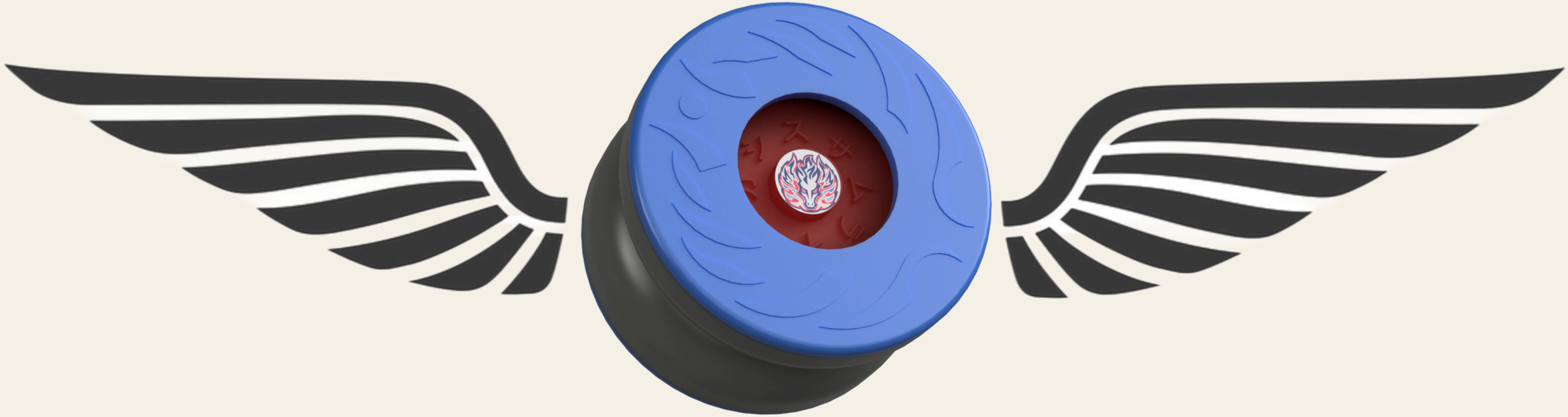
2.008 DESIGN AND MANUFACTURING II

MAY 11, 2026

TEAM PEGASUS



FINAL PRESENTATION

Presented by: Bishop, Cameron, Edison, Kayode, and Leandro

DESIGN AND THEMEING

OVERVIEW

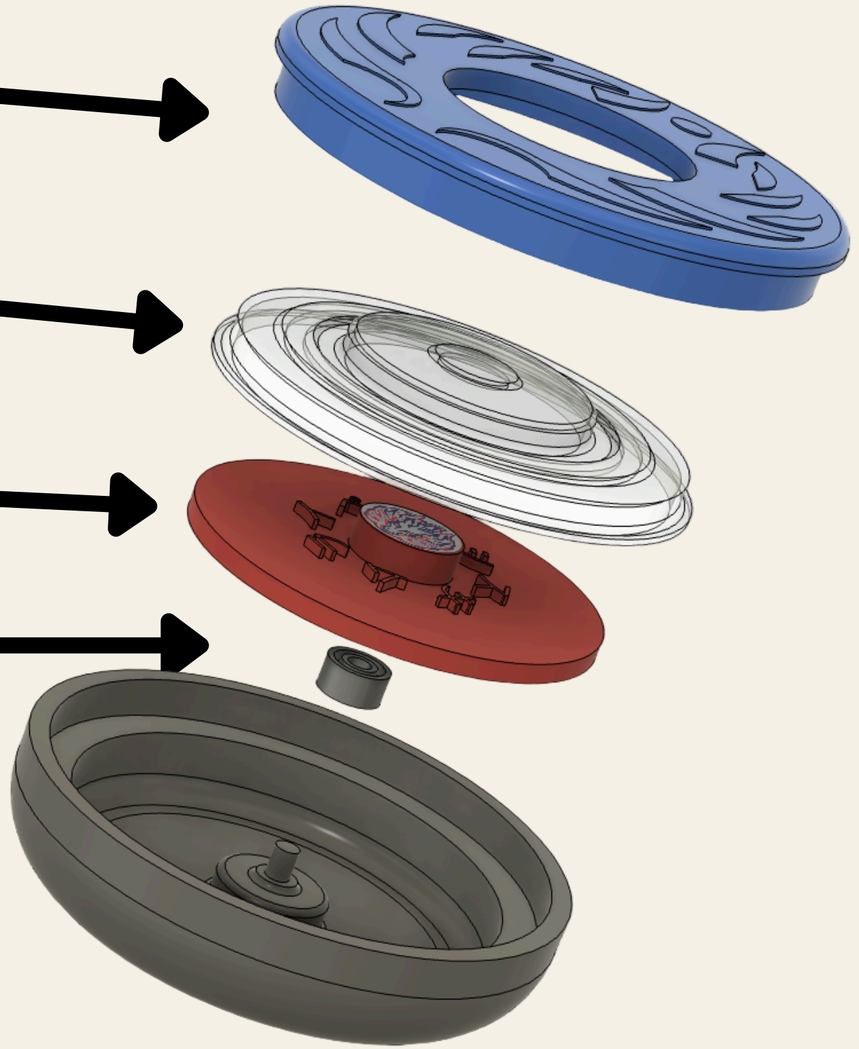
INJECTION MOLDED RING

THERMOFORMED COVER

INJECTION MOLDED SPINNER WITH STICKER

AMAZON-SOURCED BALL BEARING

INJECTION MOLDED BODY



DESIGN HIGHLIGHTS

EMBODYING SAMURAI PEGASUS



Inspiration

Samurai Pegasus Beyblade



Fierce Ring Pattern



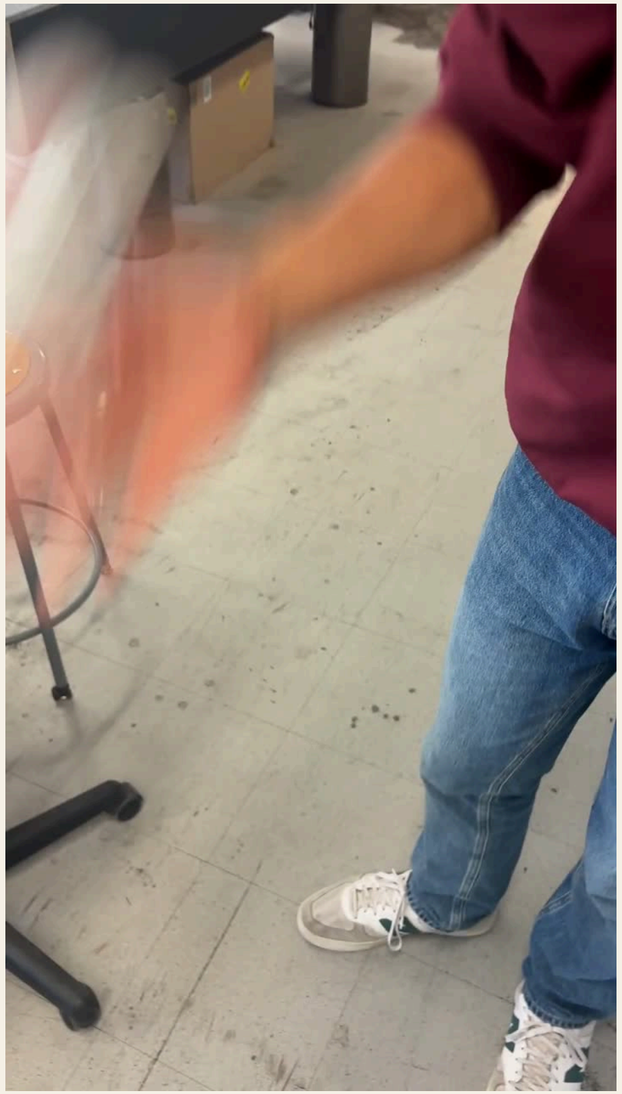
Engraved Kanji

サムライ・ペガサス

→ Samurai Pegasus

Team-Purchased Endmill

DESIGN HIGHLIGHTS



TEAM PEGASUS FINAL PRESENTATION

MAY 11, 2026

PRESS FIT ENGINEERING

Press Fit Spreadsheet

Bearing-Body Interface			
Material Properties			
Inner Member: Body		Outer Member: Bearing	
Material	Polypropelene	Material	Carbon Steel
Young's Modulus, E_i [Pa]	1200000000	Young's Modulus, E_o [Pa]	200000000000
Poisson's Ratio, v_i	0.42	Poisson's Ratio, v_o	0.29
Coefficient of static friction, μ_i	0.3	Coefficient of static friction, μ_o	0.3
Geometric Parameters			
Outer Member		Inner Member	
Outer Radius, r_o [m]	0.0040005	Inner Radius, r_i [m]	
