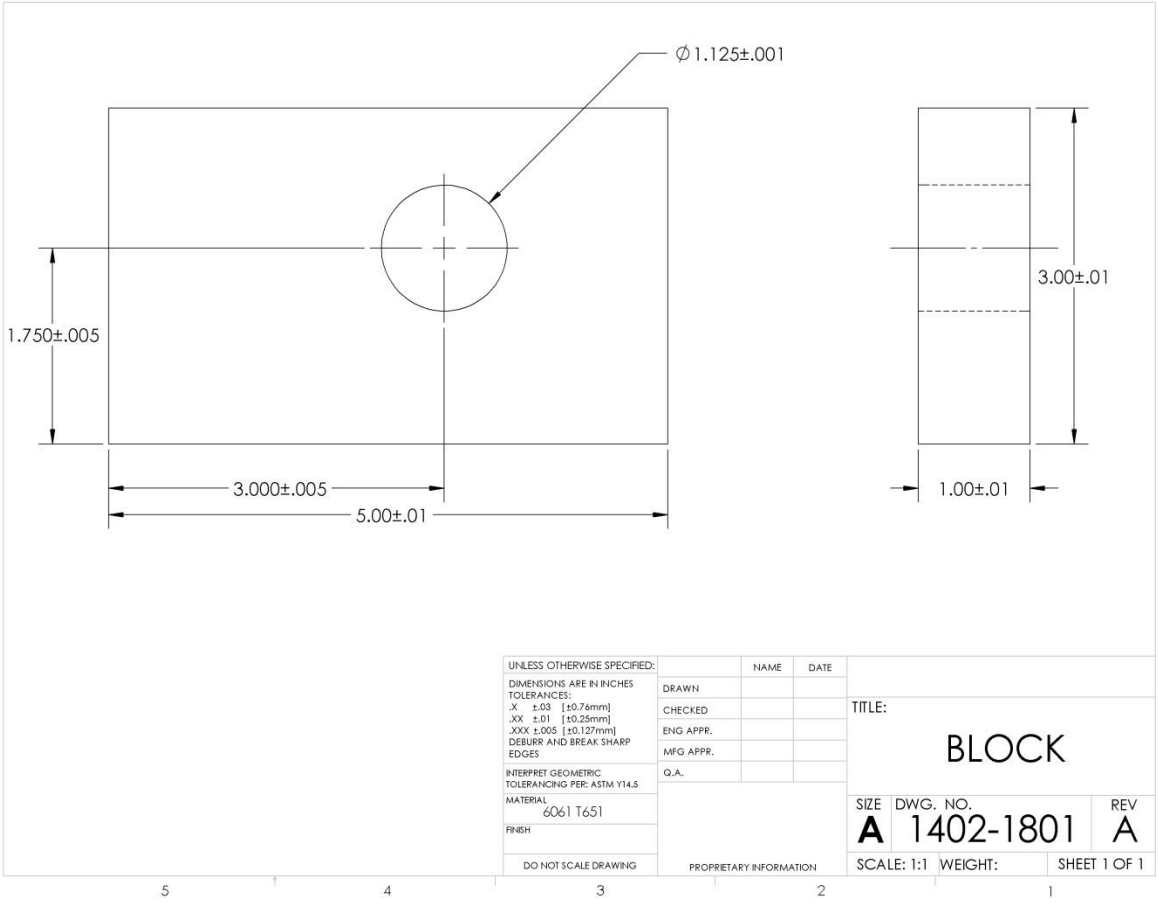
Manufacturing Error

- What are the important properties of a billiard ball?
- Why would those properties vary?
- How much variation in those properties are we ok with?

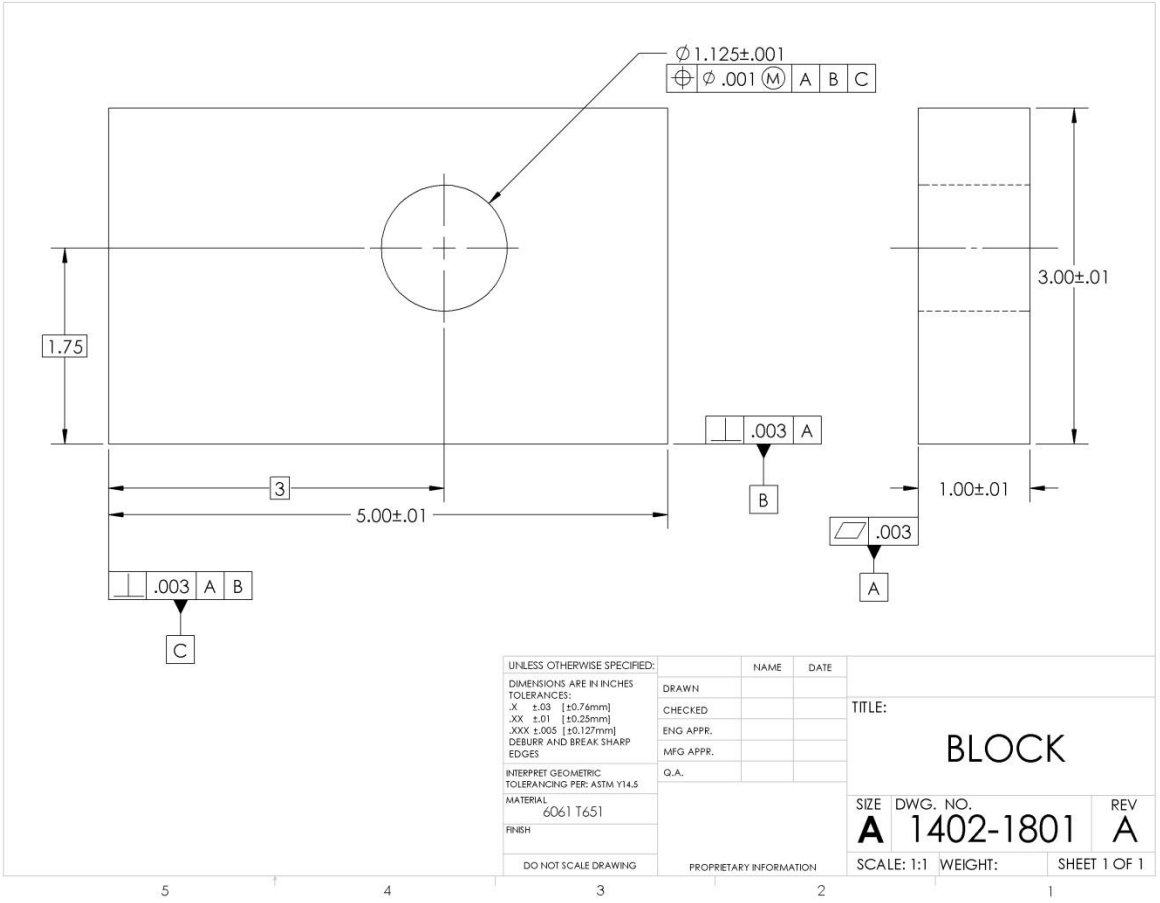
Manufacturing Error



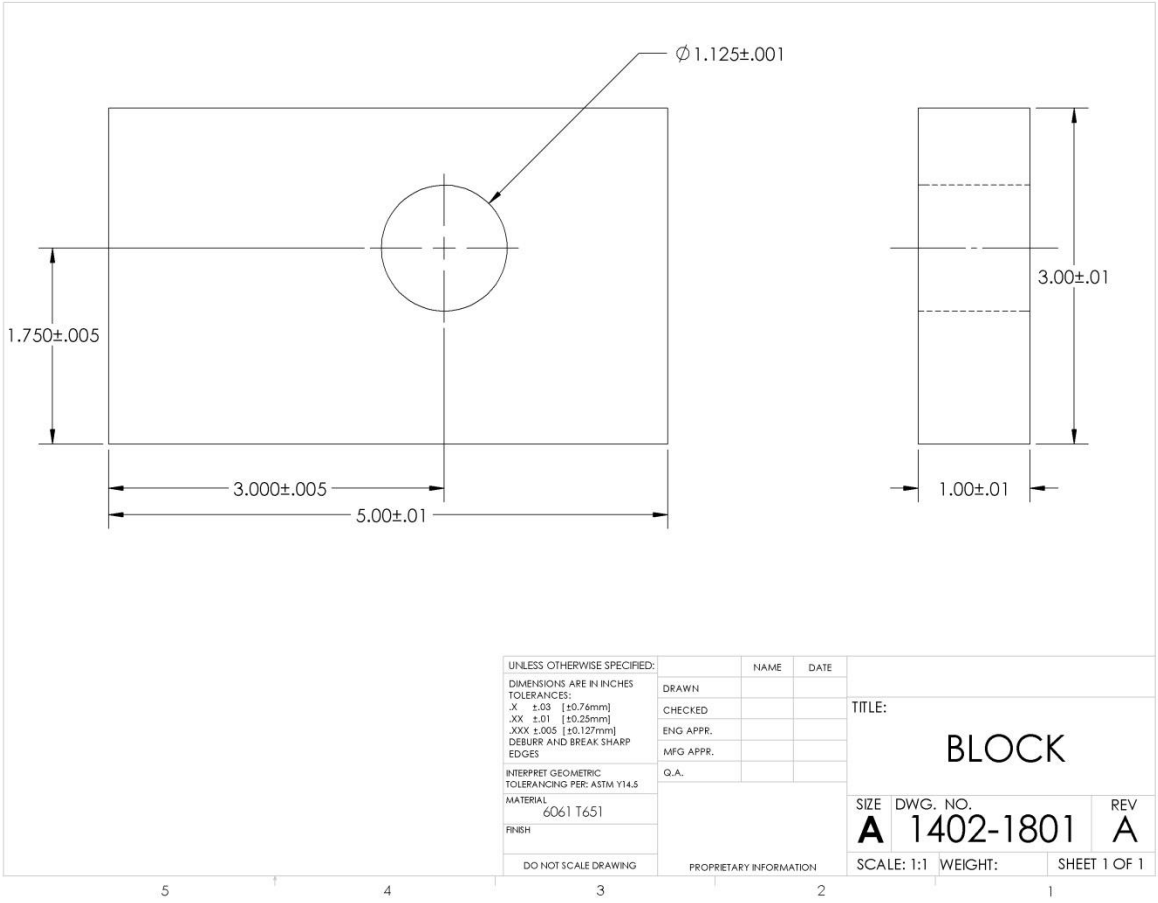
Plus/Minus Tolerancing



GD&T


∅1.125±.001
⌖ ∅ .001 Ⓜ A B C
1.75
3
5.00±.01
.003 A
B
3.00±.01
1.00±.01
.003
A
.003 A B
C
UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
.X ±.03 [±0.76mm]
.XX ±.01 [±0.25mm]
.XXX ±.005 [±0.127mm]
DEBURR AND BREAK SHARP EDGES
INTERPRET GEOMETRIC TOLERANCING PER: ASTM Y14.5
MATERIAL
6061 T651
FINISH
DO NOT SCALE DRAWING
NAME
DATE
DRAWN
CHECKED
ENG APPR.
MFG APPR.
Q.A.
PROPRIETARY INFORMATION
TITLE:
BLOCK
SIZE
A
DWG. NO.
1402-1801
REV
A
SCALE: 1:1
WEIGHT:
SHEET 1 OF 1
5
4
3
2
1

What is this telling us?



Envelope Rule

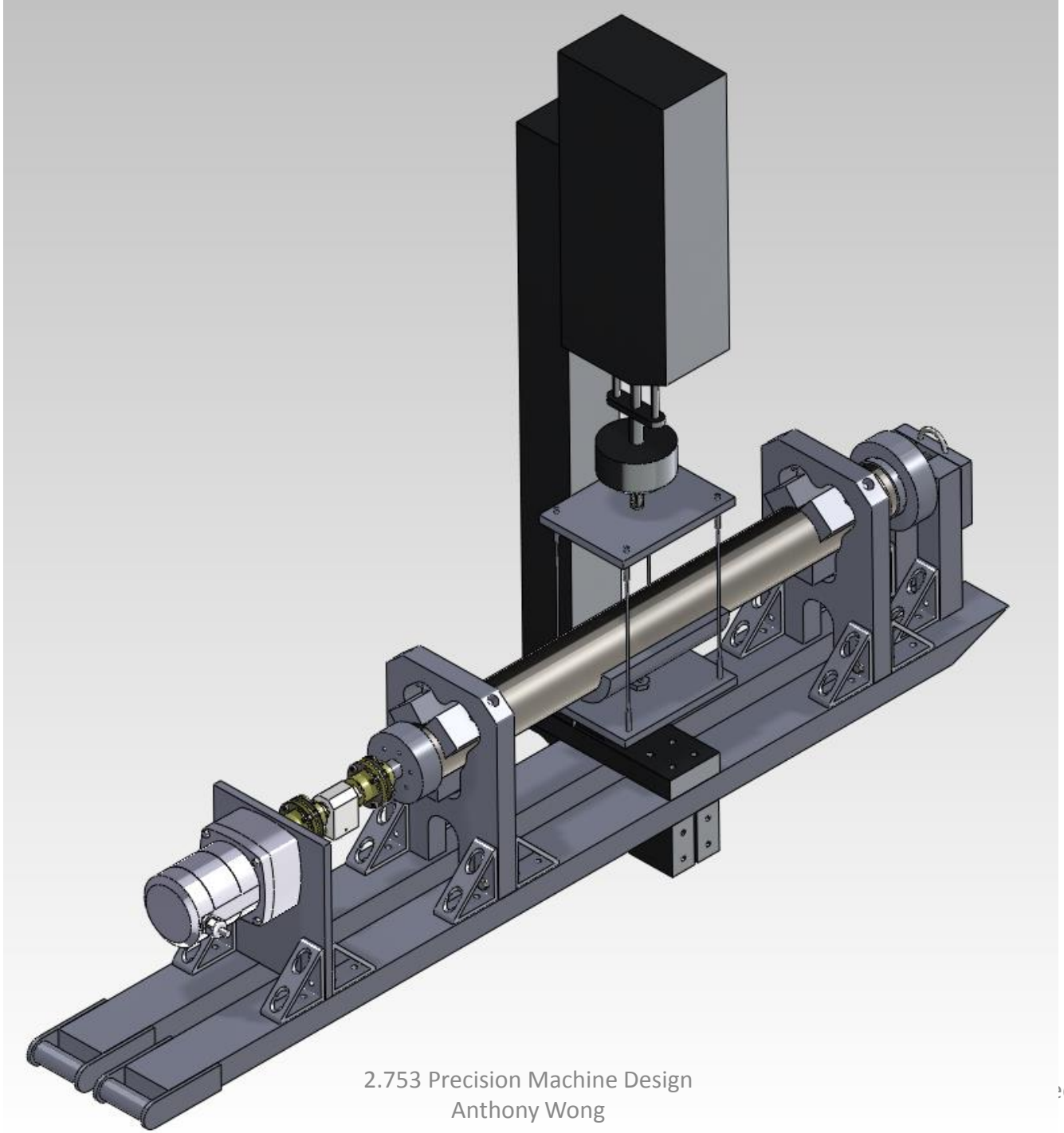
Perfect form at Most Material Condition (MMC Ⓜ)

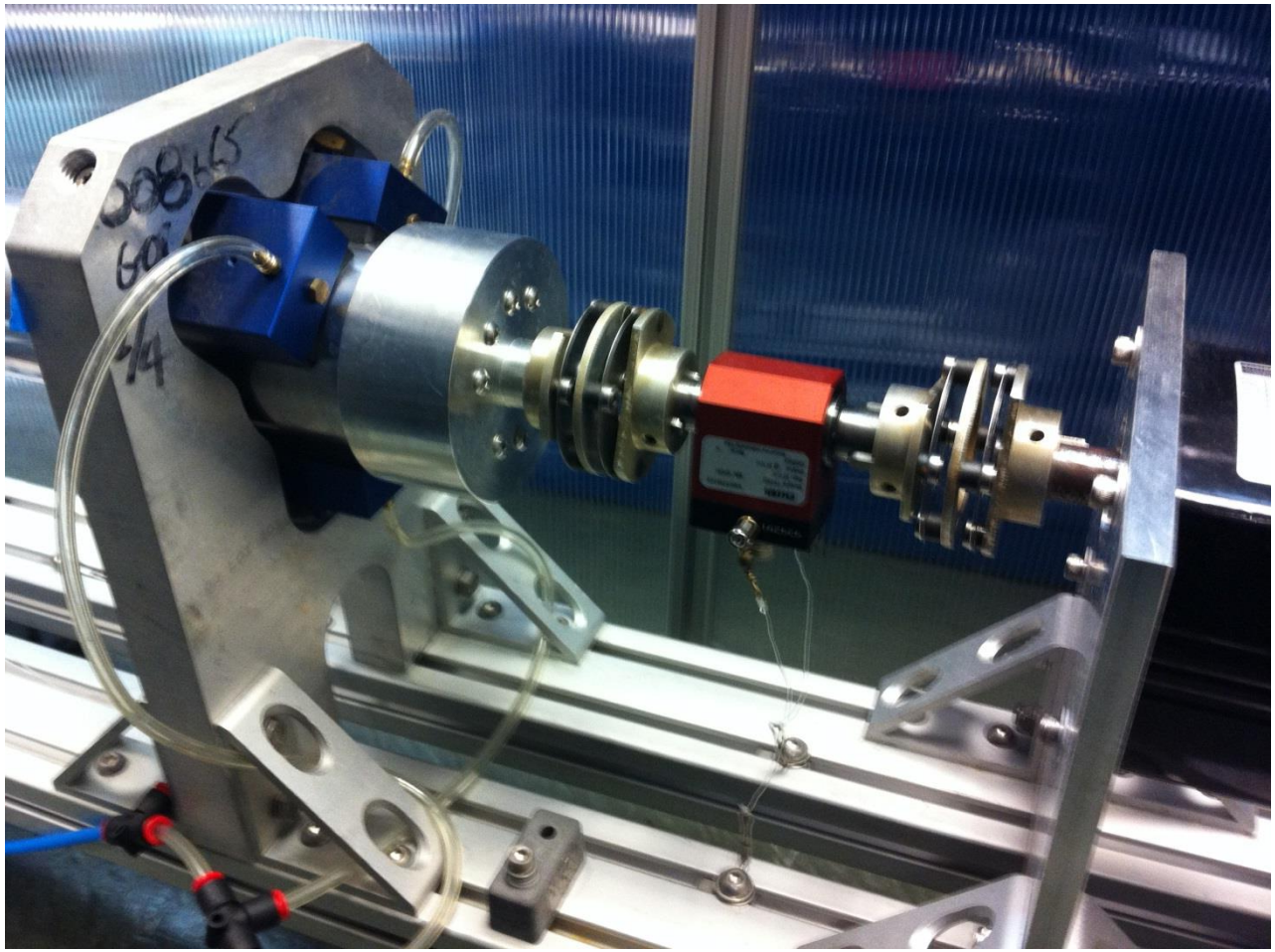
GD&T Characteristics

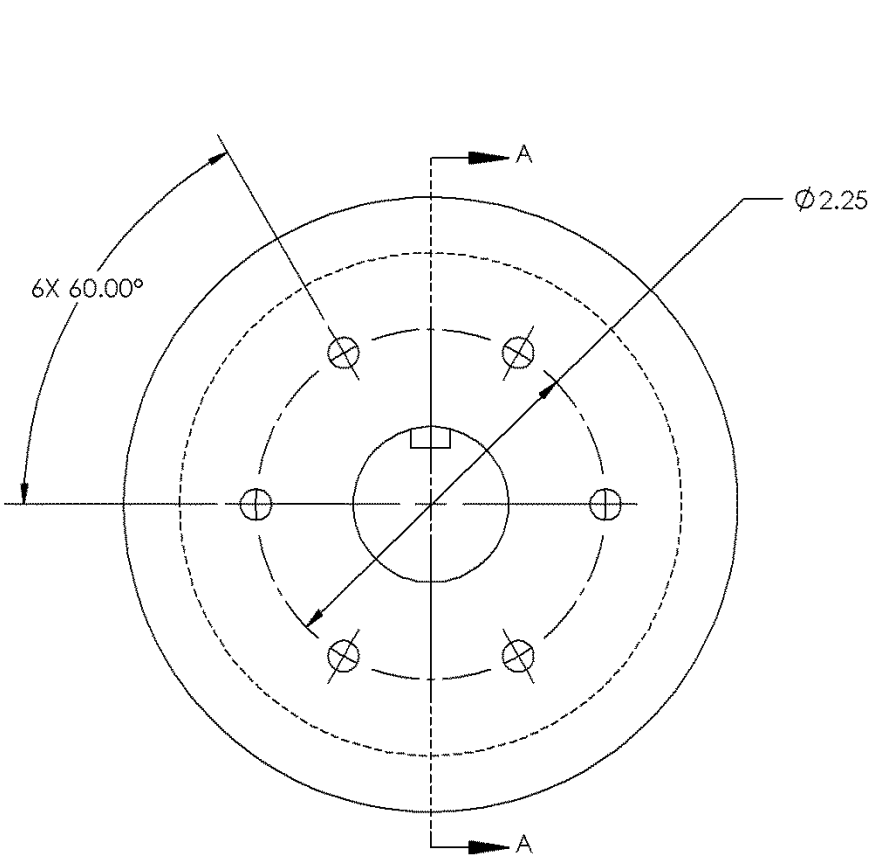
Type	Application	Characteristic	Symbol	Datums	Shape of tolerance zone
Form	Single Feature	Straightness		Datums not allowed	Parallel lines or planes, cylinder
		Flatness			Parallel planes
		Circularity			Concentric circles
		Cylindricity			Concentric cylinders
Profile	Single or Related Feature	Profile of line		Datums required*	2D uniform boundary
		Profile of surface			3D uniform boundary
Location	Related Feature	Position			Parallel planes, cylinder, sphere, cone
		Concentricity		Datums required	Cylinder
		Symmetry			Parallel planes
Orientation		Parallelism			Parallel planes, cylinder
		Perpendicularity			
		Angularity			
Run-Out		Circular Runout			Concentric circles, parallel circles
		Total Runout			Concentric cylinders, parallel planes