Engagement Length, x [m]			0.004
Critical Radius [m]			0.0015748
Body Height [m]			0.004
Body Thickness [m]			
Nominal Radius, R [m]			0.0015748
Radial Interference, δ [m]			0.0000635
Press Fit Calculations			
Pressure at Interface, p [Pa]			27016585.38
Separation Force, [N]			320.7871612
Separation Force, [lbf]			72.11582267

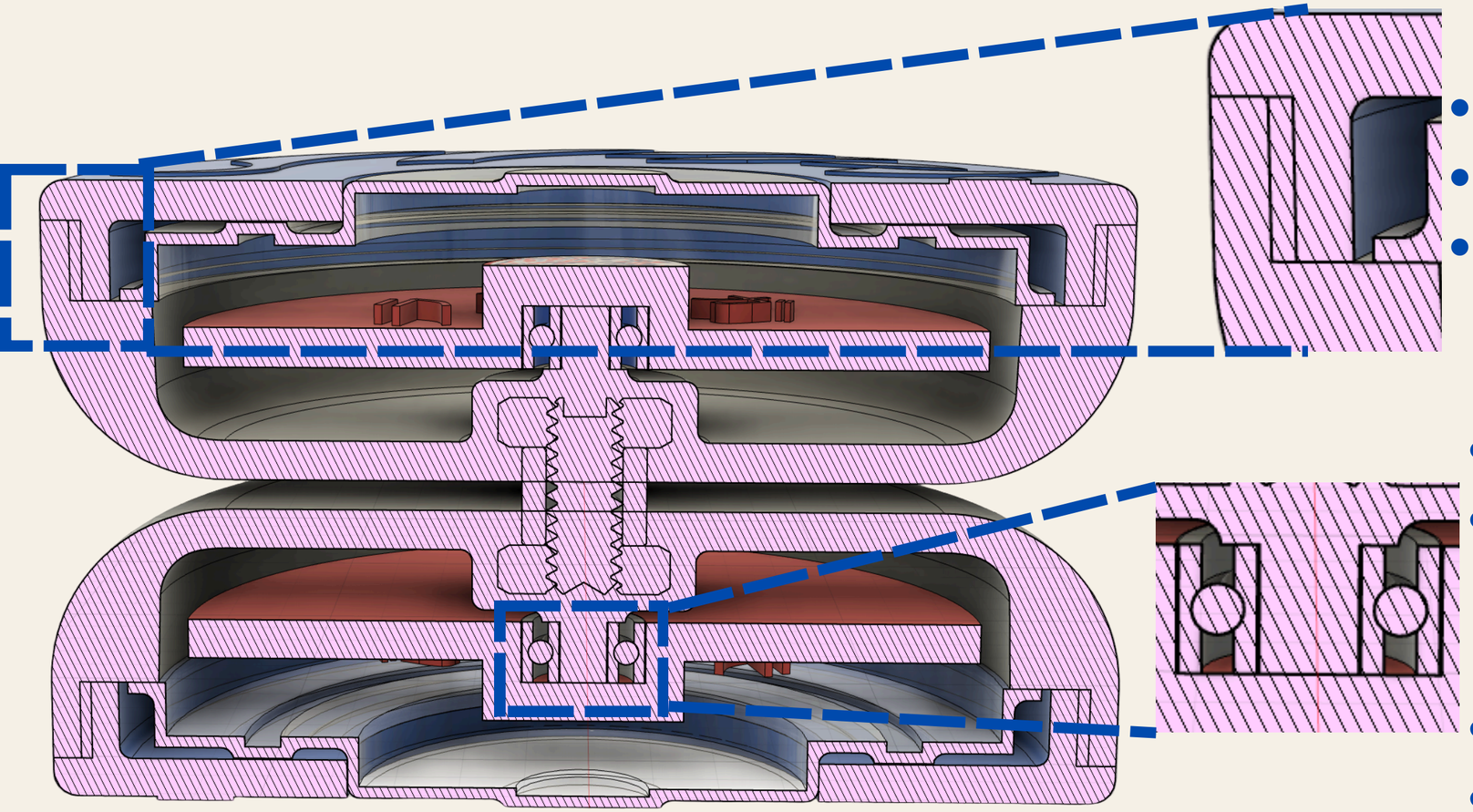
Bearing-Spinner Interface			
Material Properties			
Outer Member: Spinner		Inner Member: Bearing	
Material	Polypropelene	Material	Carbon Steel
Young's Modulus, E_i [Pa]	1200000000	Young's Modulus, E_o [Pa]	200000000000
Poisson's Ratio, v_i	0.42	Poisson's Ratio, v_o	0.29
Coefficient of static friction, μ_i	0.3	Coefficient of static friction, μ_o	0.3
Geometric Parameters			
Outer Member		Inner Member	
Outer Radius, r_o [m]	0.006477	Inner Radius, r_i [m]	0.003
Engagement Length, x [m]			0.004
Critical Radius [m]			
Body Height [m]			0.004
Body Thickness [m]			
Nominal Radius, R [m]			0.0039365
Radial Interference, δ [m]			0.0000635
Press Fit Calculations			
Pressure at Interface, p [Pa]			7409875.333
Separation Force, [N]			219.9288845
Separation Force, [lbf]			49.44198009

Ring-Body Interface			
Material Properties			
Outer Member: Body		Inner Member: Ring	
Material	Polypropelene	Material	Polypropylene
Young's Modulus, E_o [Pa]	1200000000	Young's Modulus, E_i [Pa]	1200000000
Poisson's Ratio, v_o	0.42	Poisson's Ratio, v_i	0.42
Coefficient of static friction, μ_o	0.3	Coefficient of static friction, μ_i	0.3
Geometric Parameters			
Outer Member		Inner Member	
Outer Radius, r_o [m]	0.03429	Inner Radius, r_i [m]	0.029591
Engagement Length, x [m]			0.00508
Critical Radius [m]			0.03175
Body Height [m]			0.01651
Body Thickness [m]			0.00254
Nominal Radius, R [m]			0.03175
Radial Interference, δ [m]			0.000381
Press Fit Calculations			
Pressure at Interface, p [Pa]			528581.7463
Separation Force, [N]			160.7017945
Separation Force, [lbf]			36.12720057

Particularly useful in:

- Documenting key press fit parameters (e.g., separation force, nominal radius, and pressure)
- Comparing intended diametrical interference with past yo-yo's
- Understanding how difficult it would be to take yo-yo apart

Nominal Press Fits



Ring - Body

- 0.0300" diametrical Interference
- 0.2000" length of engagement
- 36.1272 lbf to separate

Bearing - Body

- 0.0050" diametrical Interference
- 0.1575" length of engagement

Bearing - Spinner

- 0.0050" diametrical Interference
- 0.1575" length of engagement

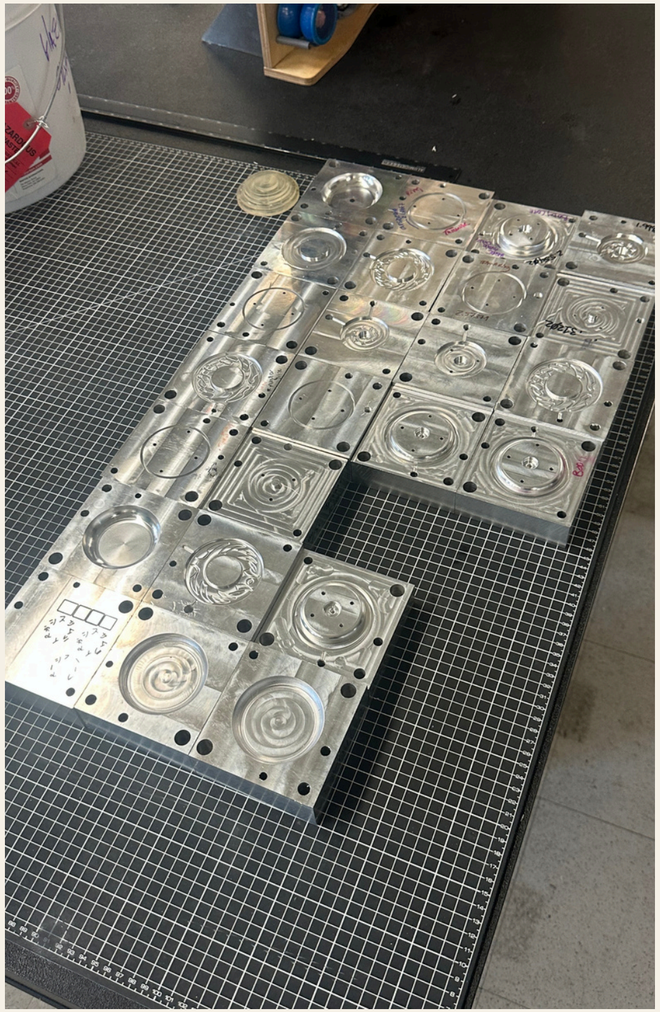
Machined Molds

CMM Measurements

	Current Values		Archived Values		Archived Values		
Date:	5/4/2026		04/06/2026		03/31/2026		
Body, mold diameter:	2.55402	[in]		[in]		[in]	core side
Ring, mold diameter:	2.57379	[in]	2.60667	[in]	2.60667	[in]	core side
Spinner, Nominal Diameter:	1.99924	[in]		[in]		[in]	cavity side
Spinner Bearing, Nominal Diameter:	0.31202	[in]		[in]		[in]	core side