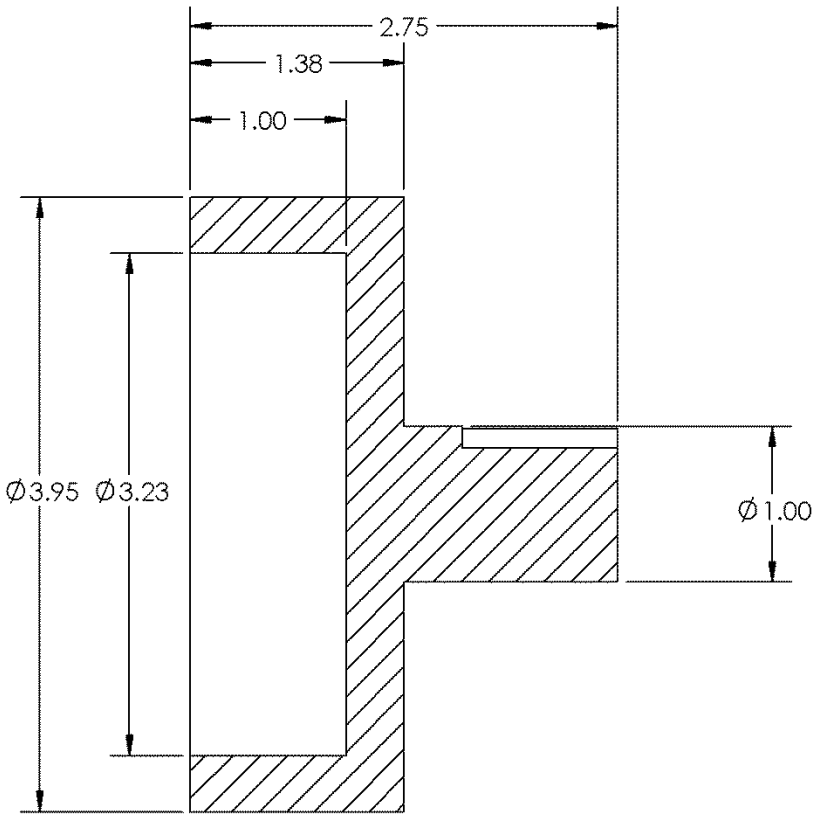
* There are some exceptions when profile and position may not require a datum.

Tolerance Exercise









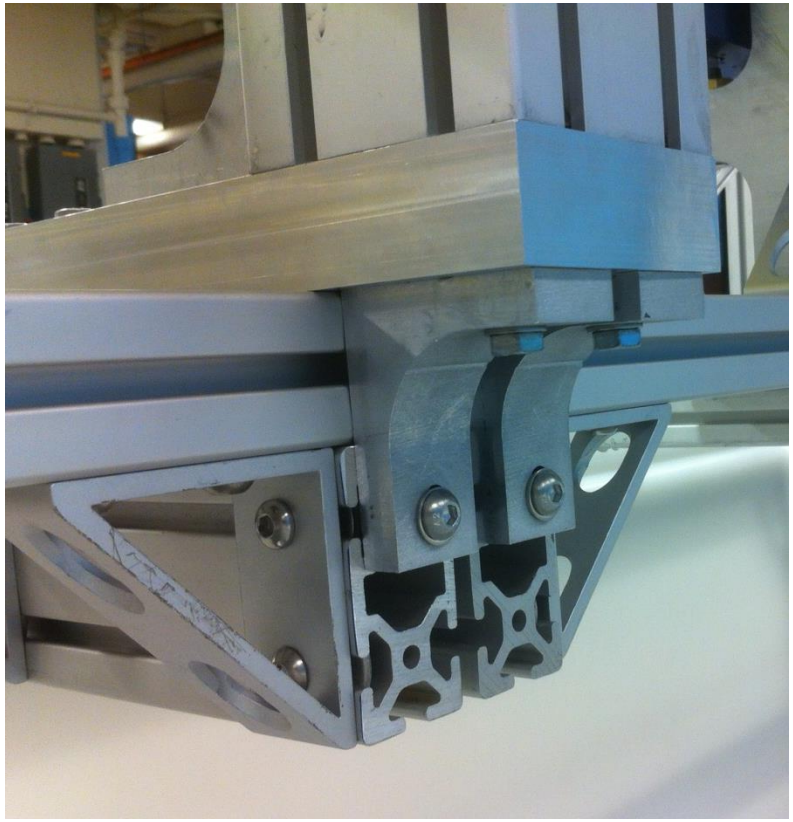
SECTION A-A

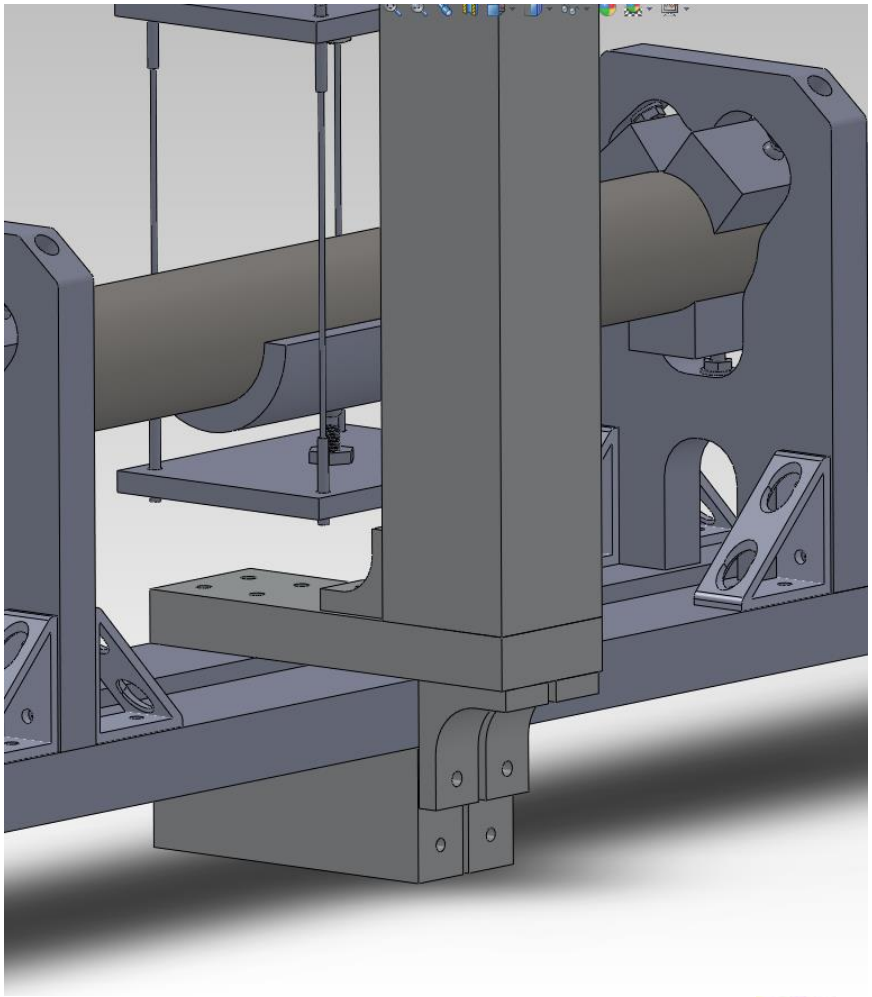
Exercise

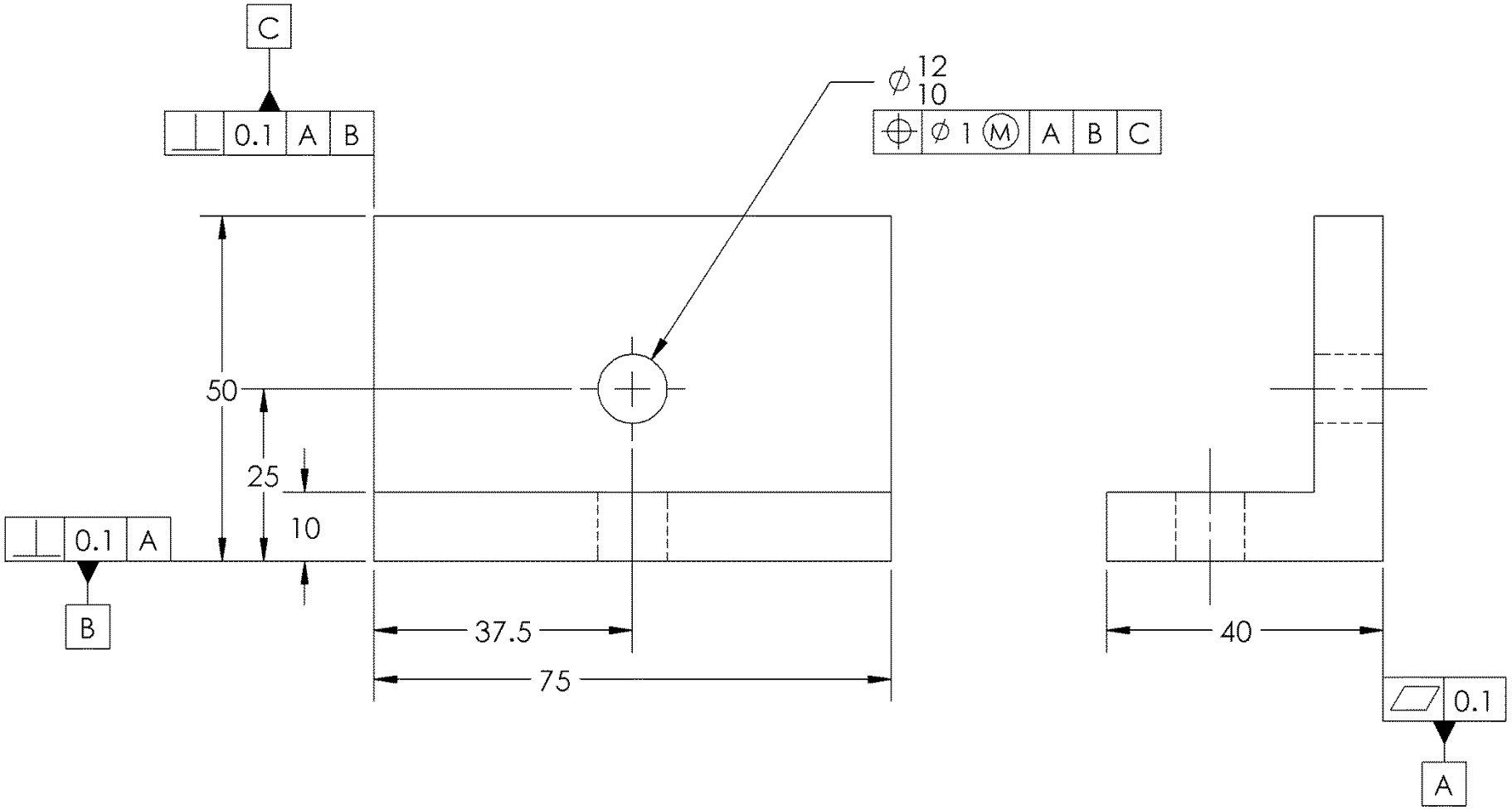
- What are the important features you want to control?
- Sketch the tolerance zone on the drawing