Comparison of CMM Measurements to Expected, Scaled CAD (Percent Difference)

Body, mold diameter:	0.01542	[%]	100.00000	[%]	100.00000	[%]
Ring, mold diameter:	0.00141	[%]	1.27892	[%]	1.27892	[%]
Spinner, Nominal Diameter:	0.03800	[%]	100.00000	[%]	100.00000	[%]
Spinner Bearing, Nominal Diameter:	0.93365	[%]	100.00000	[%]	100.00000	[%]



- Many iterations had to be made in order to finalize shrinkage percentages and final molds
- Latest CMM measurements showed minimal mold variation from expected scaled CAD

RING OD MEASUREMENTS

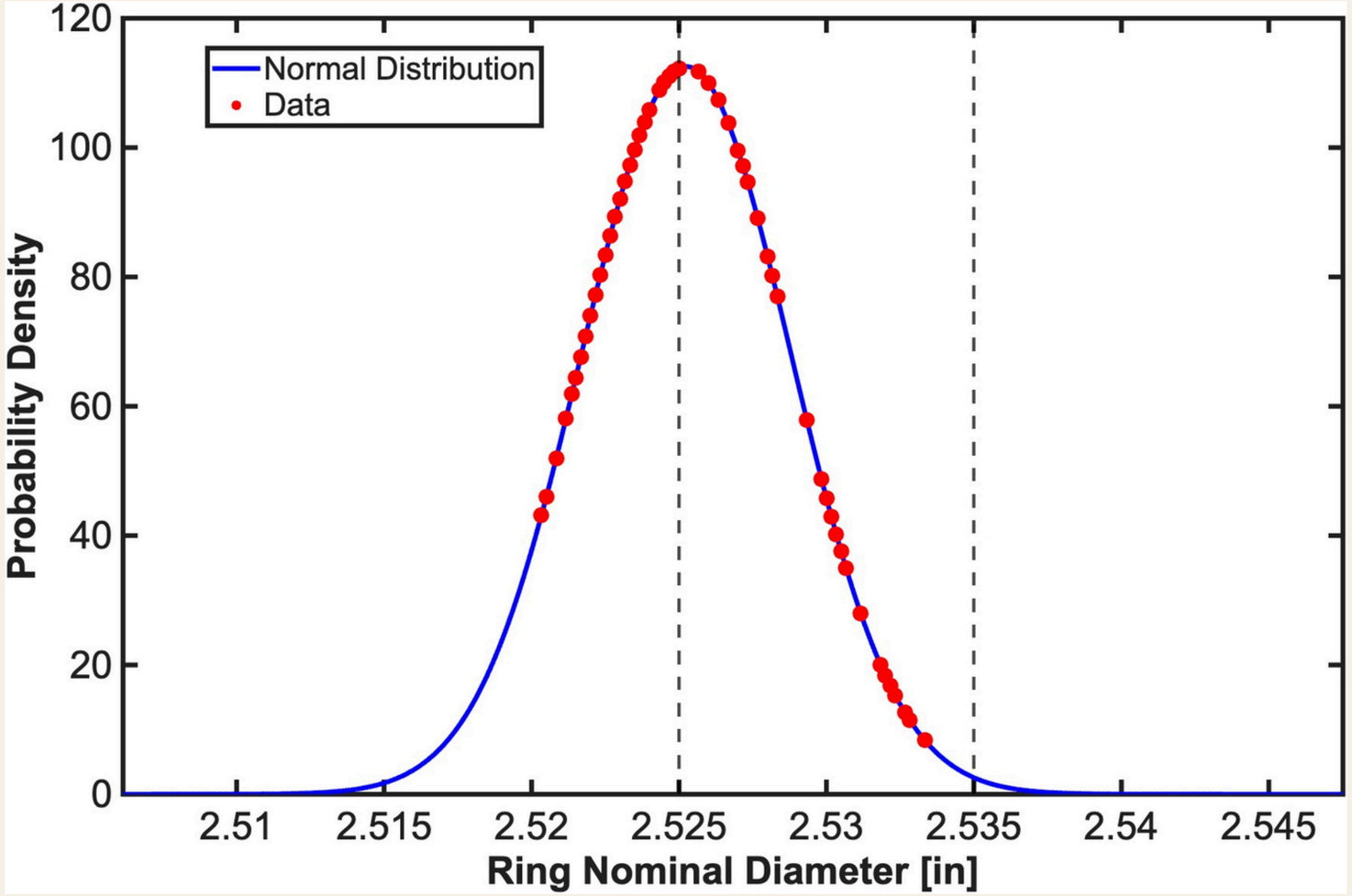
100 Measured

2.5252″ Average

0.0035″ SD

2.5300″ Target

-0.0048″ Difference



BODY ID MEASUREMENTS