Bonus Tolerance

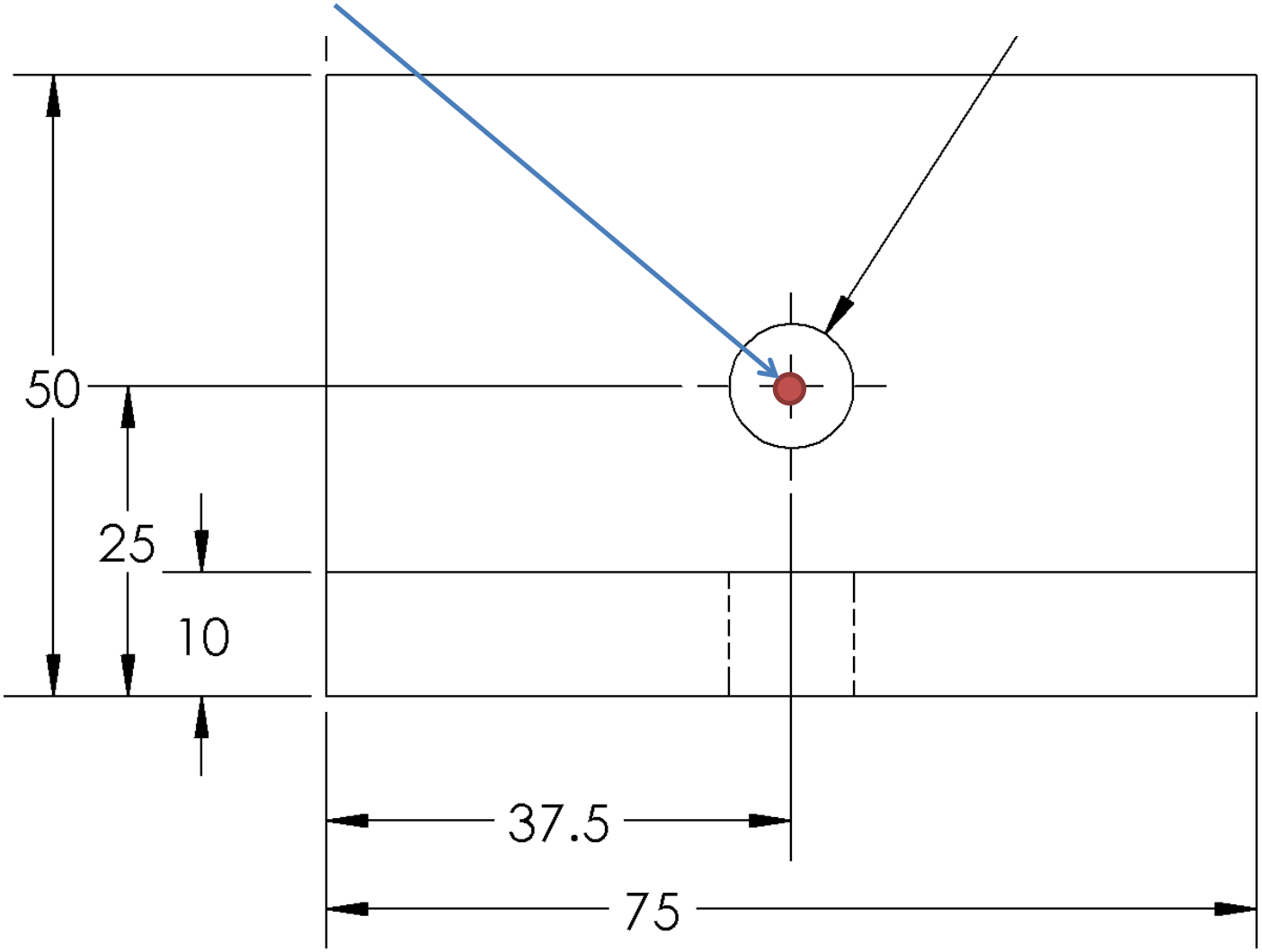
Bracket Example



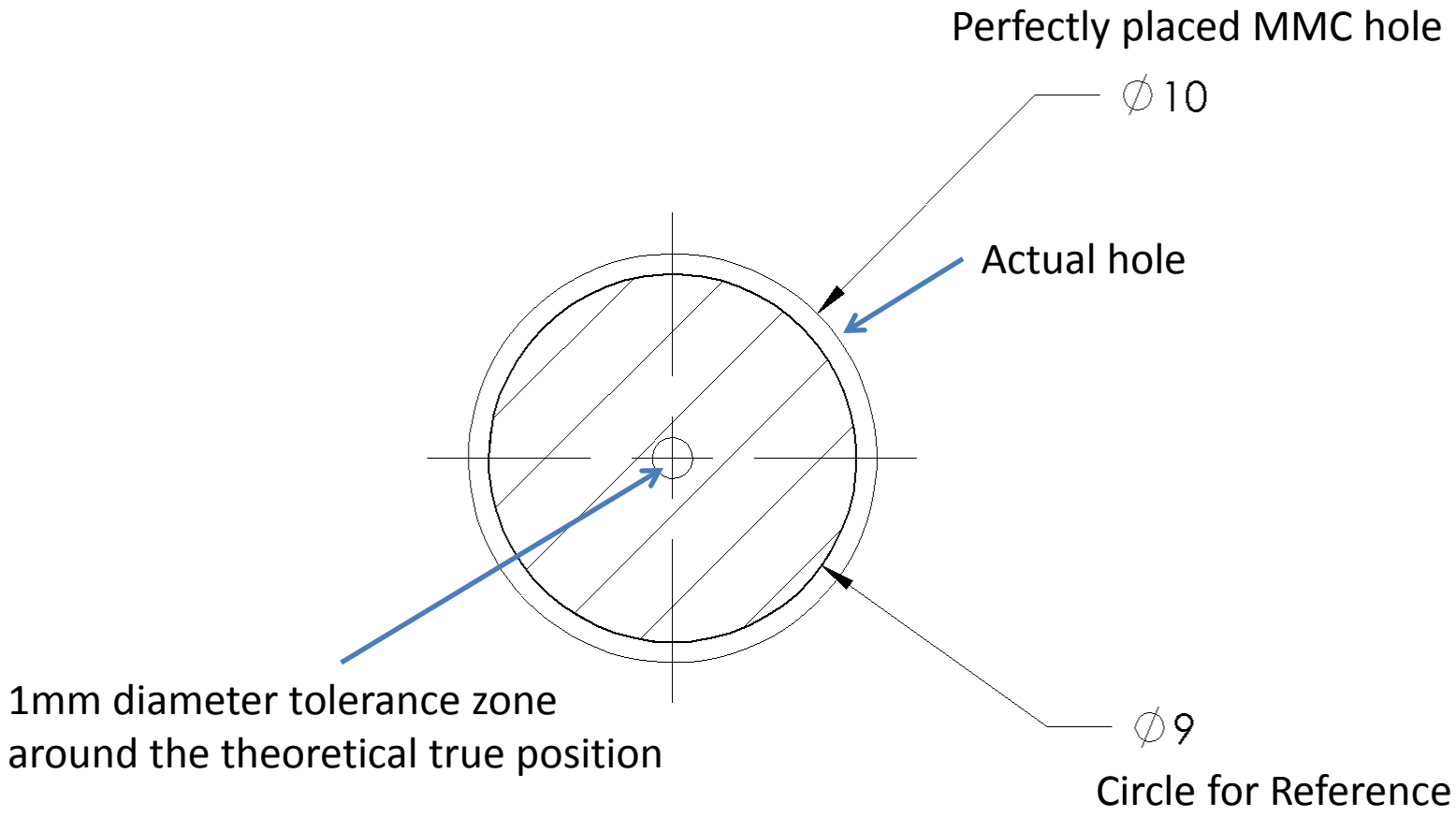



C
0.1 A B
⌀12
10
⌀ 1 M A B C
50
25
10
0.1 A
B
37.5
75
40
0.1
A

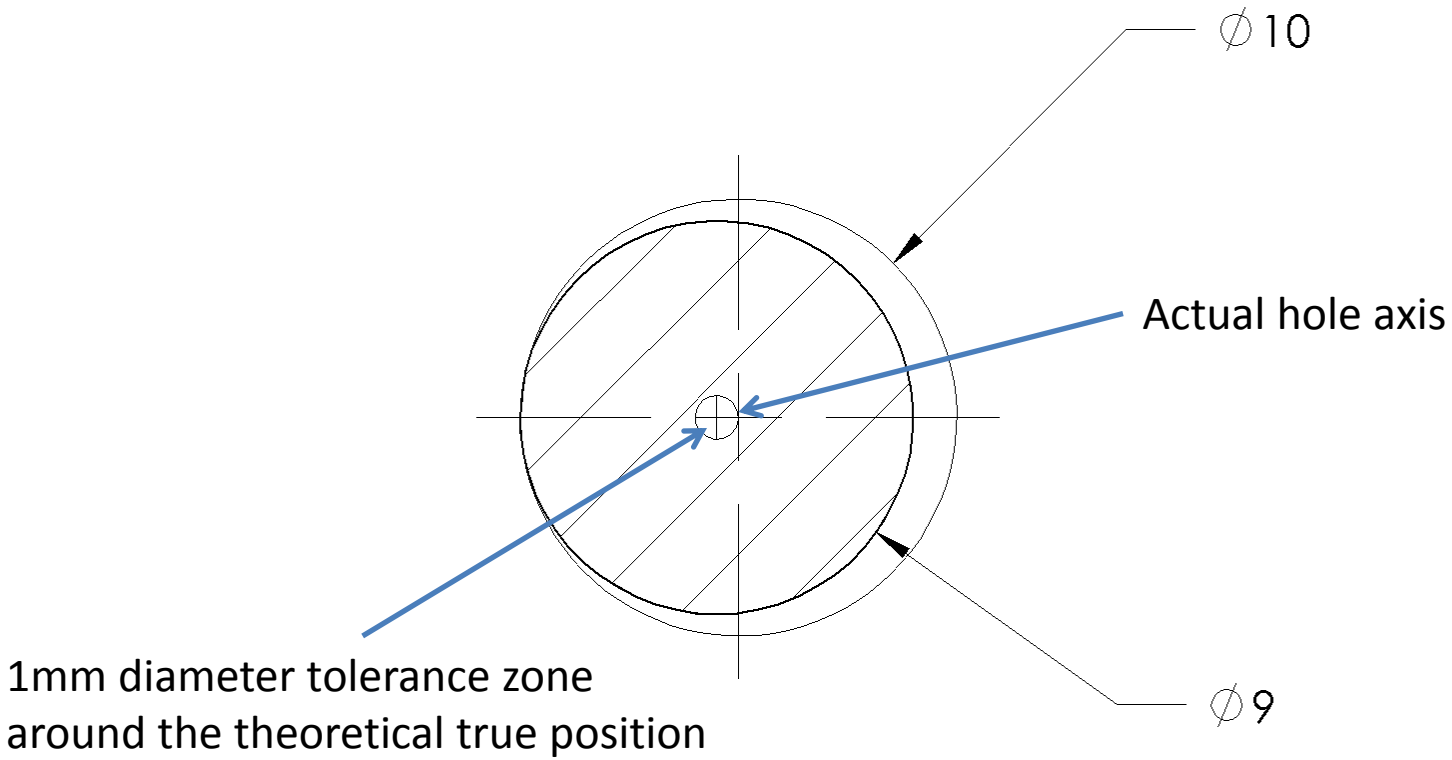
1mm diameter cylinder tolerance zone



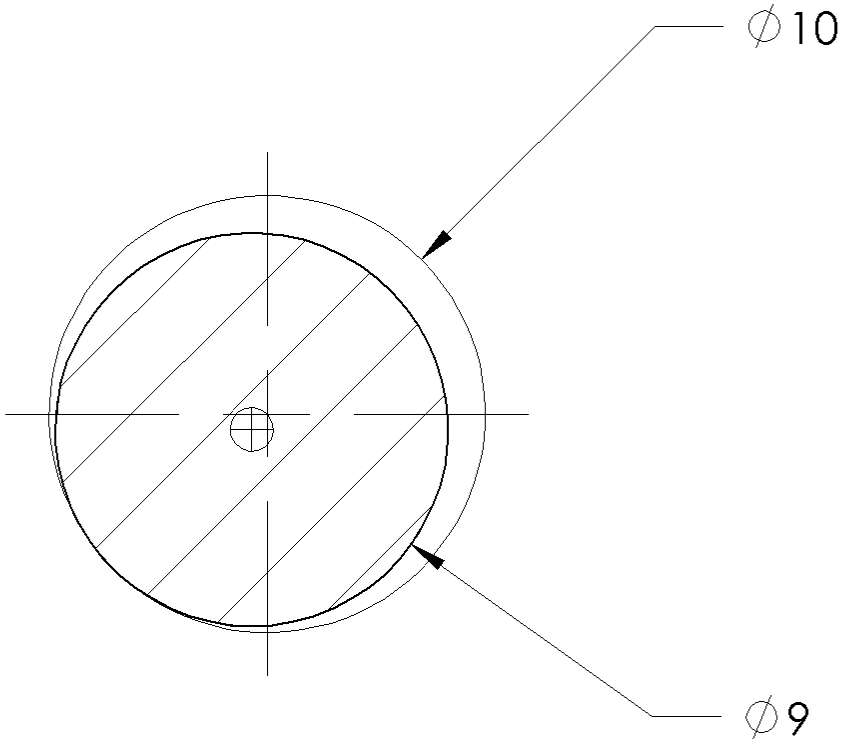
Perfect MMC Hole



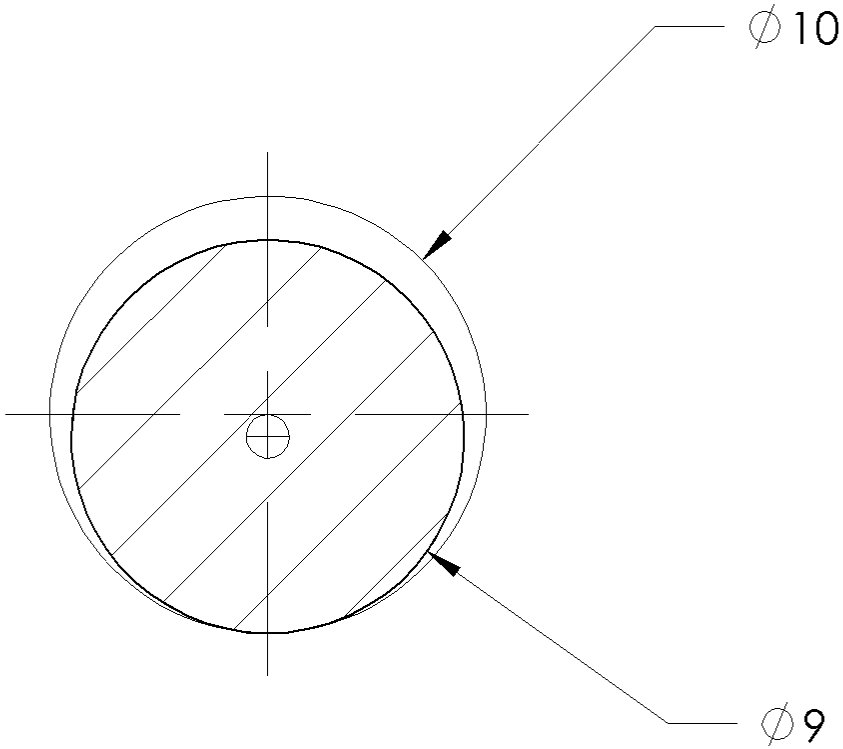
.5mm Displaced MMC Hole



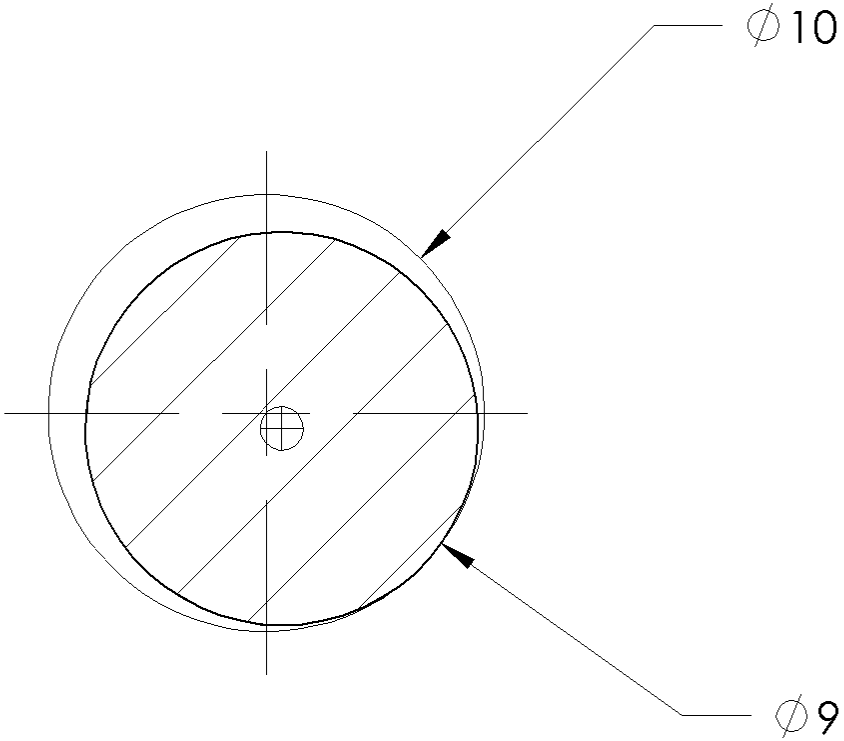
.5mm Displaced MMC Hole



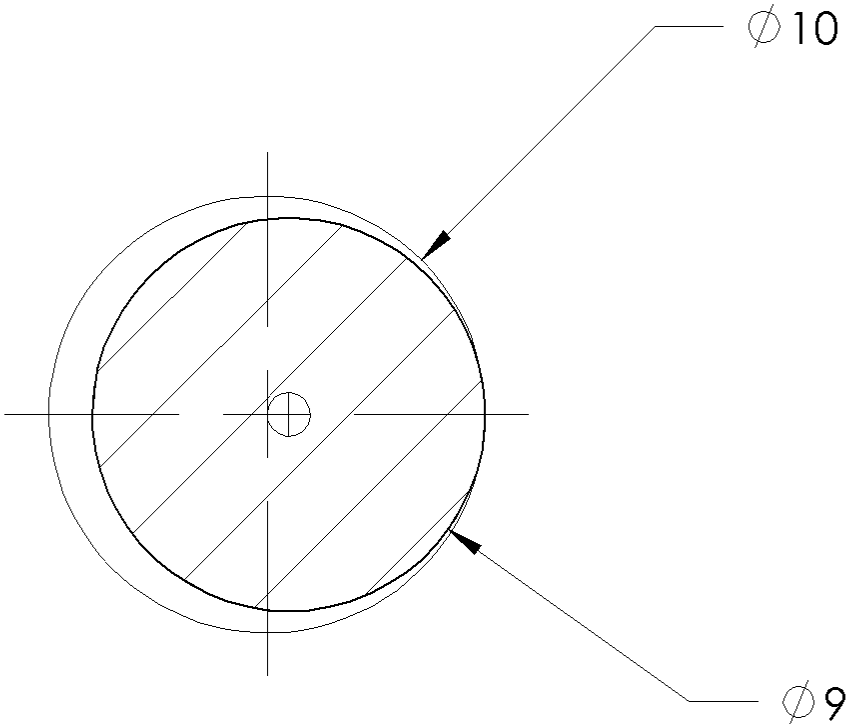
.5mm Displaced MMC Hole



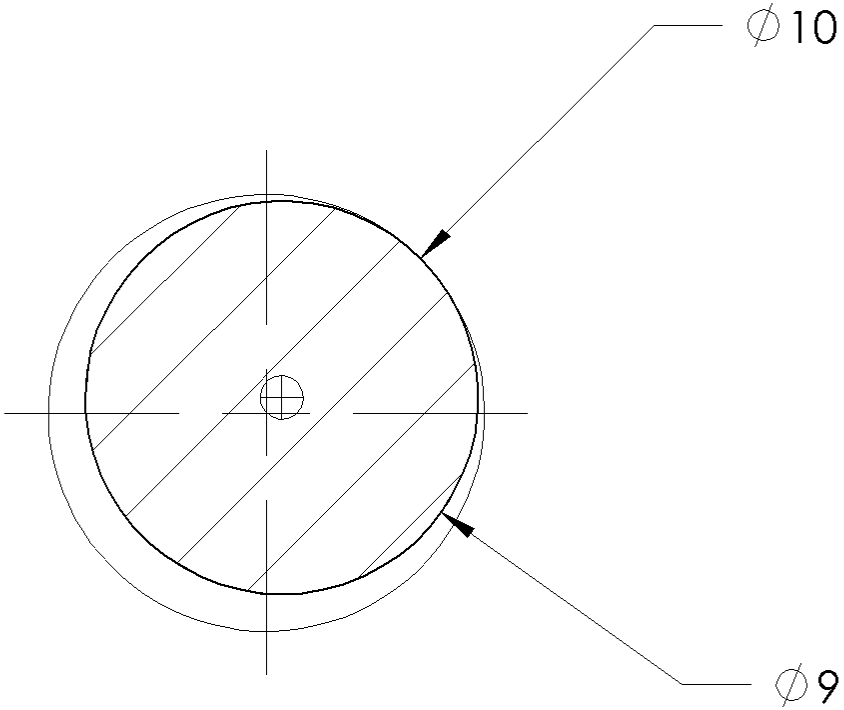
.5mm Displaced MMC Hole



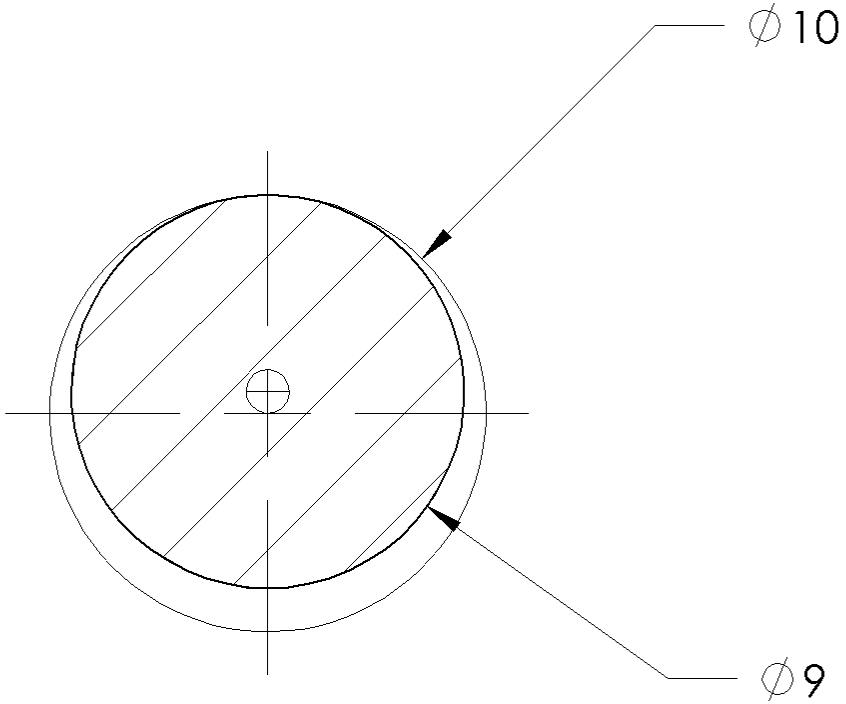