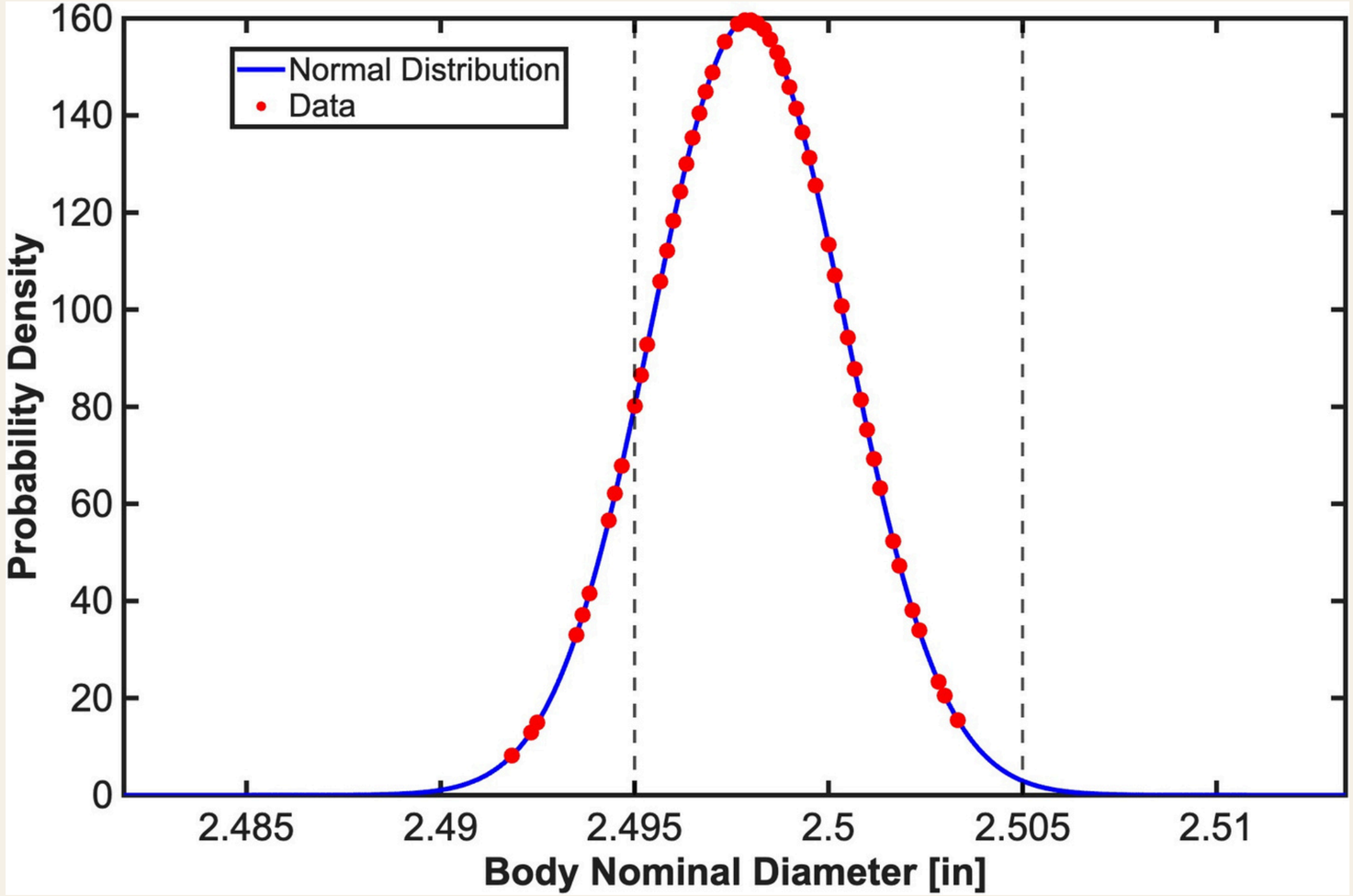
100 Measured

2.4979″ Average

0.0025″ SD

2.5000″ Target

−0.0021″ Difference



BEARING POST MEASUREMENTS

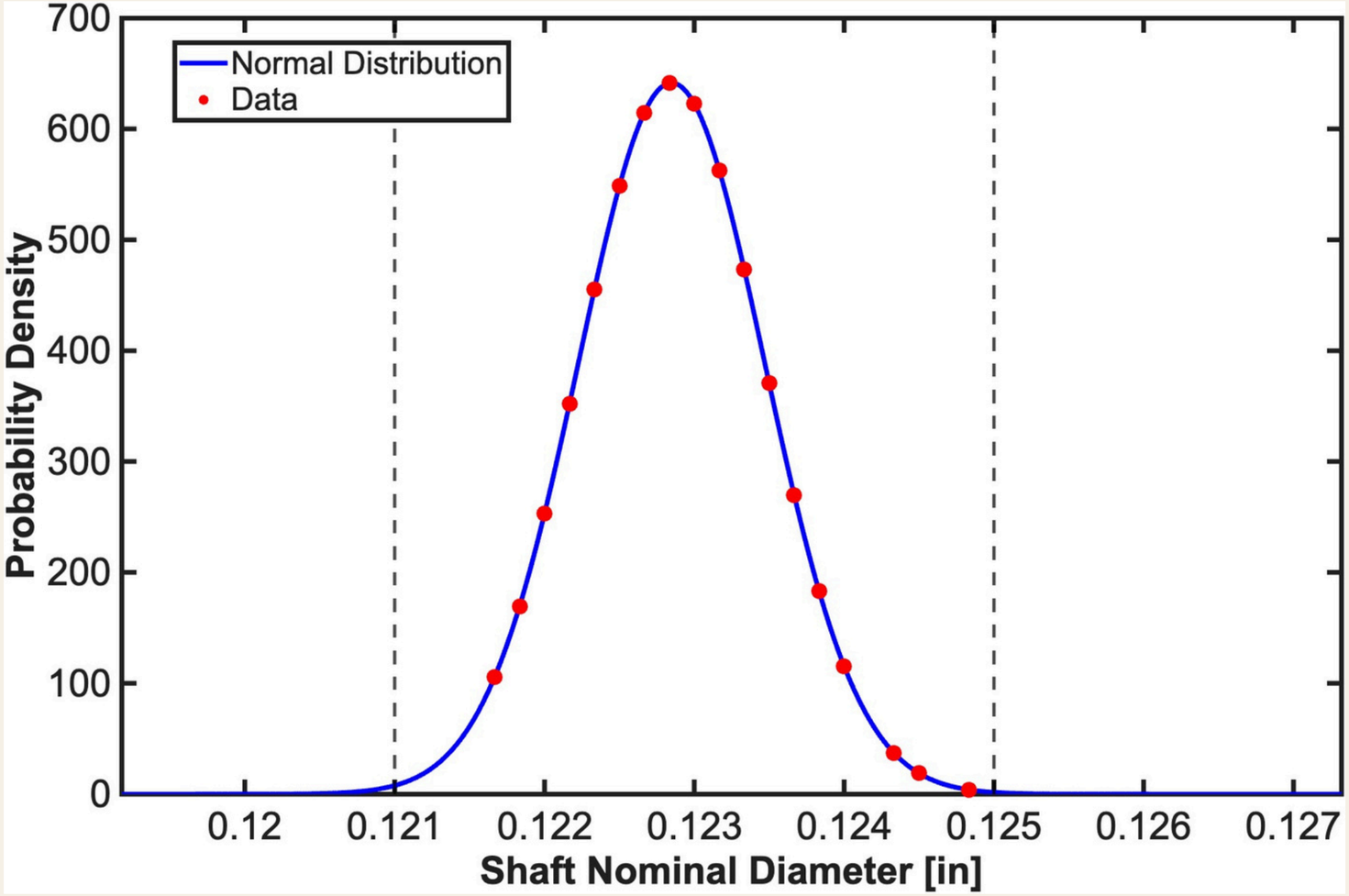
100 Measured

0.1228” Average

0.0006” SD

0.1230” Target

-0.0002” Difference



SPINNER OD MEASUREMENTS

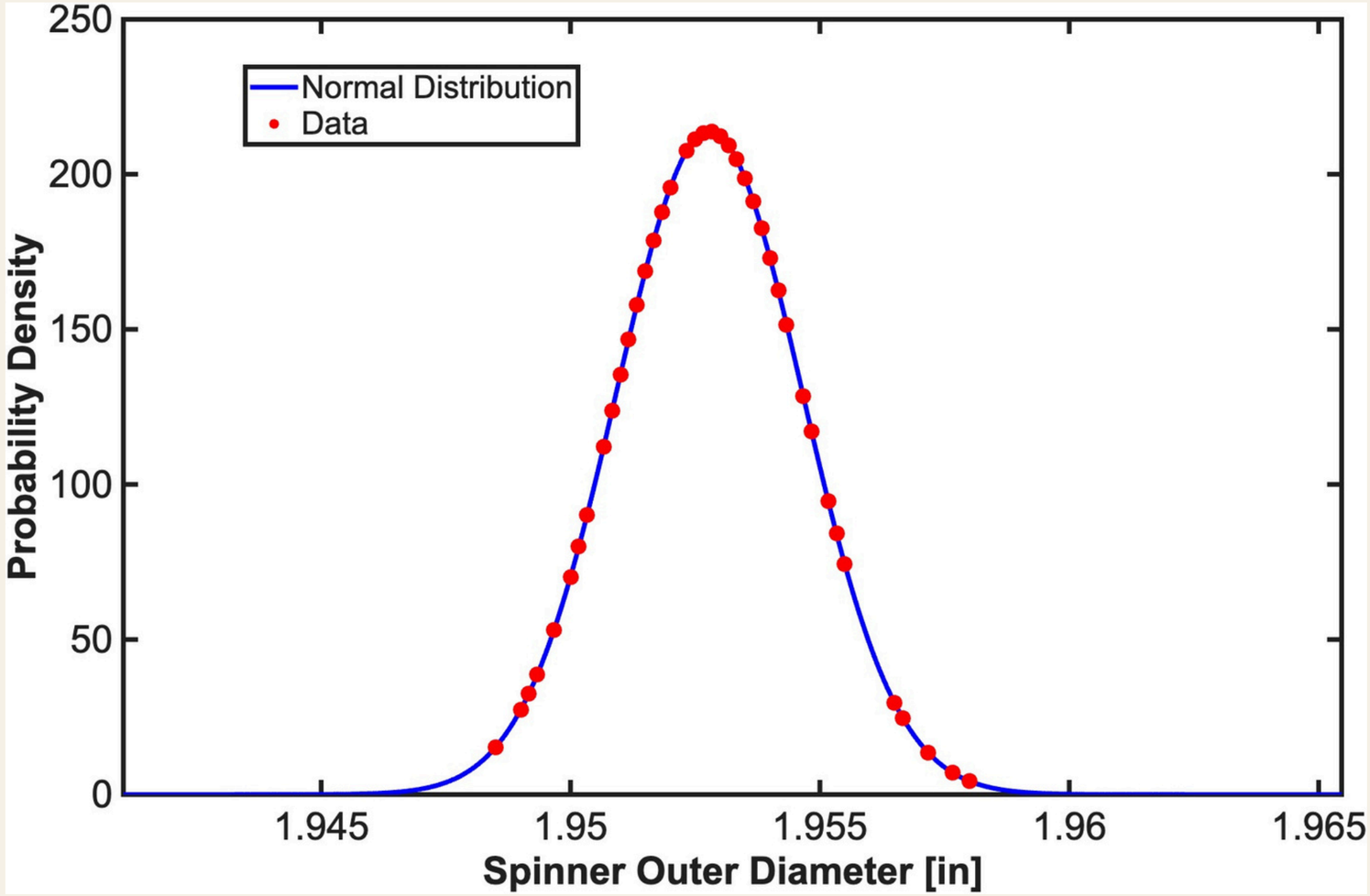
100 Measured

1.9528" Average

0.0019” SD

2.0000” Target

-0.0472” Difference



SPINNER ID MEASUREMENTS

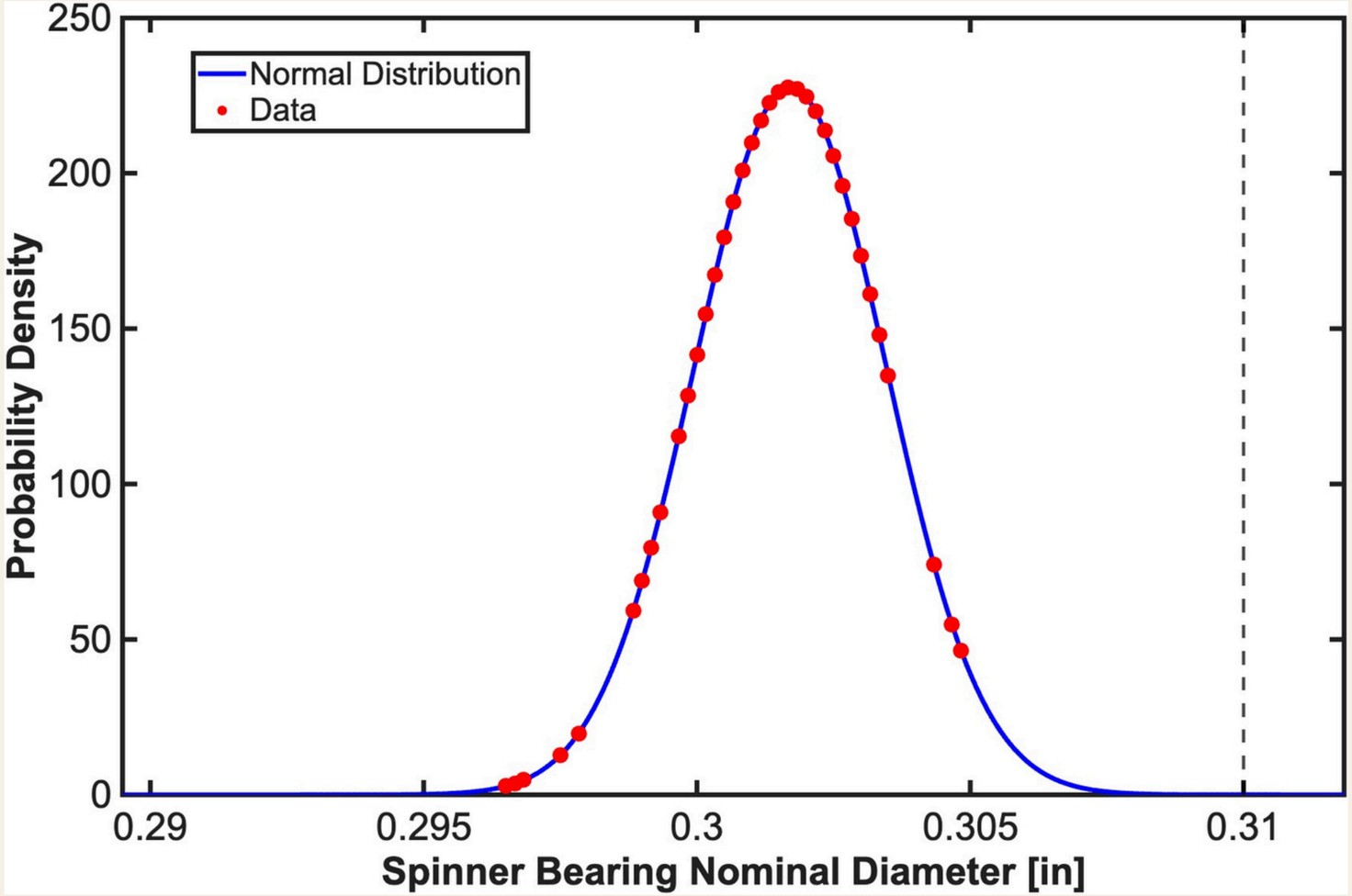
100 Measured

0.3017" Average

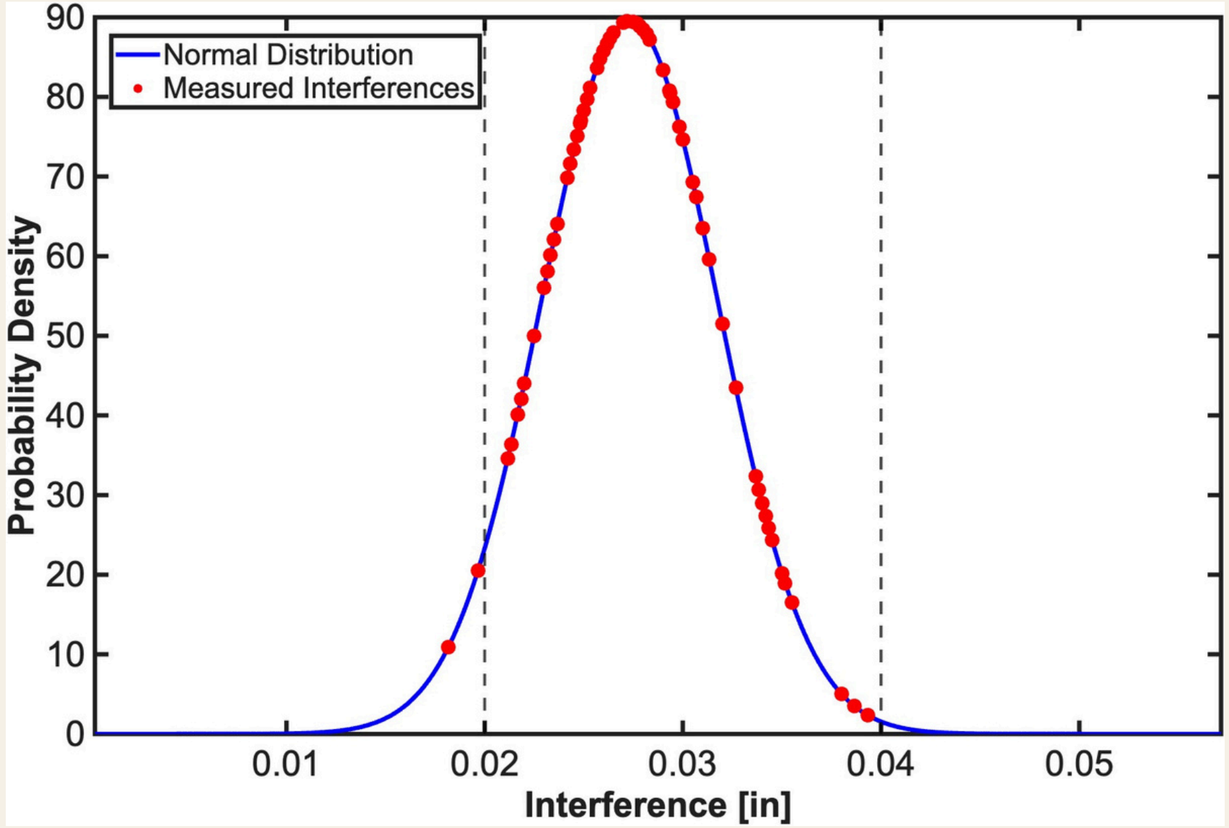
0.0018” SD

0.3100” Target

-0.0083” Difference



BODY-RING FIT STATISTICS



Body Range in Spec: [2.4950, 2.5050] in

Ring Range In Spec: [2.5250, 2.5350] in

Interference Range: [0.0200, 0.0400] in

SPECIFICATIONS ANALYSIS

Specification Statistics

USL	LSL	Z_LSL	Z_USL	mean	std_dev	Z_min	Cp	Cpk
0.040	0.020	-2.273	2.518948019	0.02948780488	0.004173248135	2.273	0.7987383508	0.7576666667
[in]	[in]	[-]	[-]	[in]	[in]	[-]	[-]	[-]

For Body

USL	LSL	Z_LSL	Z_USL	mean	std_dev	Z_min	Cp	Cpk
2.505	2.495	-1.175	2.827995561	2.497934667	0.002498353757	1.175	0.6671059542	0.3916666667
[in]	[in]	[-]	[-]	[in]	[in]	[-]	[-]	[-]

For Ring

USL	LSL	Z_LSL	Z_USL	mean	std_dev	Z_min	Cp	Cpk
2.535	2.525	-0.069	2.750972455	2.525245333	0.003545897615	0.069	0.4700267316	0.023
[in]	[in]	[-]	[-]	[in]	[in]	[-]	[-]	[-]

For Spinner

USL	LSL	Z_LSL	Z_USL	mean	std_dev	Z_min	Cp	Cpk
2.200	1.900	-28.287	132.4791253	1.952785	0.001866067575	28.287	26.79431371	9.429
[in]	[in]	[-]	[-]	[in]	[in]	[-]	[-]	[-]

For Spinner Bearing

USL	LSL	Z_LSL	Z_USL	mean	std_dev	Z_min	Cp	Cpk
0.320	0.310	4.71	10.41843572	0.3017083333	0.001751922945	4.71	0.9513356001	1.57
[in]	[in]	[-]	[-]	[in]	[in]	[-]	[-]	[-]

Possible reasons for differences between specifications and measured parts:

- Improper shrinkage percentages (additional shrinkage unaccounted for)
- Human error in measuring corresponding nominal diameters (i.e. measurement uncertainty)
- Machine variability (HASS-VF2/BOY)