.5mm Displaced MMC Hole



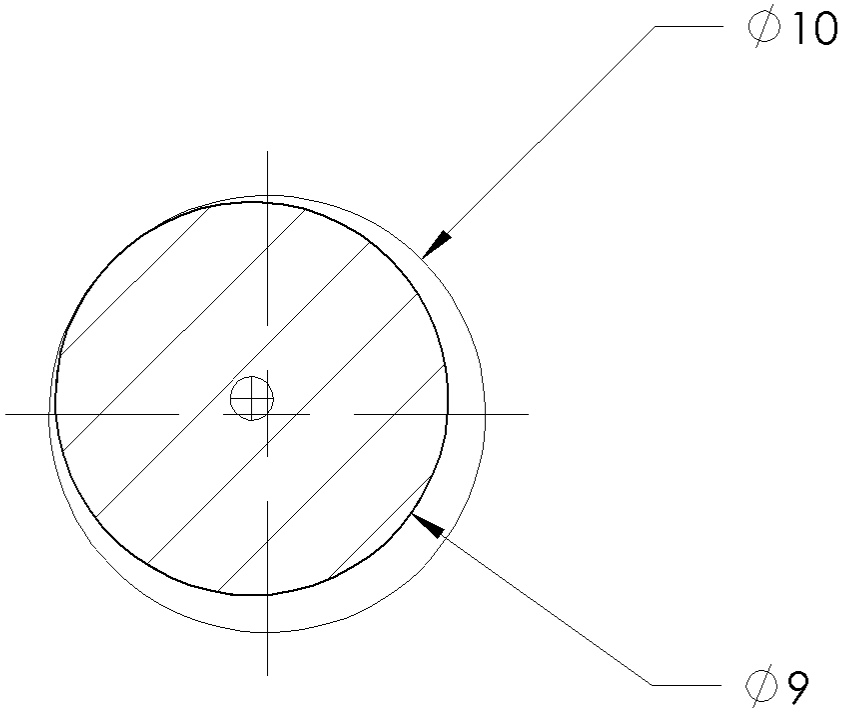
.5mm Displaced MMC Hole



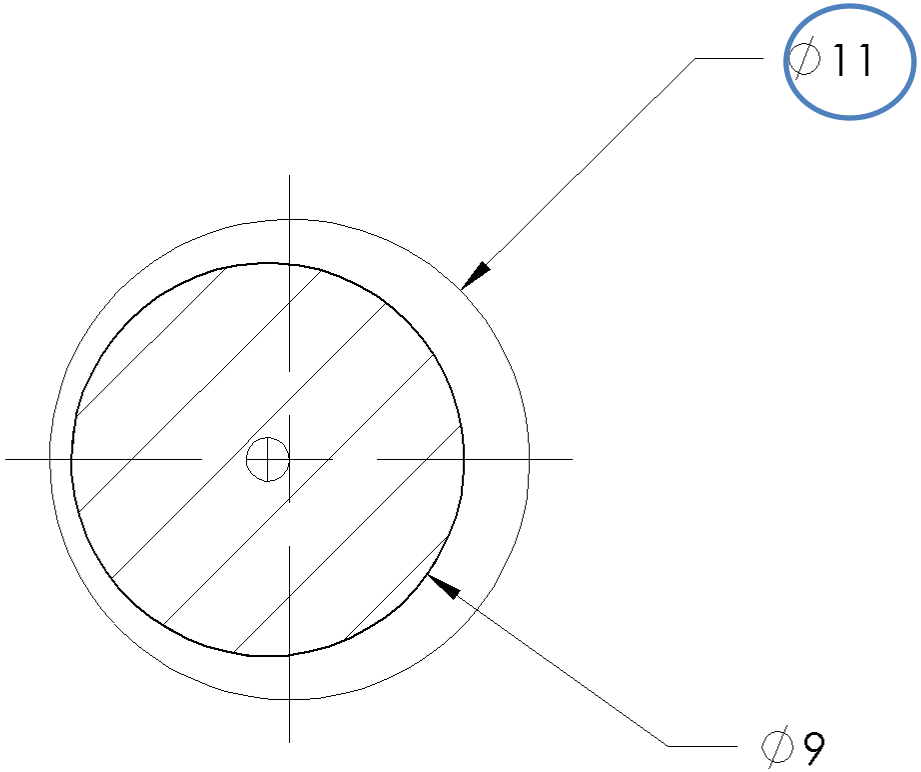
.5mm Displaced MMC Hole



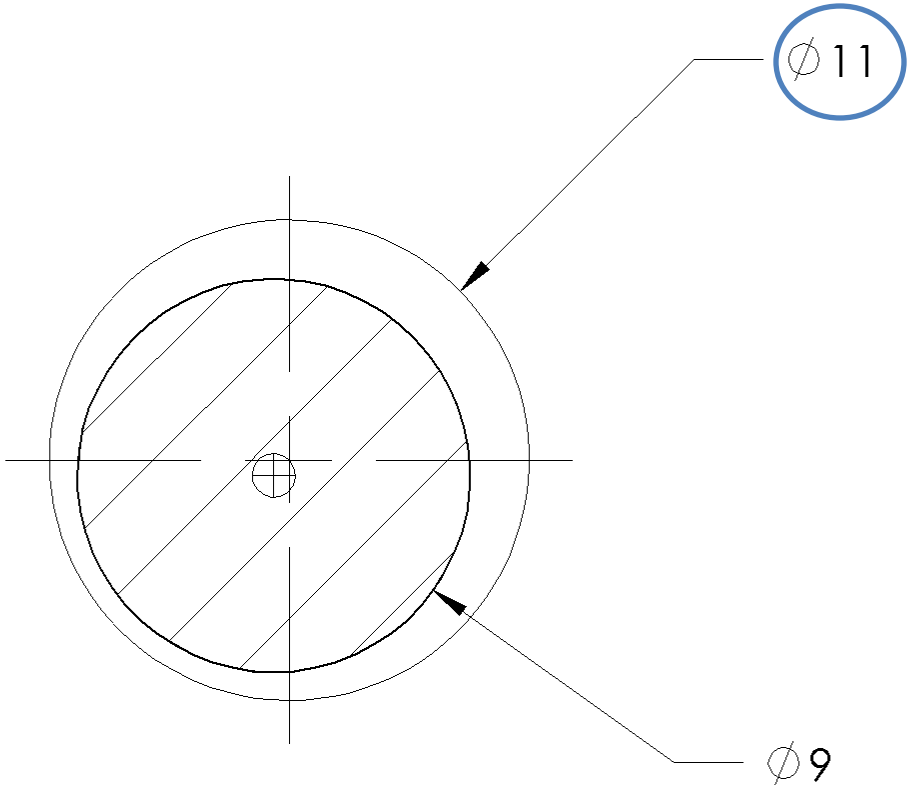
.5mm Displaced MMC Hole



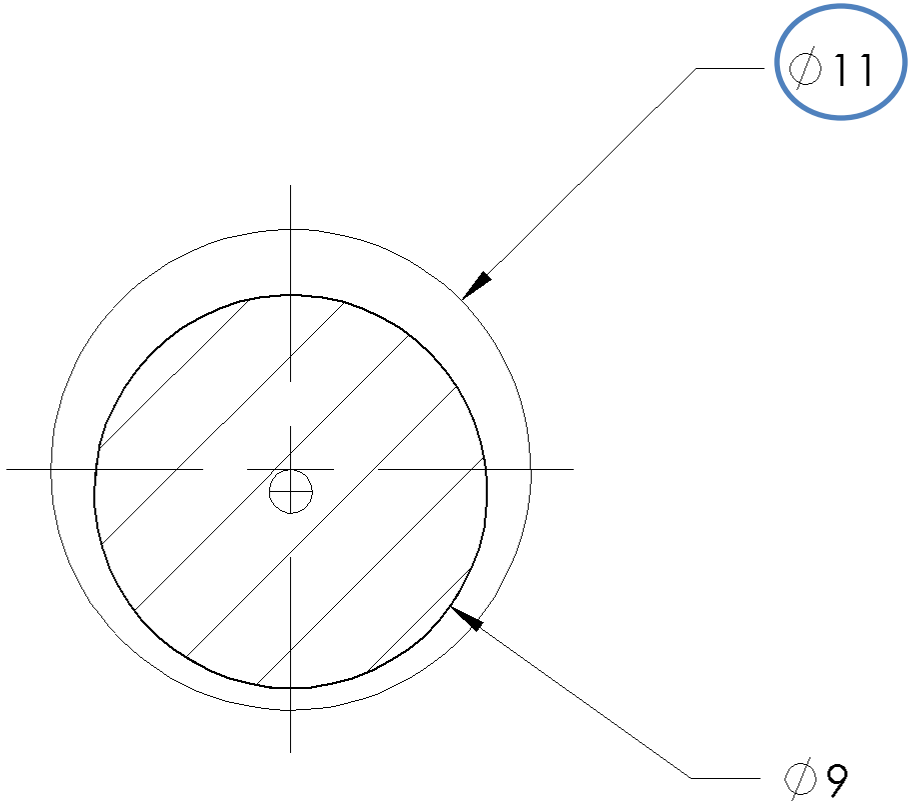
Larger Hole



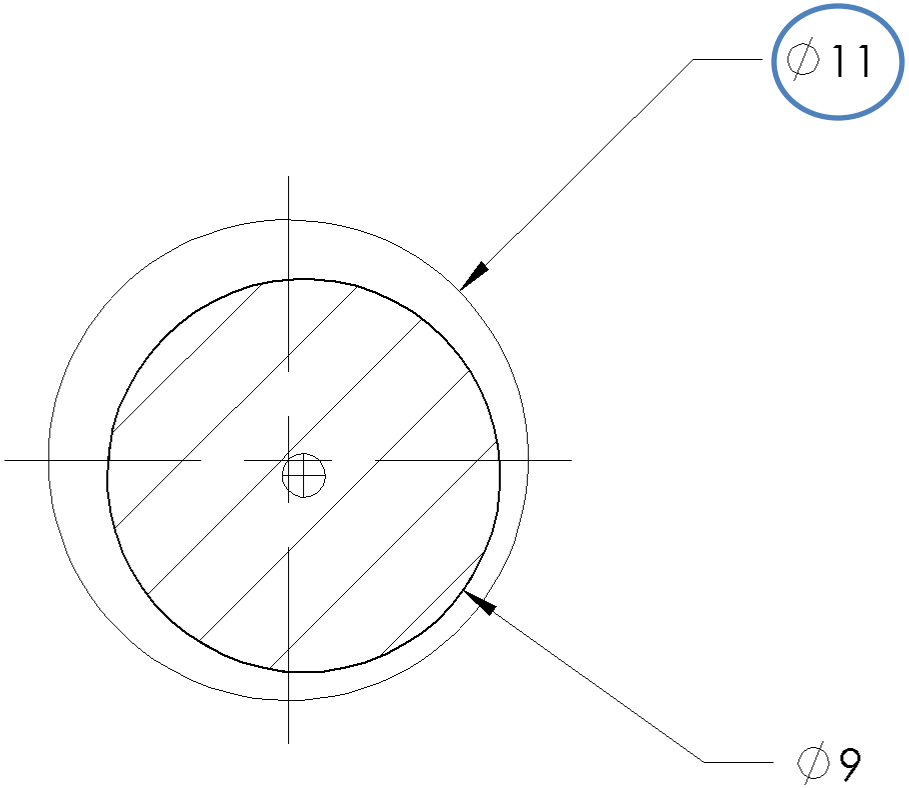
Larger Hole



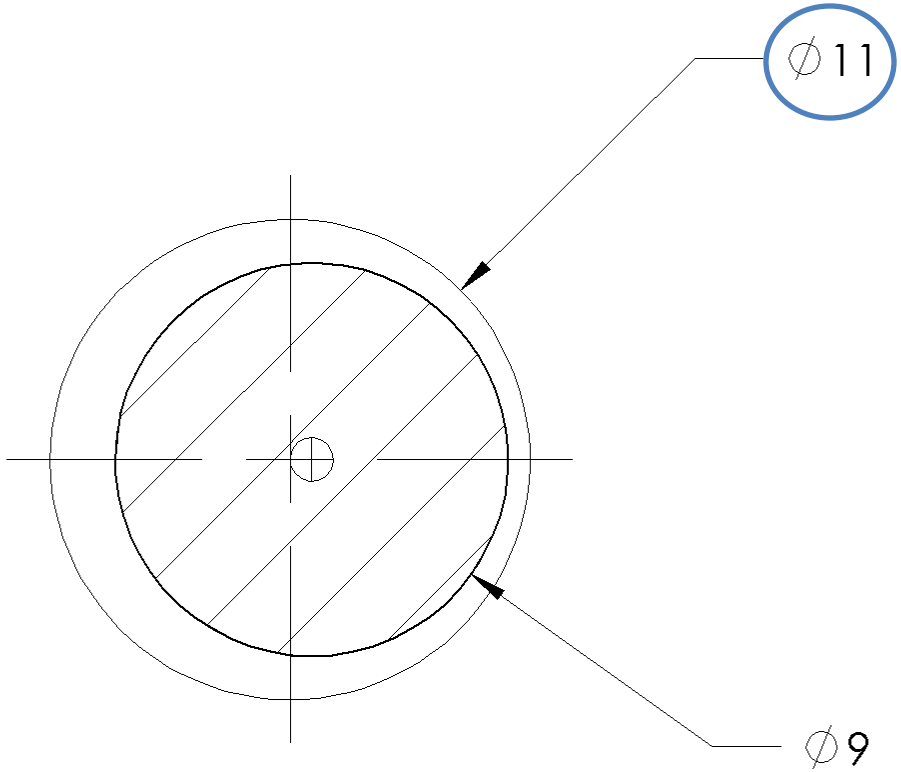
Larger Hole



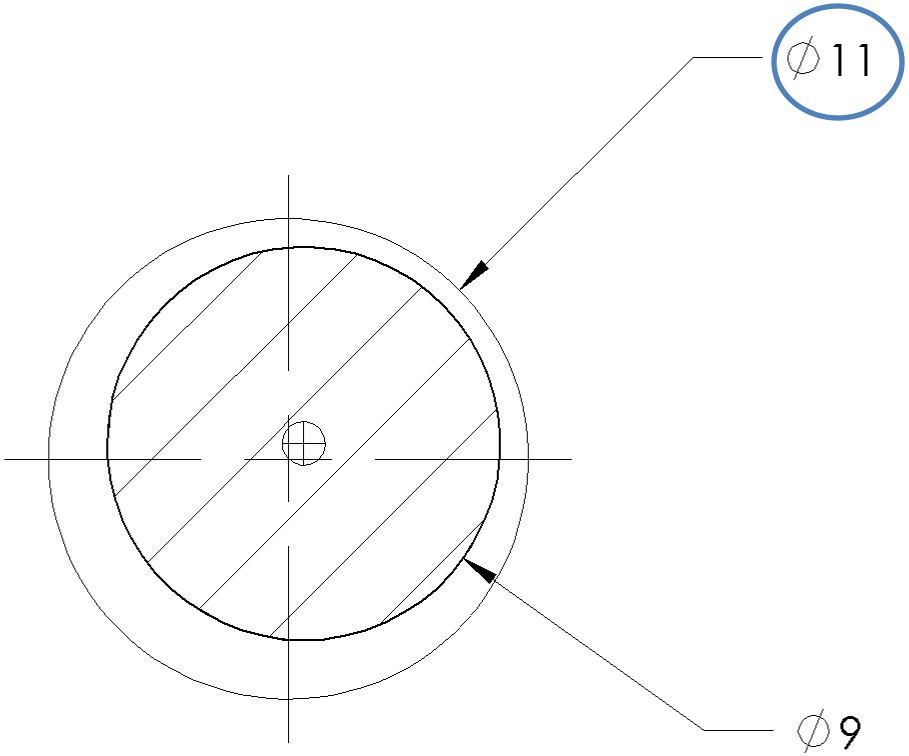
Larger Hole



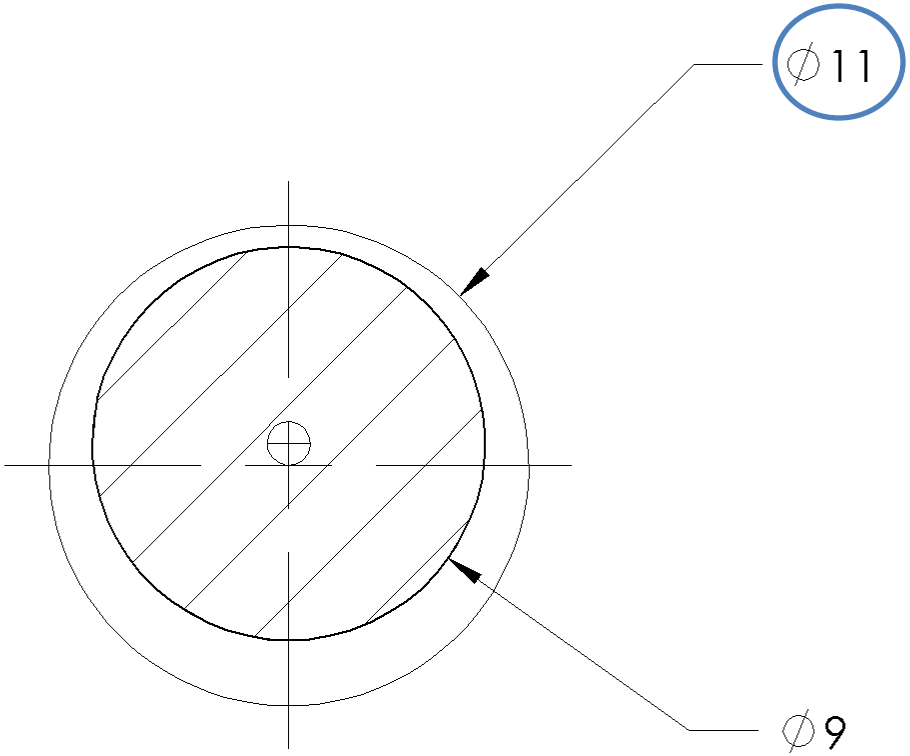
Larger Hole



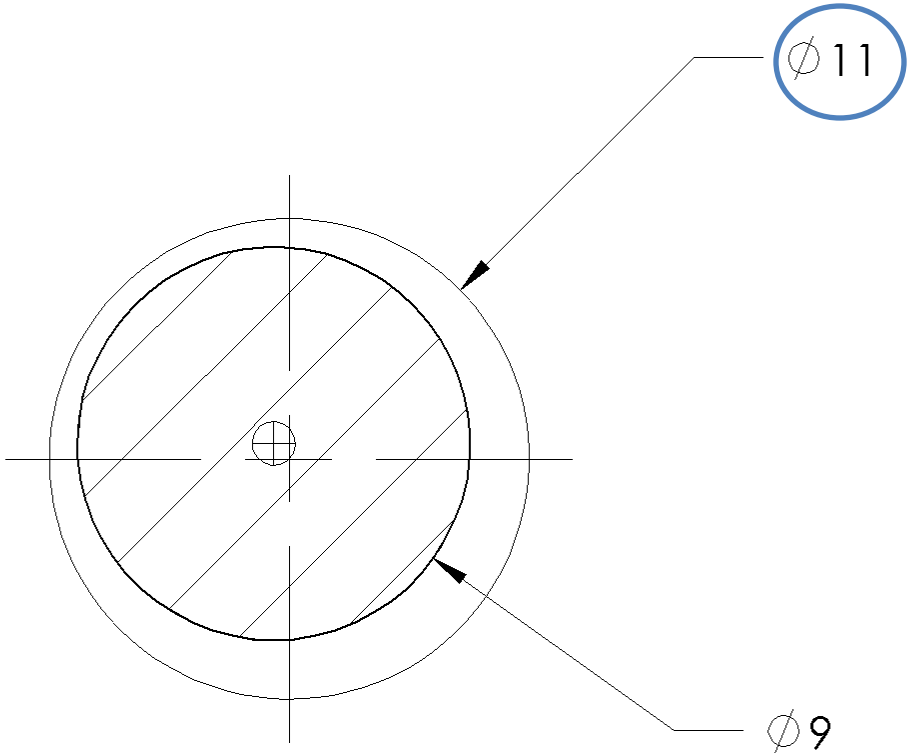
Larger Hole



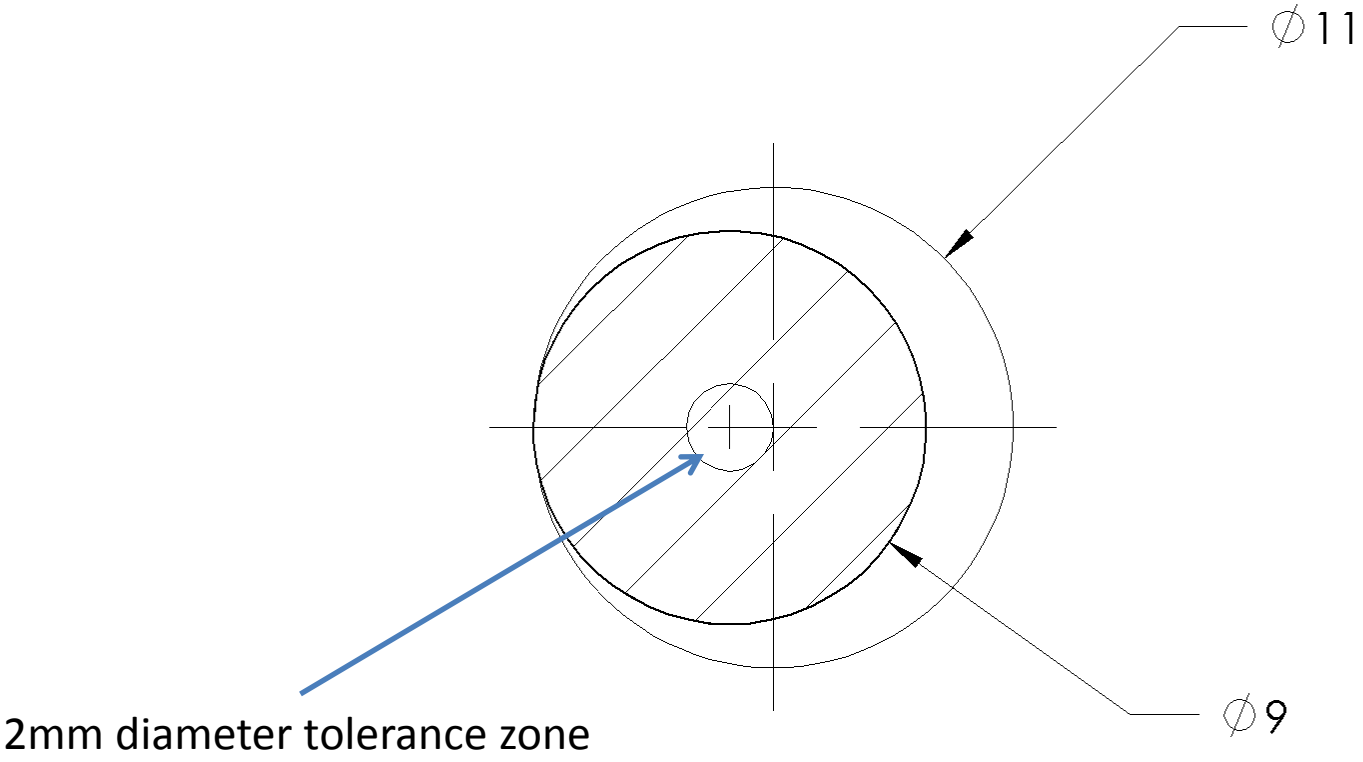
Larger Hole



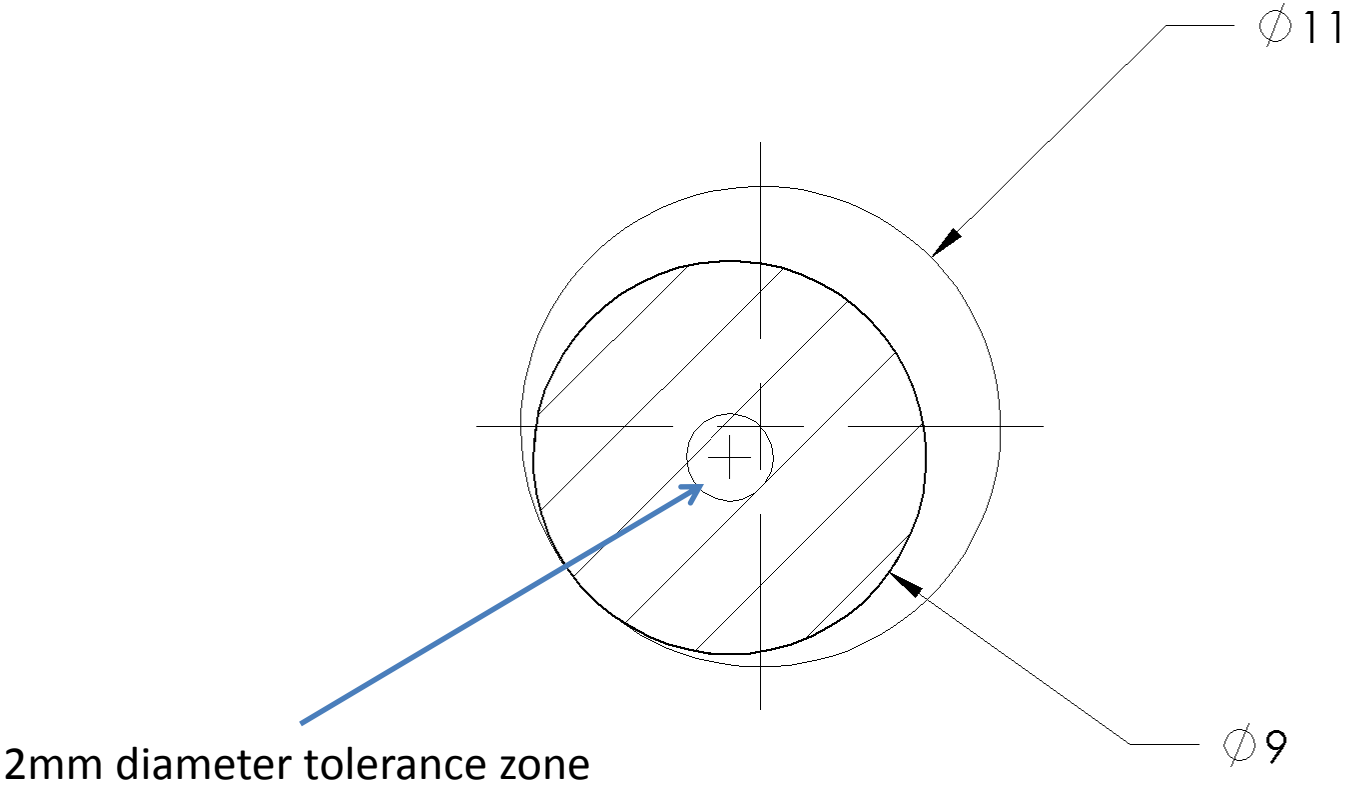
Larger Hole



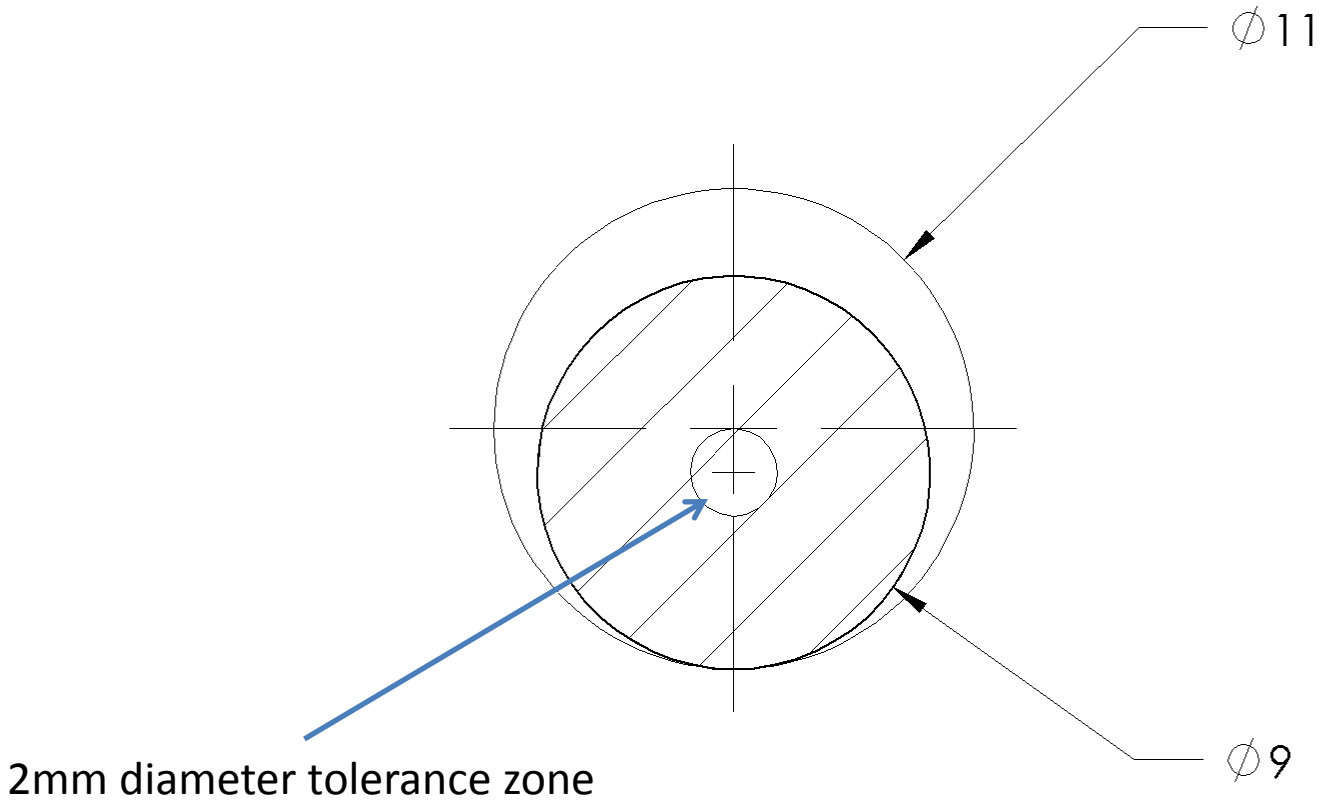
Larger Hole, Larger Tolerance



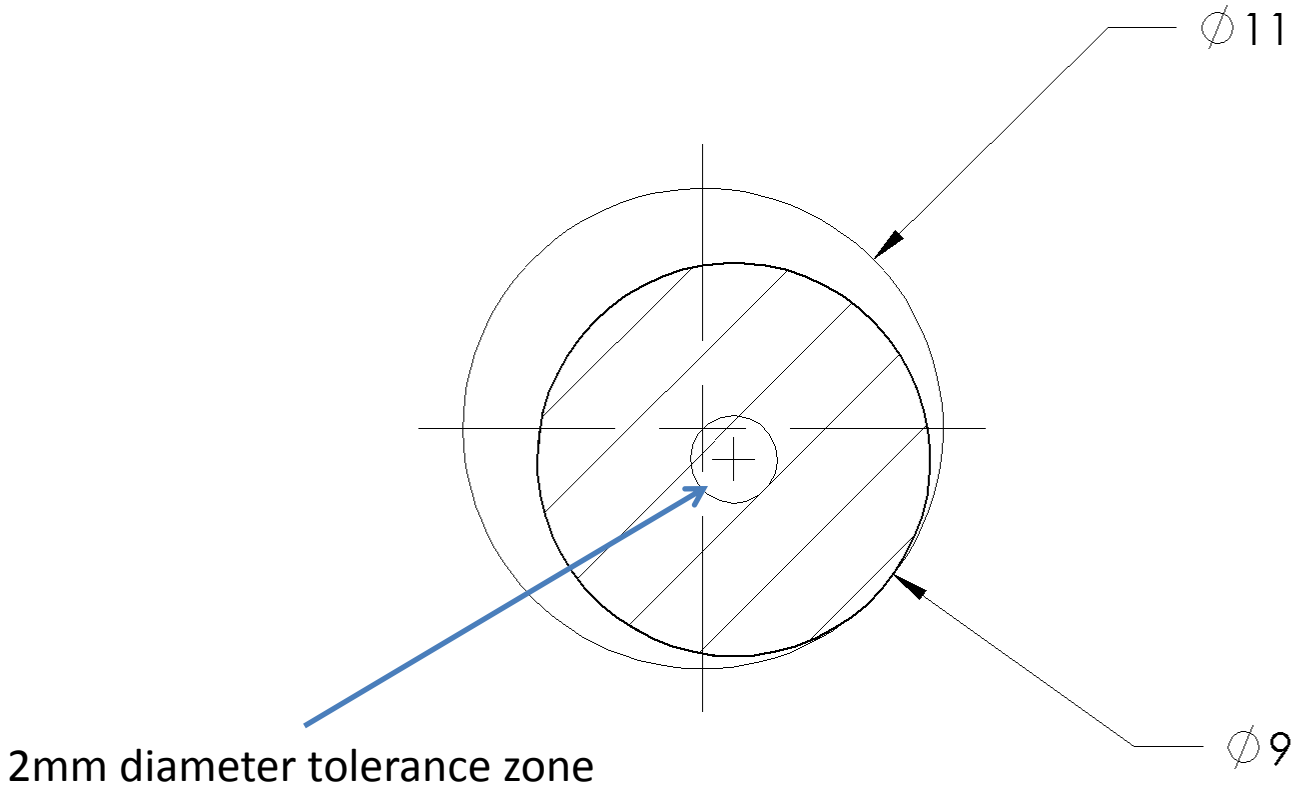
Larger Hole, Larger Tolerance



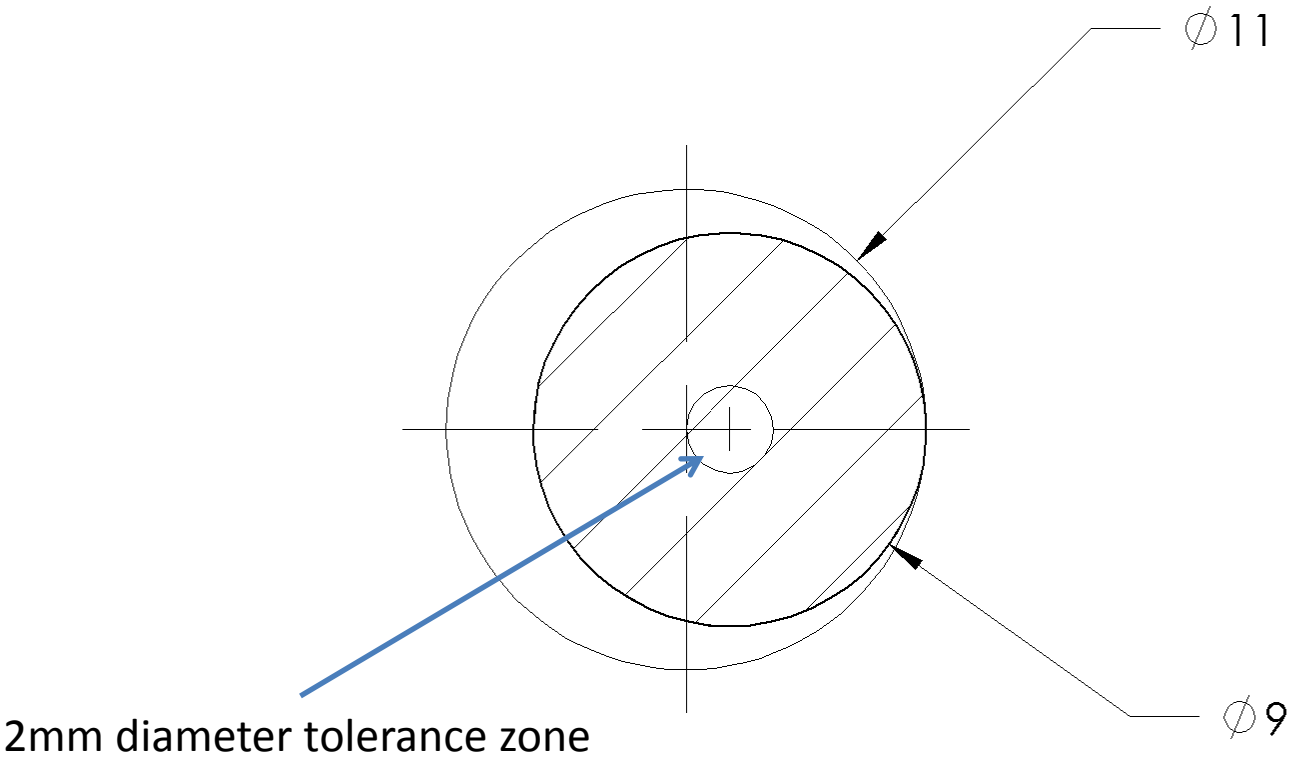
Larger Hole, Larger Tolerance



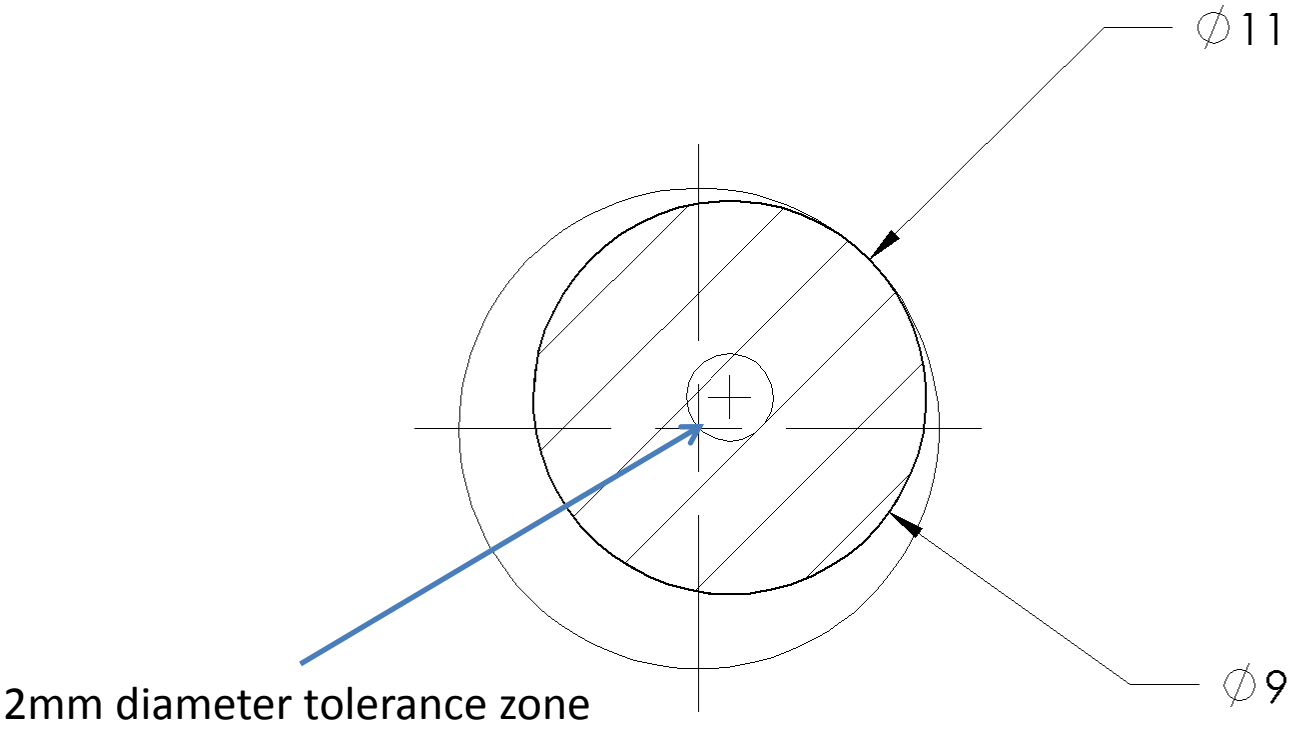
Larger Hole, Larger Tolerance



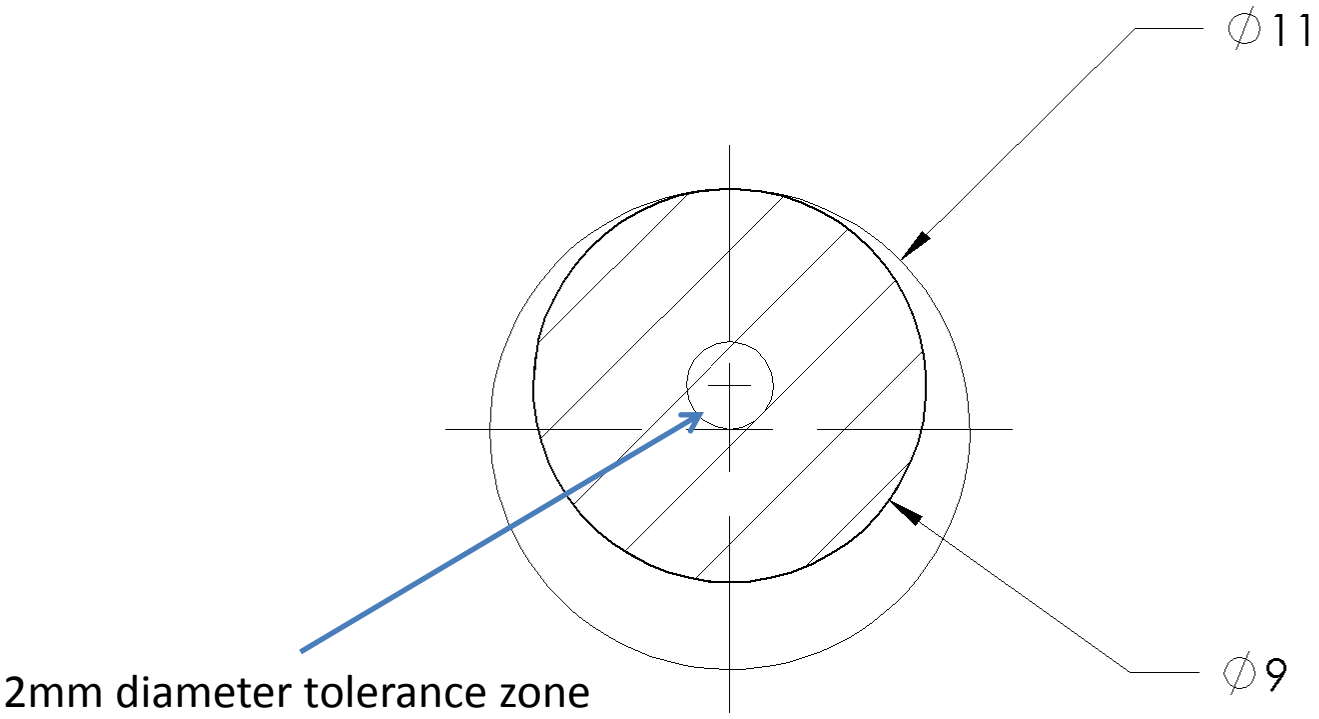
Larger Hole, Larger Tolerance



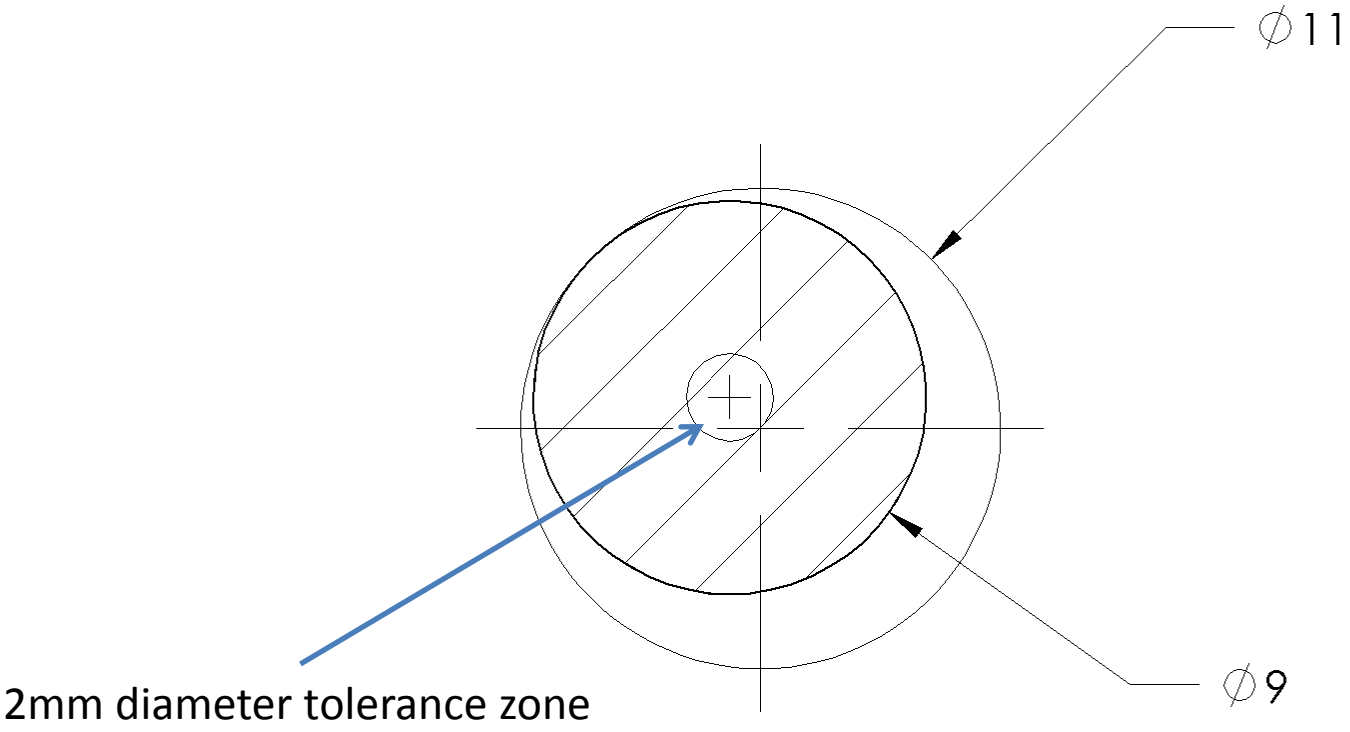
Larger Hole, Larger Tolerance



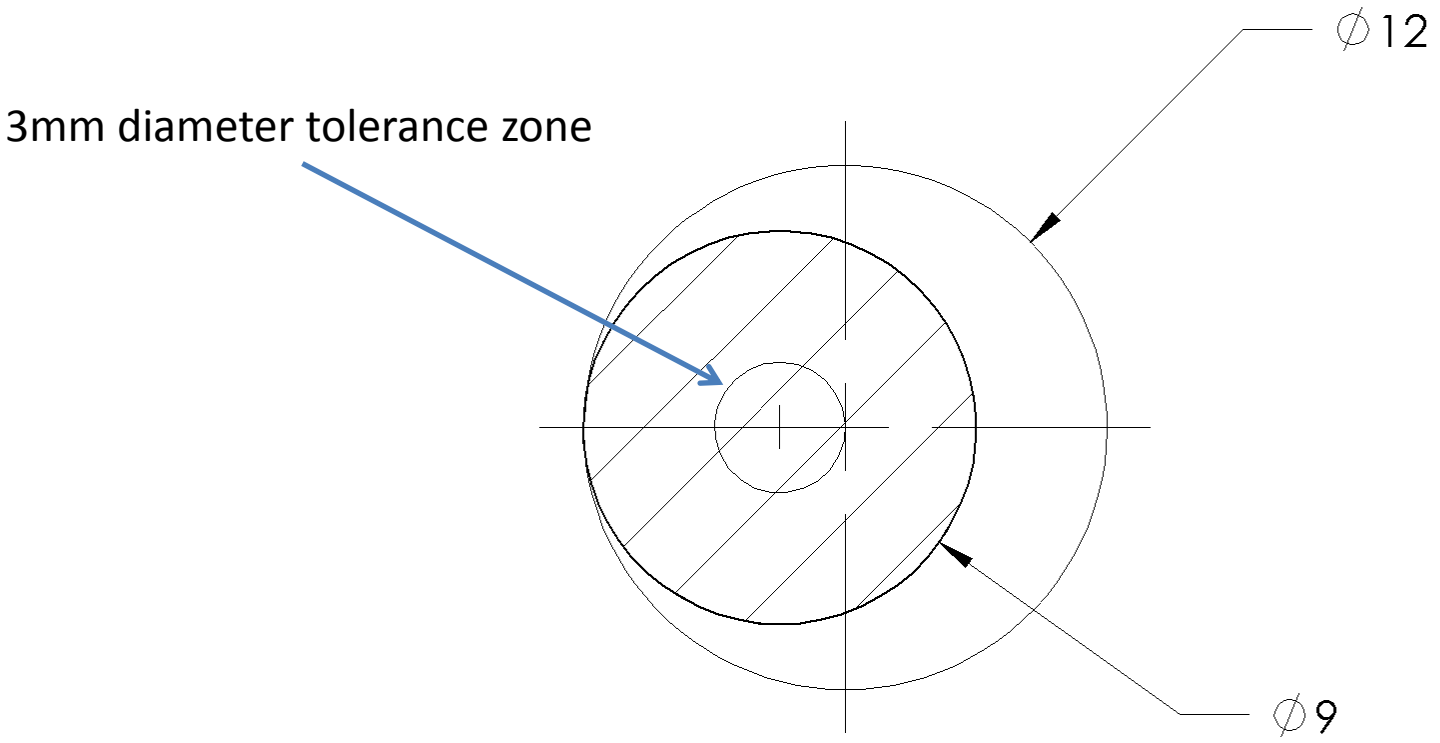
Larger Hole, Larger Tolerance



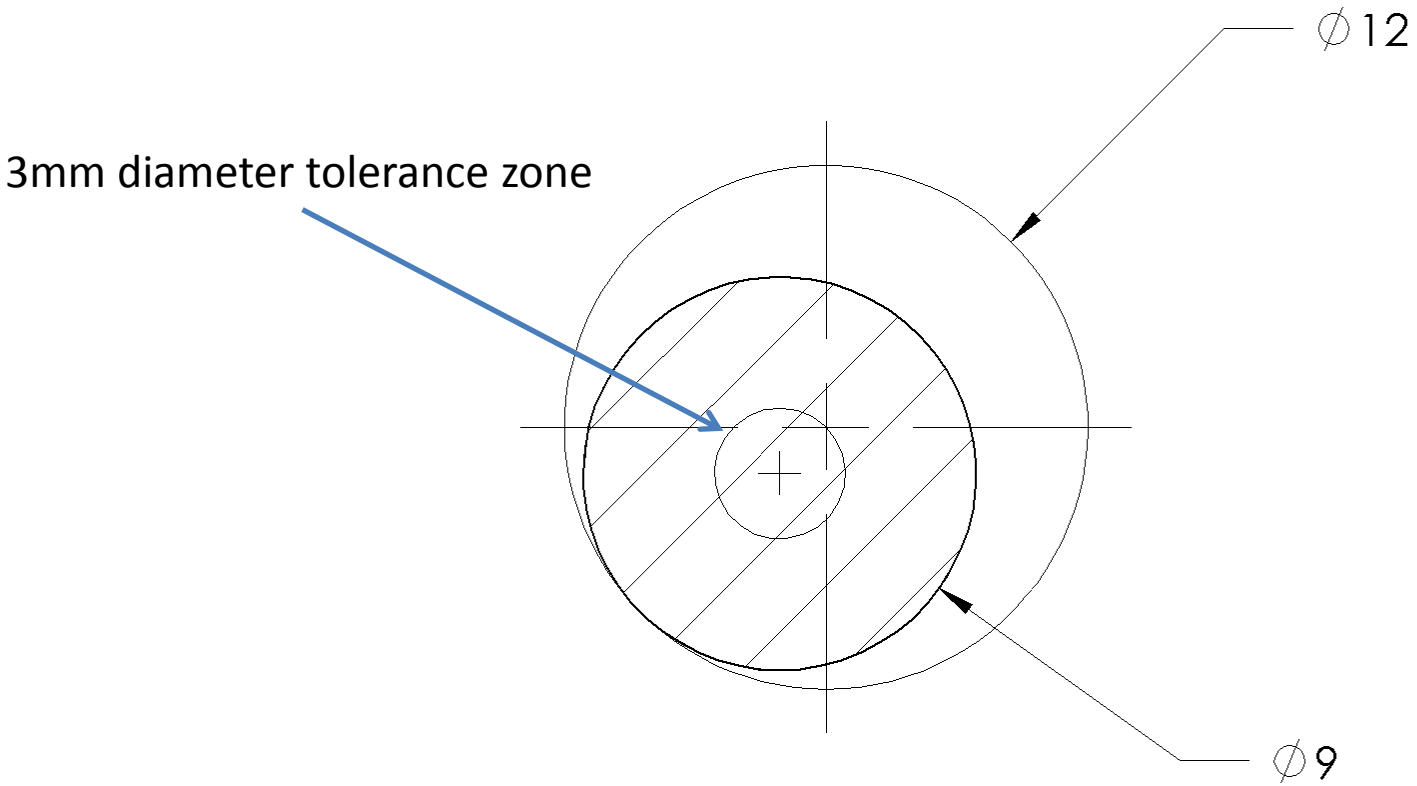
Larger Hole, Larger Tolerance



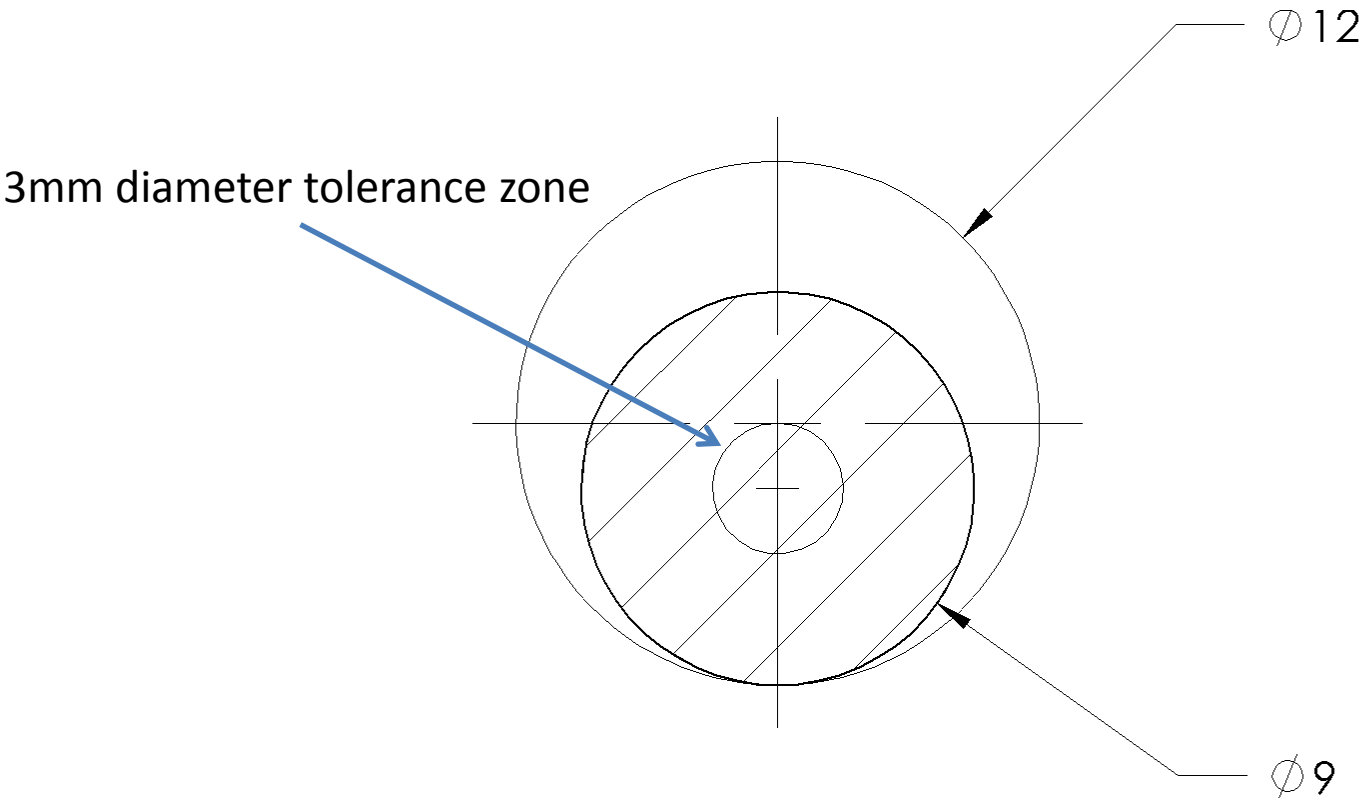
LMC Hole



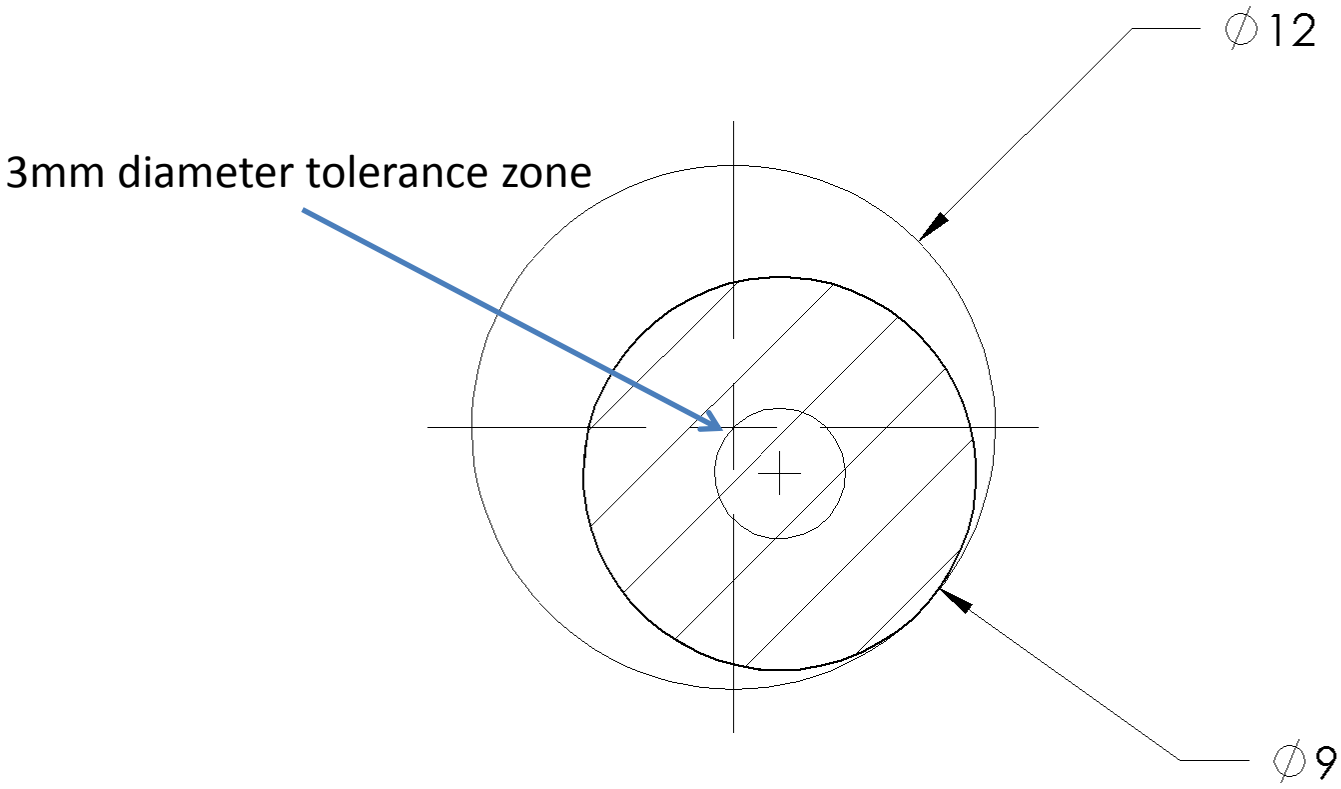
LMC Hole



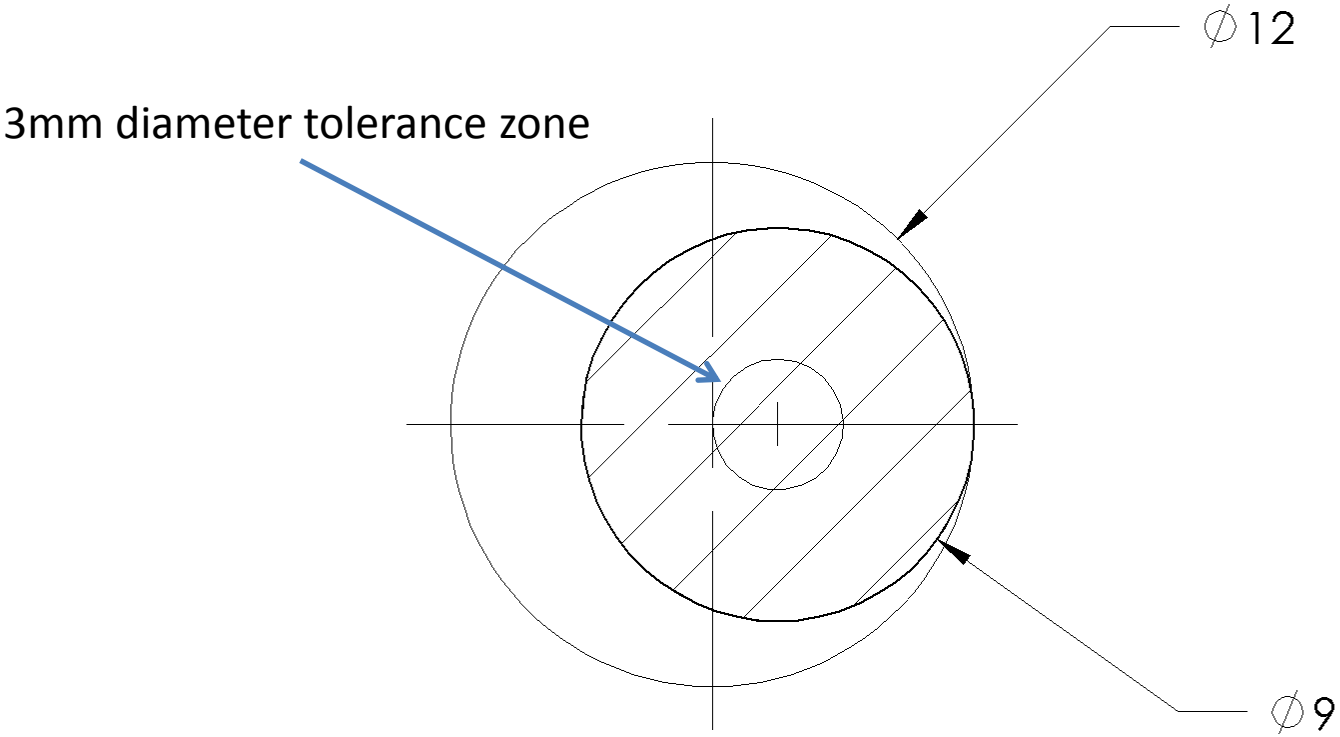
LMC Hole



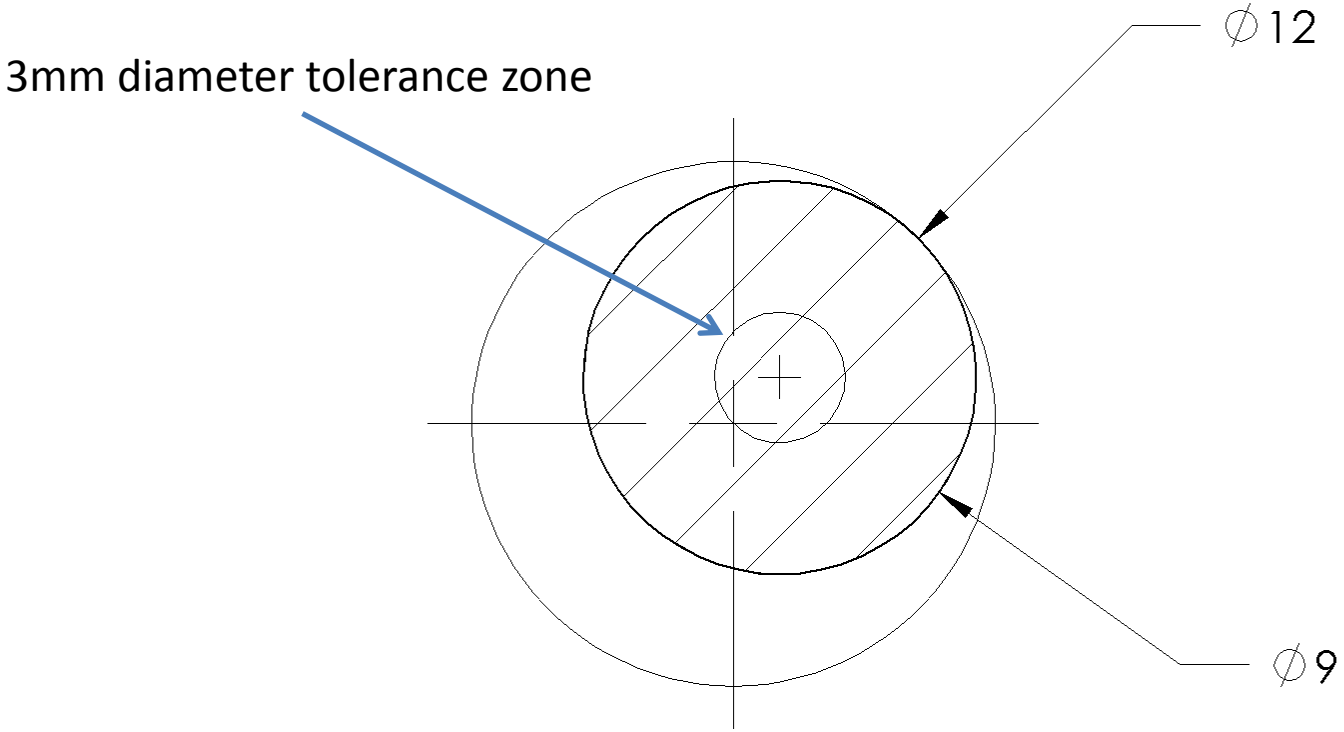
LMC Hole



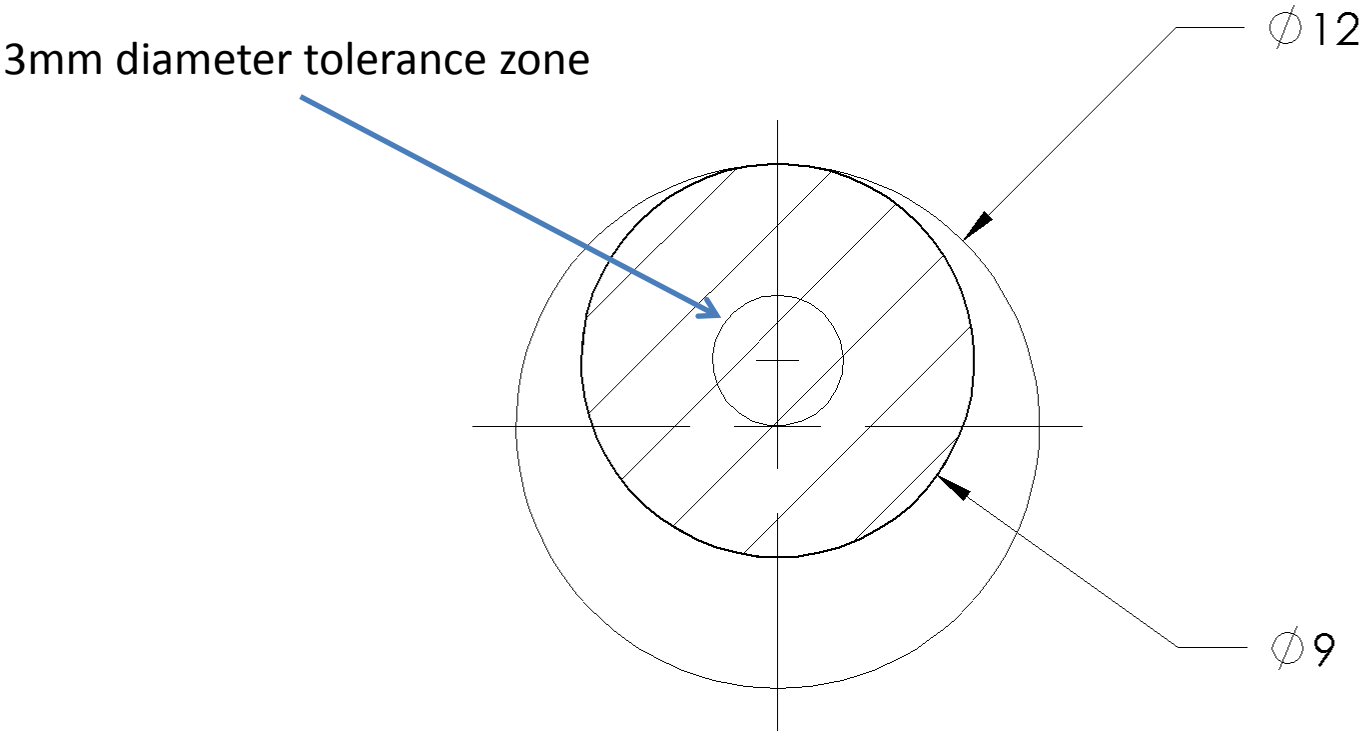
LMC Hole



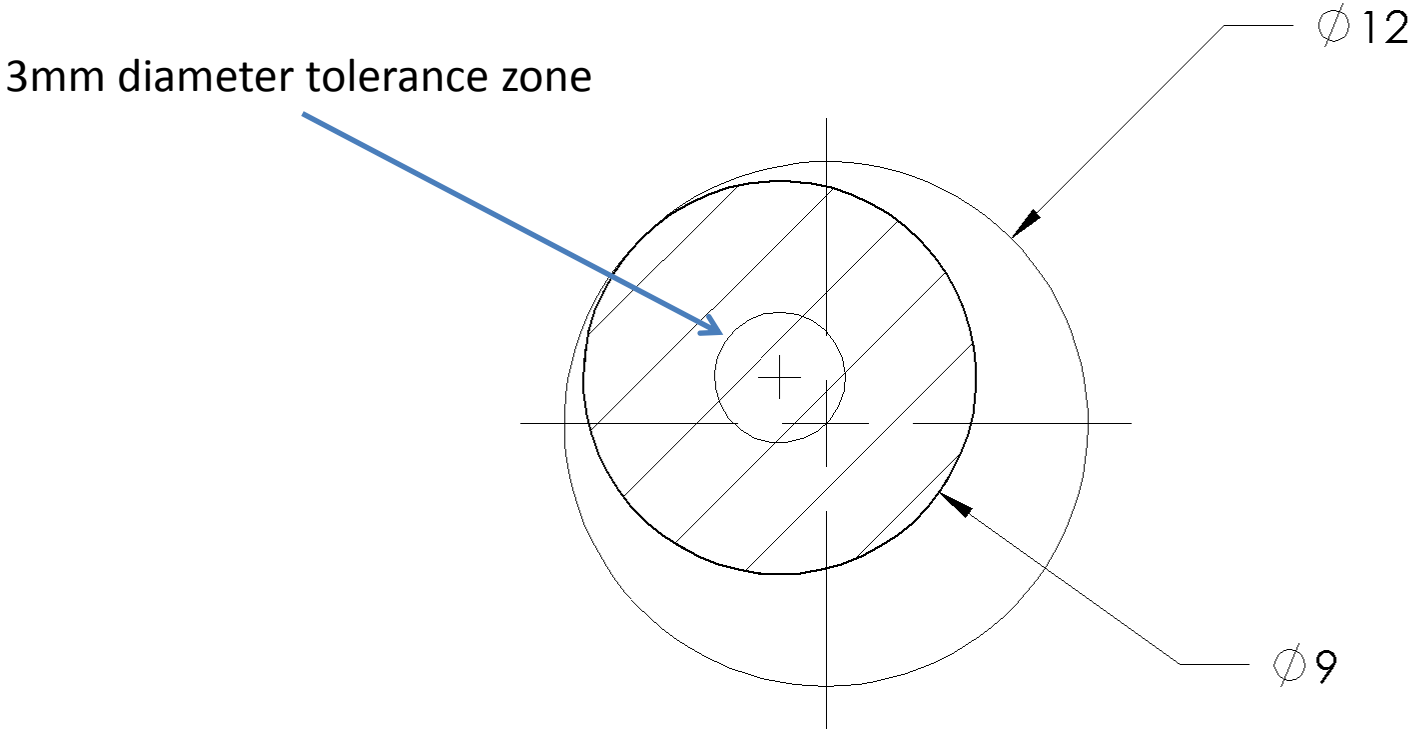
LMC Hole



LMC Hole

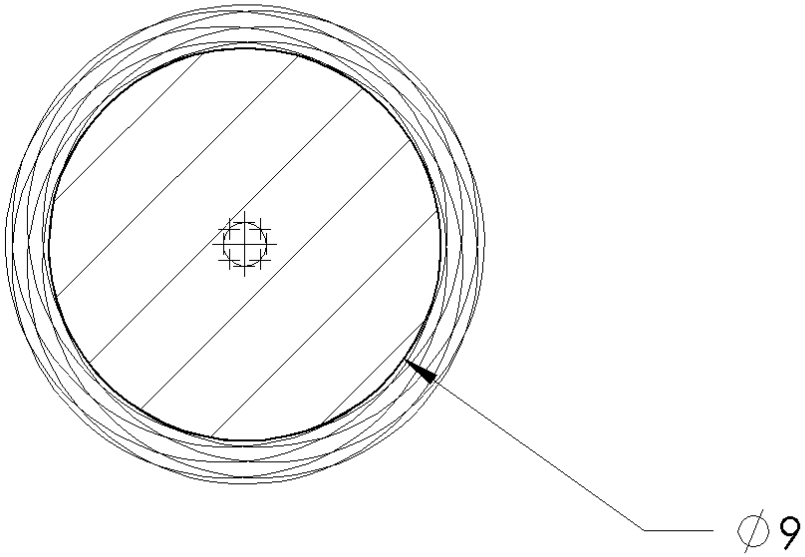


LMC Hole



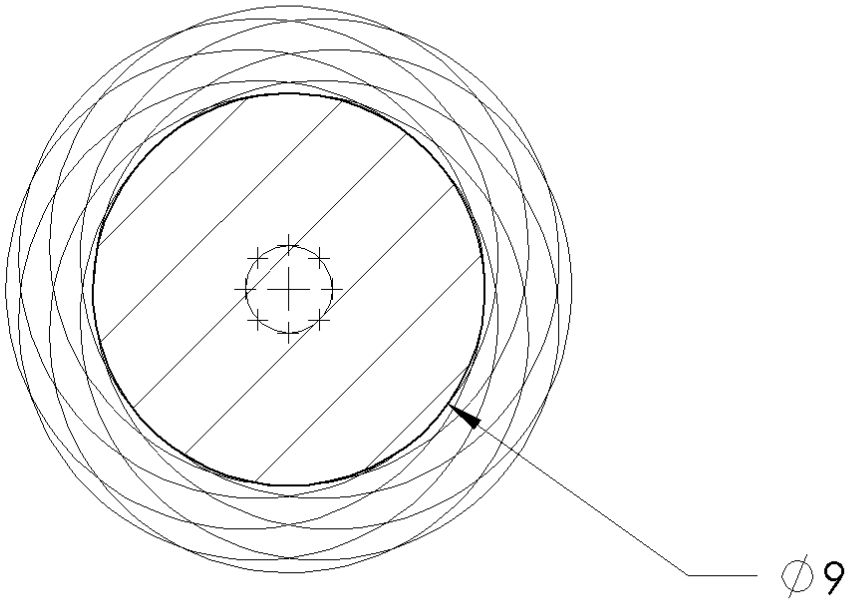
MMC Hole

10mm diameter hole
1mm diameter tolerance zone



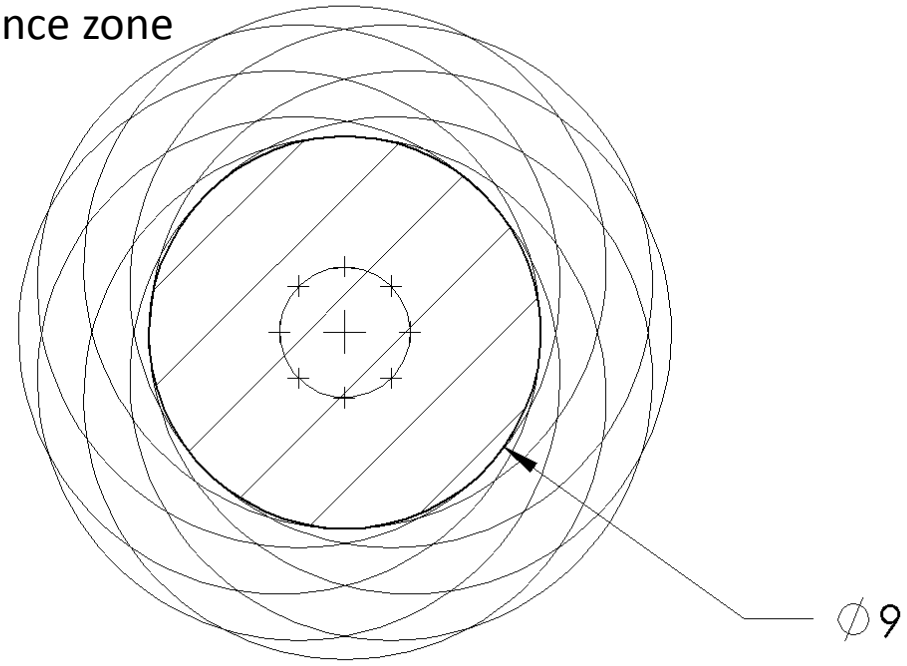
Larger Hole

11mm diameter hole
2mm diameter tolerance zone

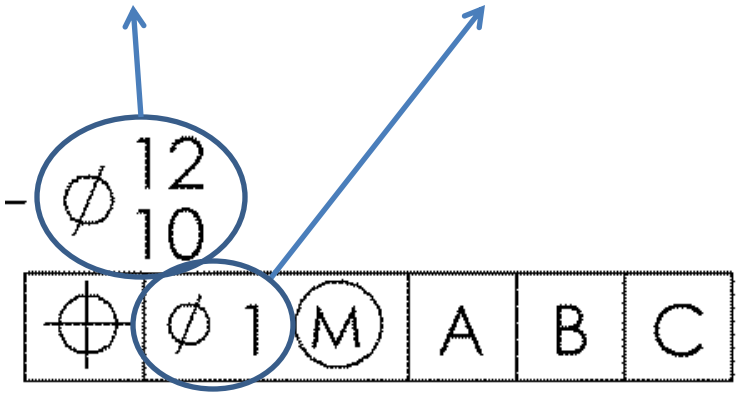


LMC Hole

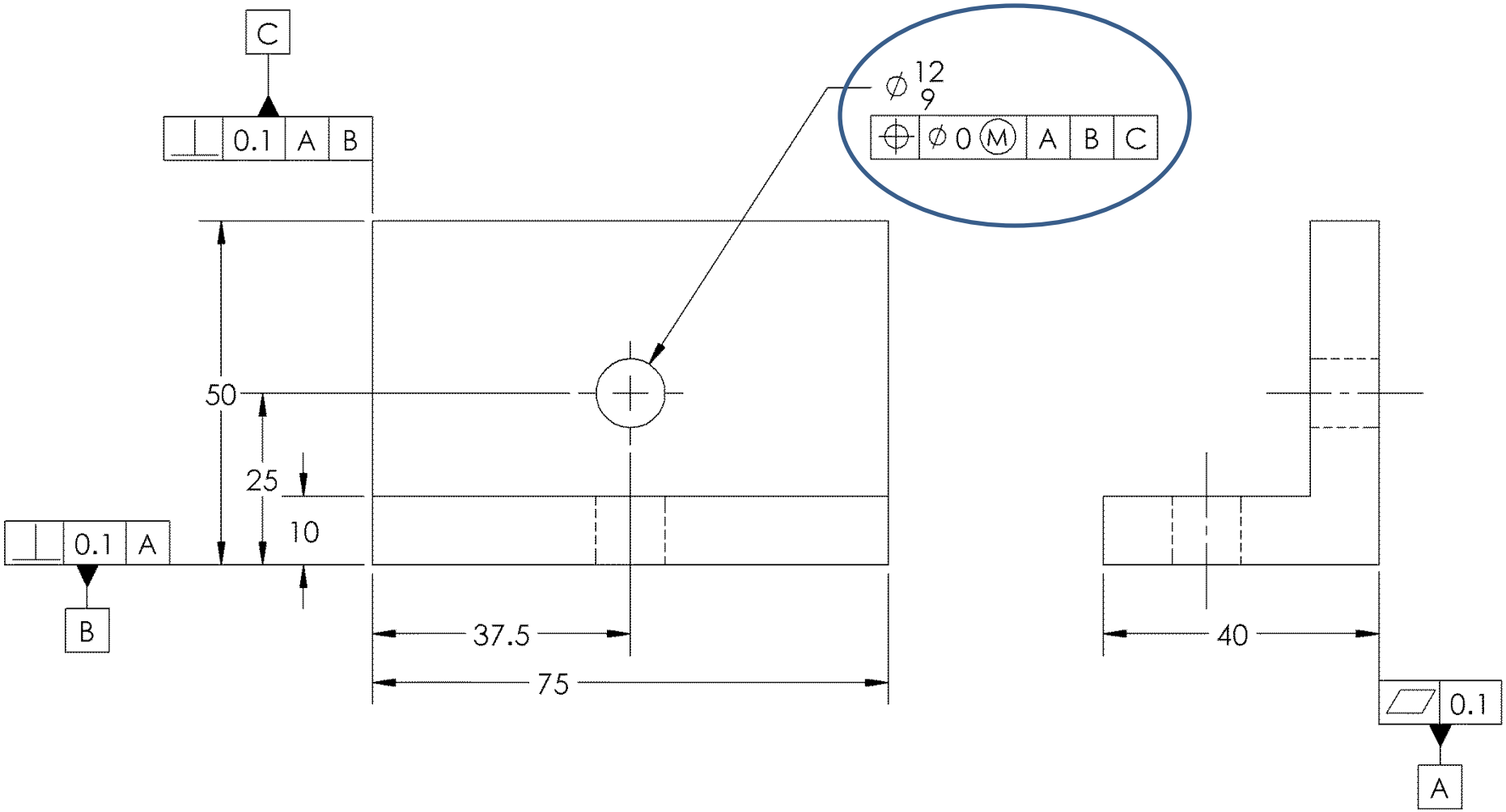
12mm diameter hole
3mm diameter tolerance zone



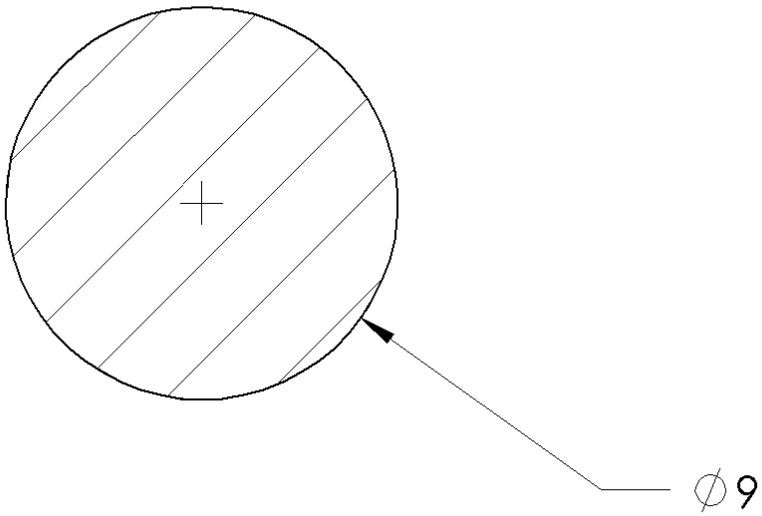
	Hole Diameter	Position Tolerance
MMC	10	1
	11	2
LMC	12	3

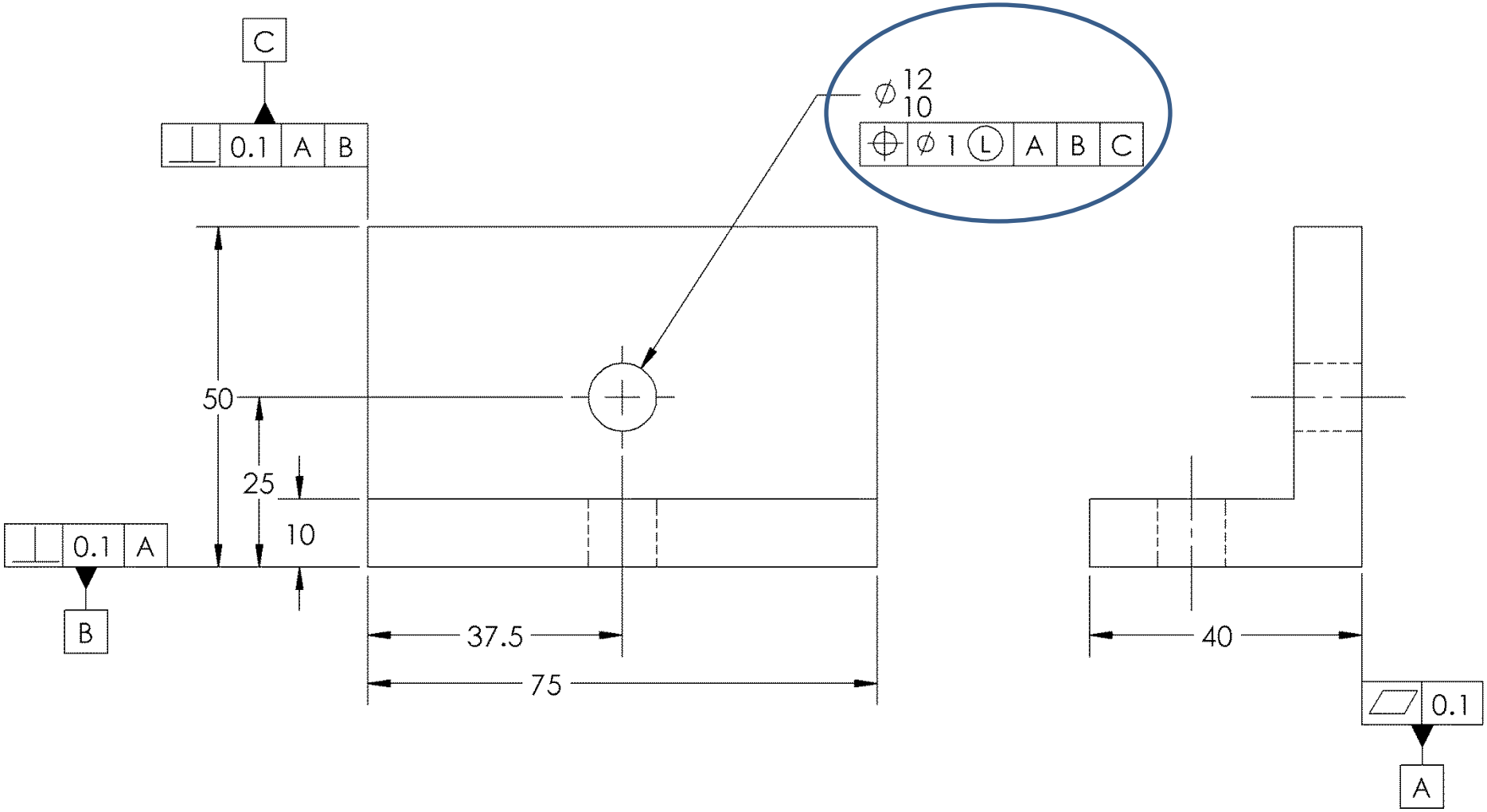


As the hole diameter increases from MMC within the limits of size the position tolerance will increase by the same amount

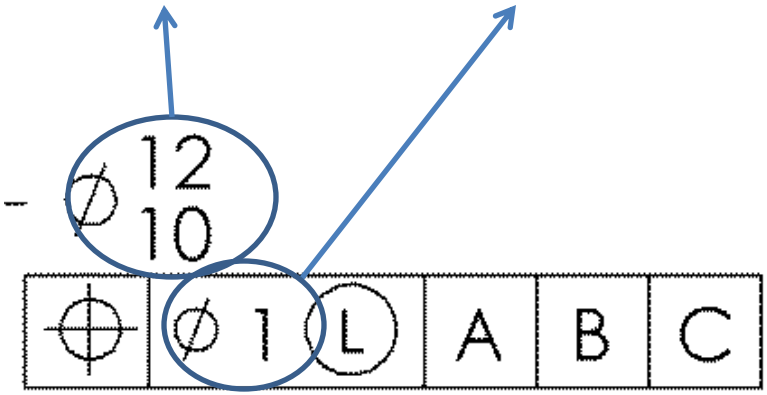

C
0.1 A B
⌀ 12 9
⌀ 0 M A B C
50
25
10
0.1 A
B
37.5
75
40
0.1
A

∅0 MMC




C
0.1 A B
⌀12
10
⌖ ⌀1 L A B C
50
25
10
0.1 A
B
37.5
75
40
0.1
A

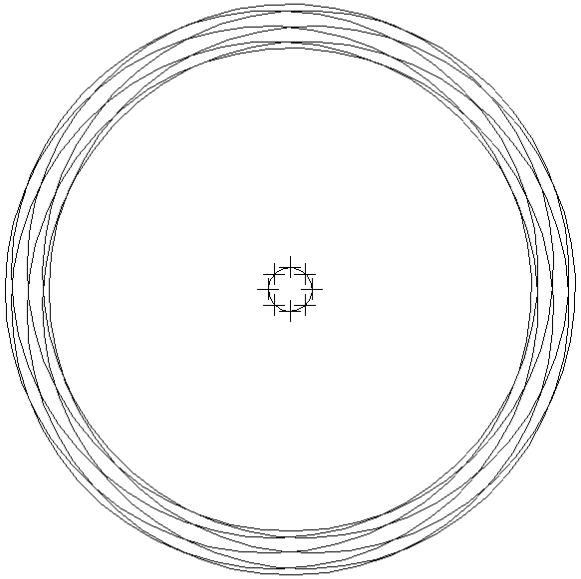
	Hole Diameter	Position Tolerance
MMC	10	3
	11	2
LMC	12	1



As the hole diameter increases from LMC within the limits of size the position tolerance will increase by the same amount

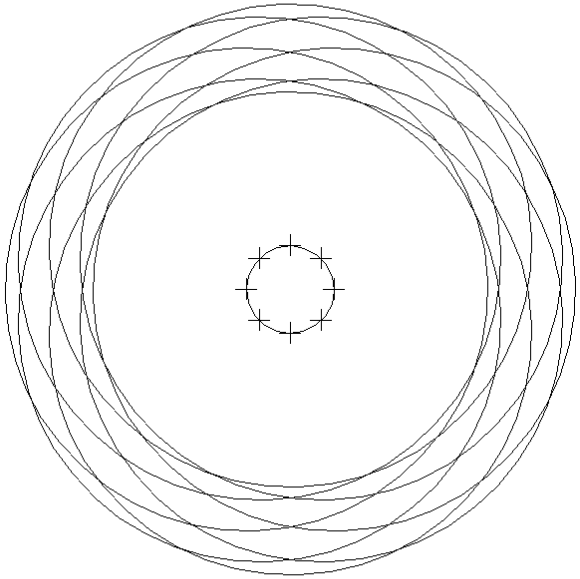
LMC Tolerance

12mm diameter hole
1mm diameter tolerance zone



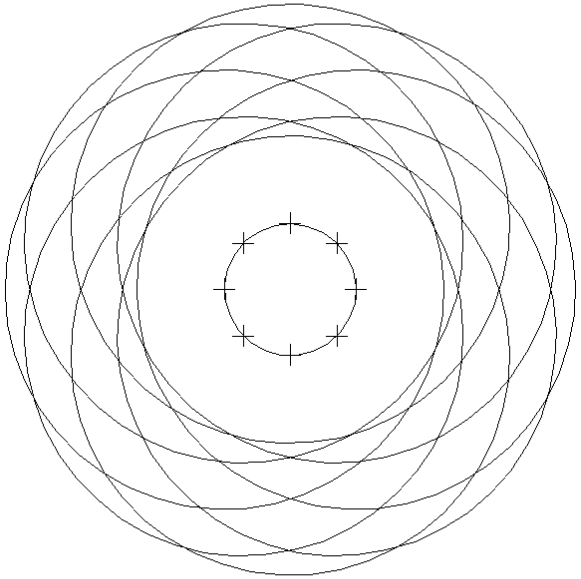
LMC Tolerance

11mm diameter hole
2mm diameter tolerance zone



LMC Tolerance

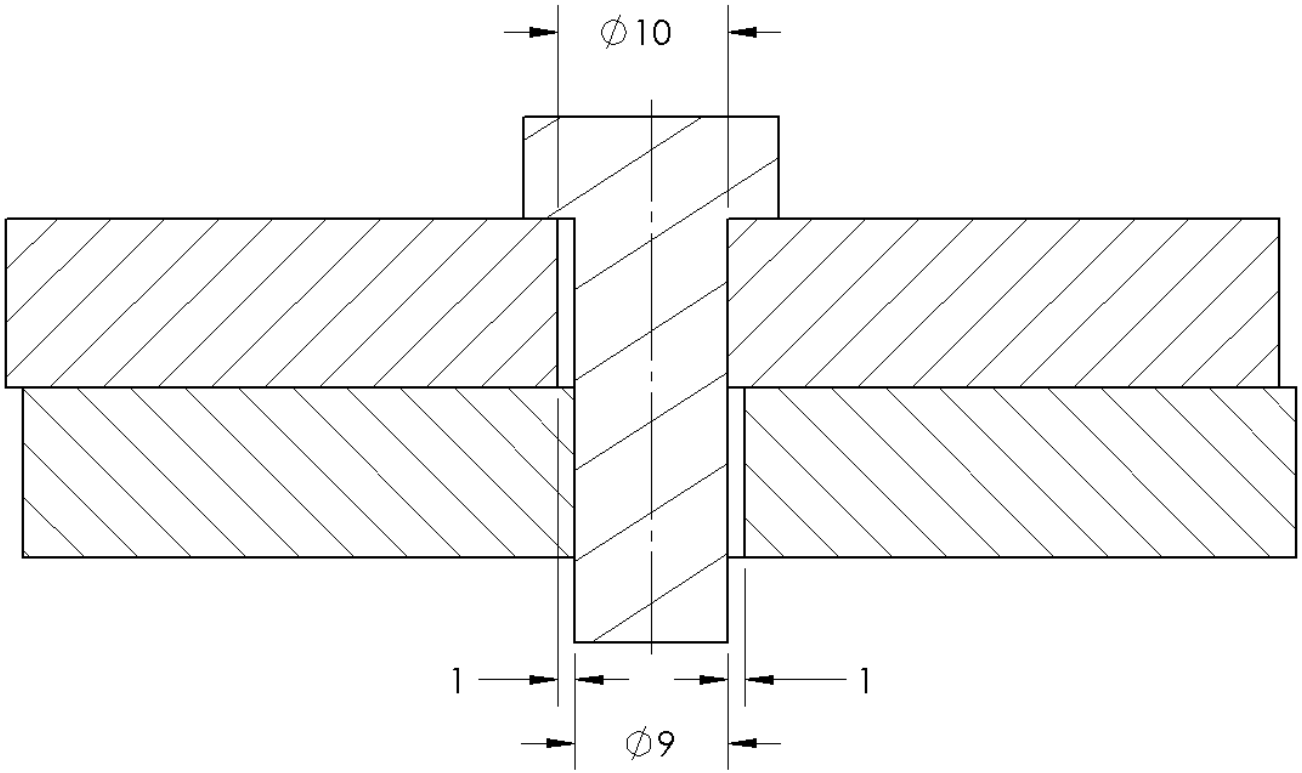
10mm diameter hole
3mm diameter tolerance zone



Where Do the Numbers Come From?

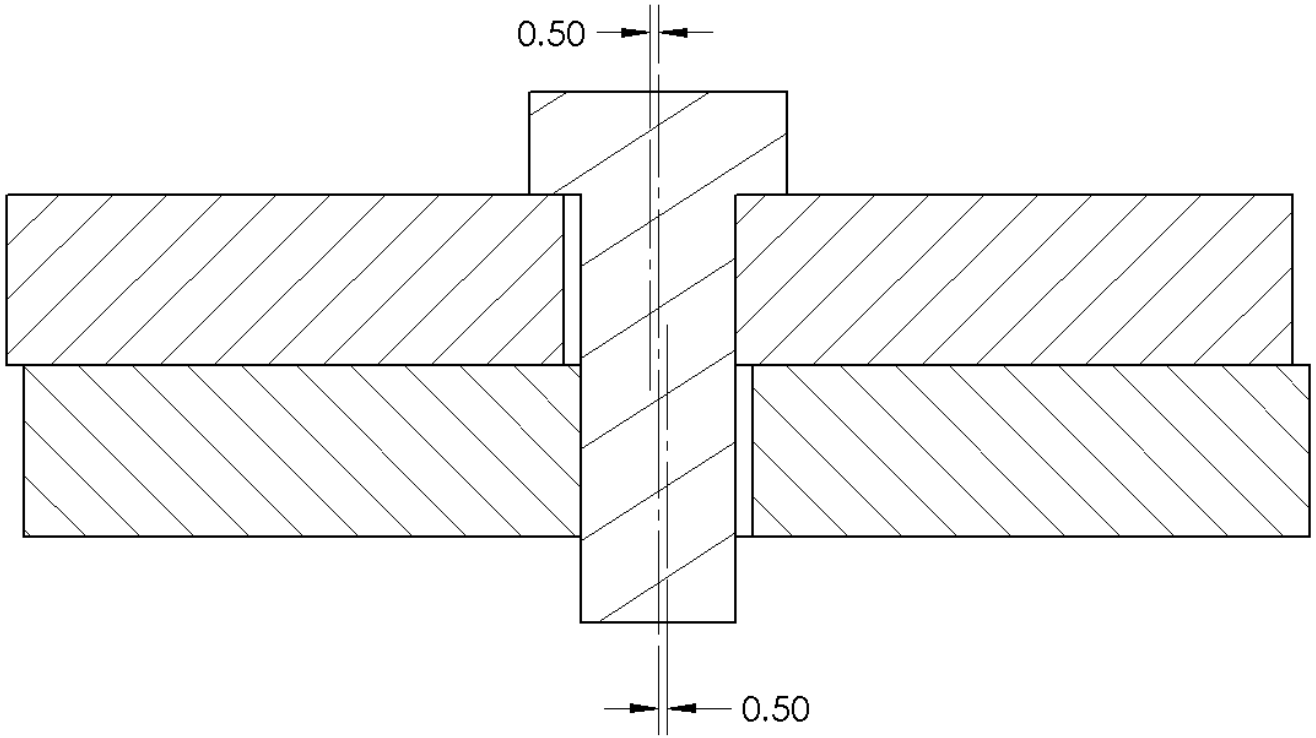
- Calculations
  - Engineering
  - Fit (See Section 16-17)
- Empirical Data
- Cp, Cpk

Floating Fastener



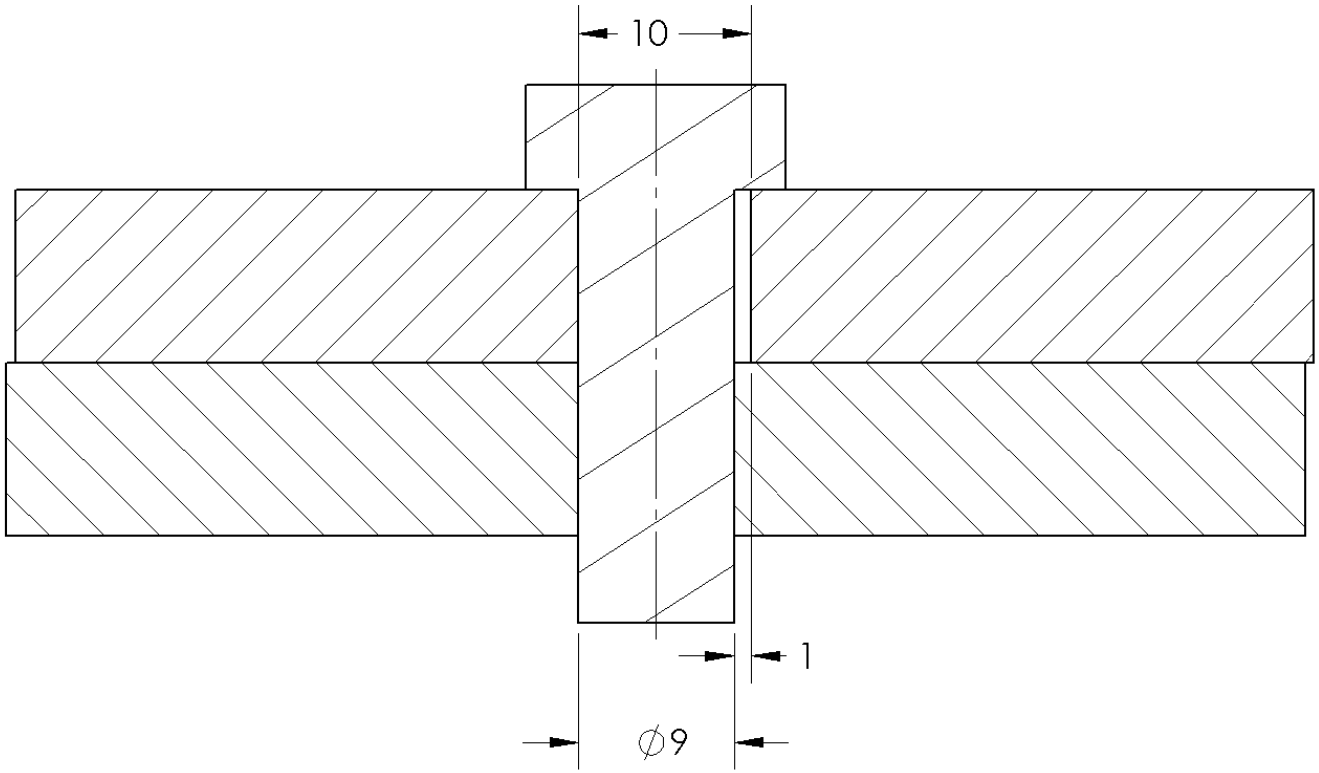
Min Hole-Max Fastener = Diametric Tolerance

Floating Fastener



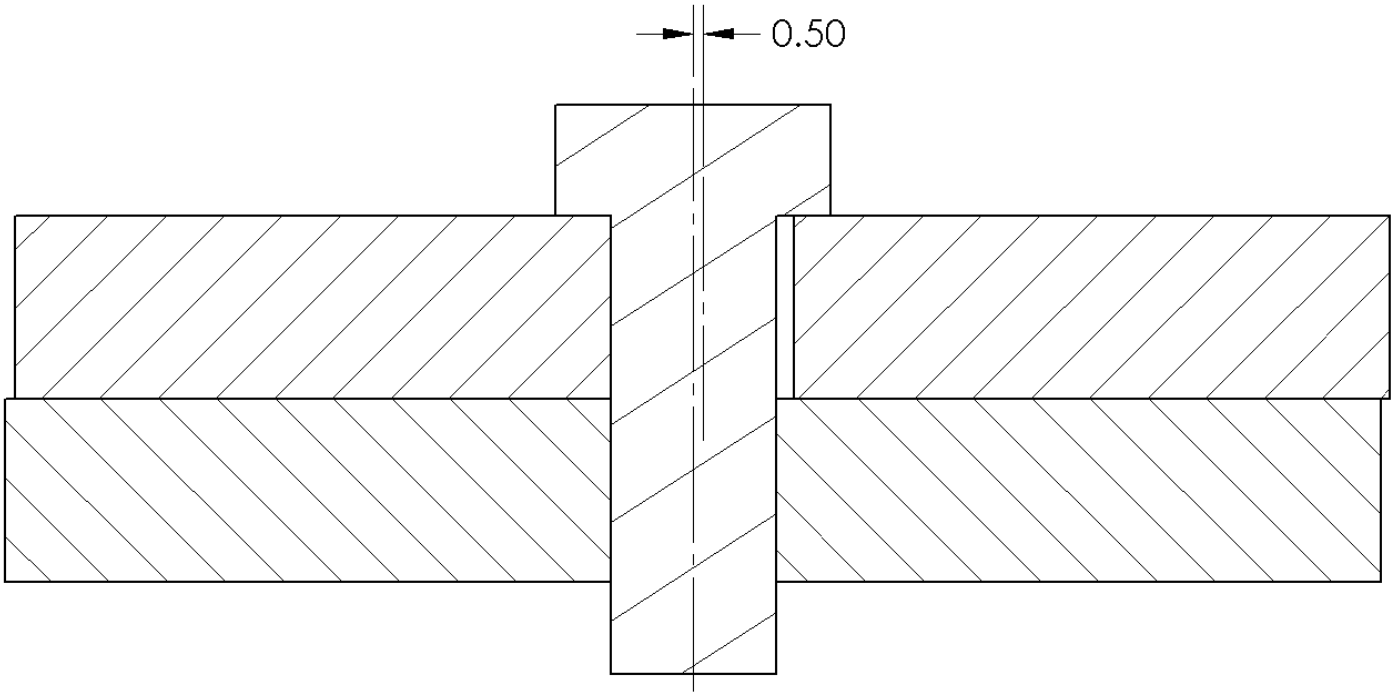
Min Hole-Max Fastener = Diametric Tolerance

Fixed Fastener



Min Hole-Max Fastener = Sum of Diametric Tolerances

Fixed Fastener



Min Hole-Max Fastener = Sum of Diametric Tolerances

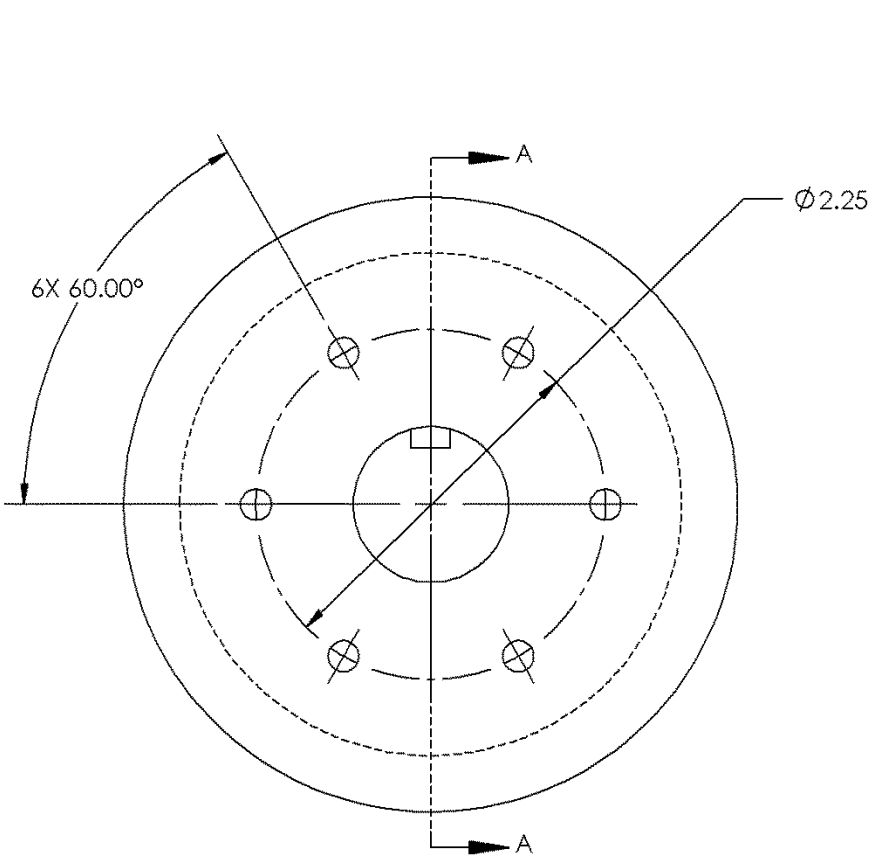
Fastener Formula

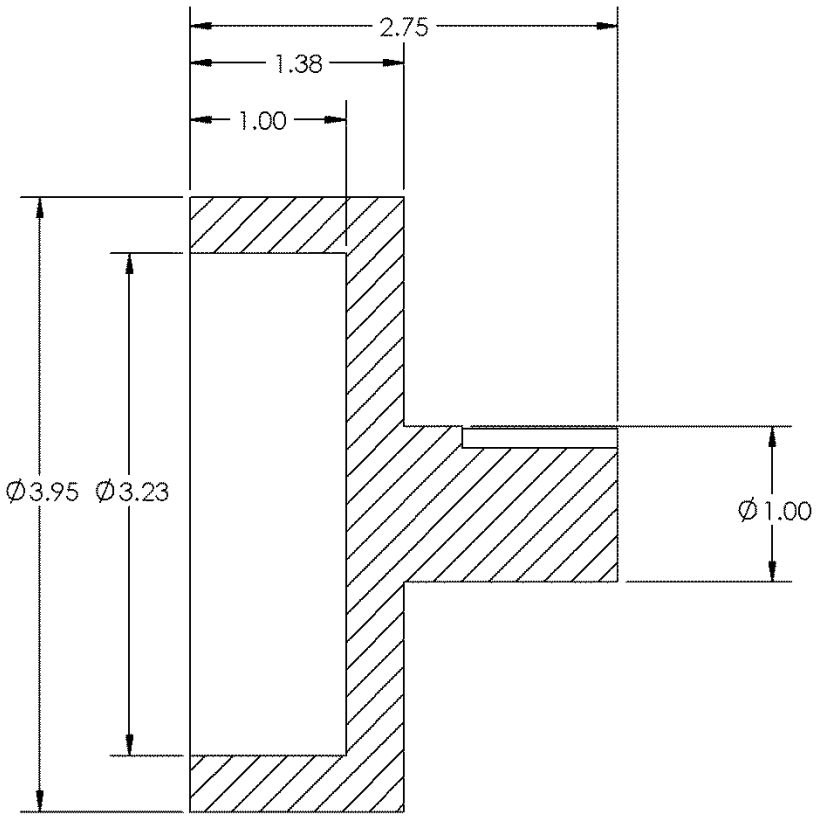
- Floating:
  Min Hole-Max Fastener = Diametric Tolerance
- Fixed:
  Min Hole-Max Fastener = Sum of Diametric Tolerances

Terminology

- **Datum**: Theoretically exact point, line, plane or combination
- **Datum Feature**: Actual feature on the part
- **Datum Feature Simulator**: Manufacturing equipment contacting the datum feature
- **Simulated Datum**: Actual point, line, plane or combination derived from the datum feature simulator

Datum Reference Frame Exercise





SECTION A-A

Exercise

- What are options for the datum reference frame?
- How would a different reference frame affect the resulting part?

General Methodology

- Design the product
- Setup the datum reference frame
- Pick the GD&T controls
- Pick the tolerance sizes

Where to go from here

- Pocket Guide
- Textbooks
- ASME Y14.5
- Library of drawings (for large companies)
- Consultants