TEAM PEGASUS FINAL PRESENTATION

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MANUFACTURING AND QUALITY

ENGRAVING VS STICKERS

- **Manufacturing Debates**
  - Front load vs Back load effort
    - Feeds, speeds, and CAM
    - Sticker Design and placement
  - Team Budget

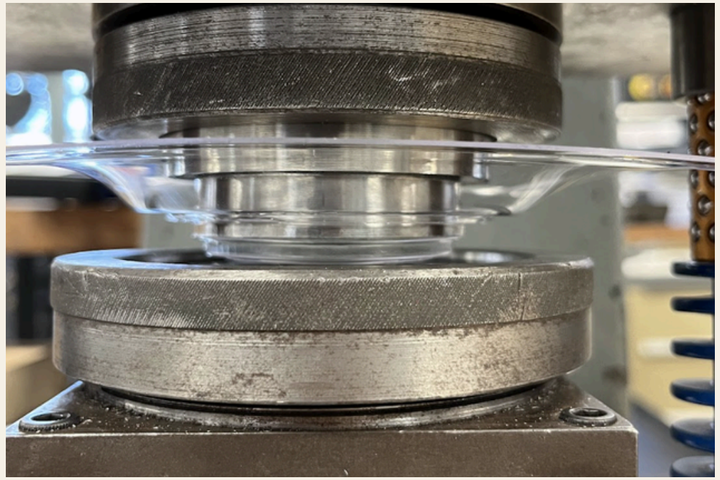
- **Quality Debates**
  - Do multiple stickers make the yo-yo look cheap? Un-precise placement?



30 Degree Carbide Endmill

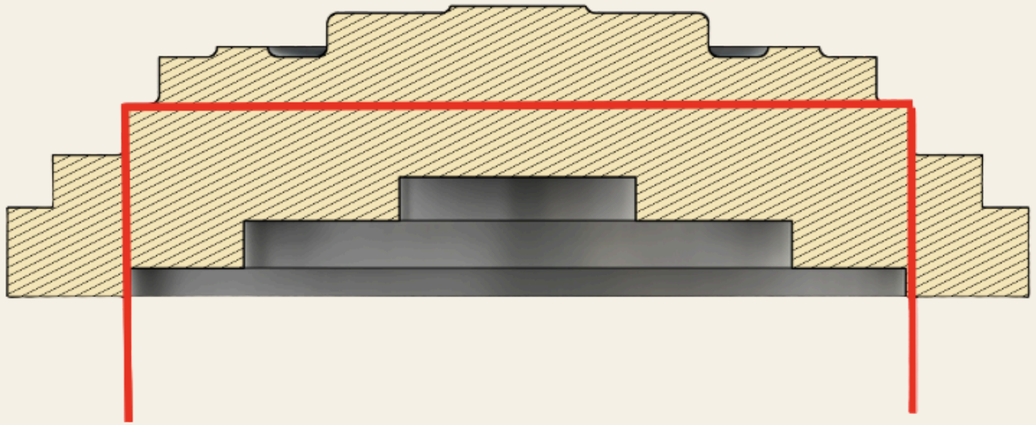


THERMOFORM PUNCH AUTOALIGNER





- Press fits onto the punch for automatic self-centering
- Alignment ensures correct part seating and clean, consistent cuts
- Zero adjustment setup saves time

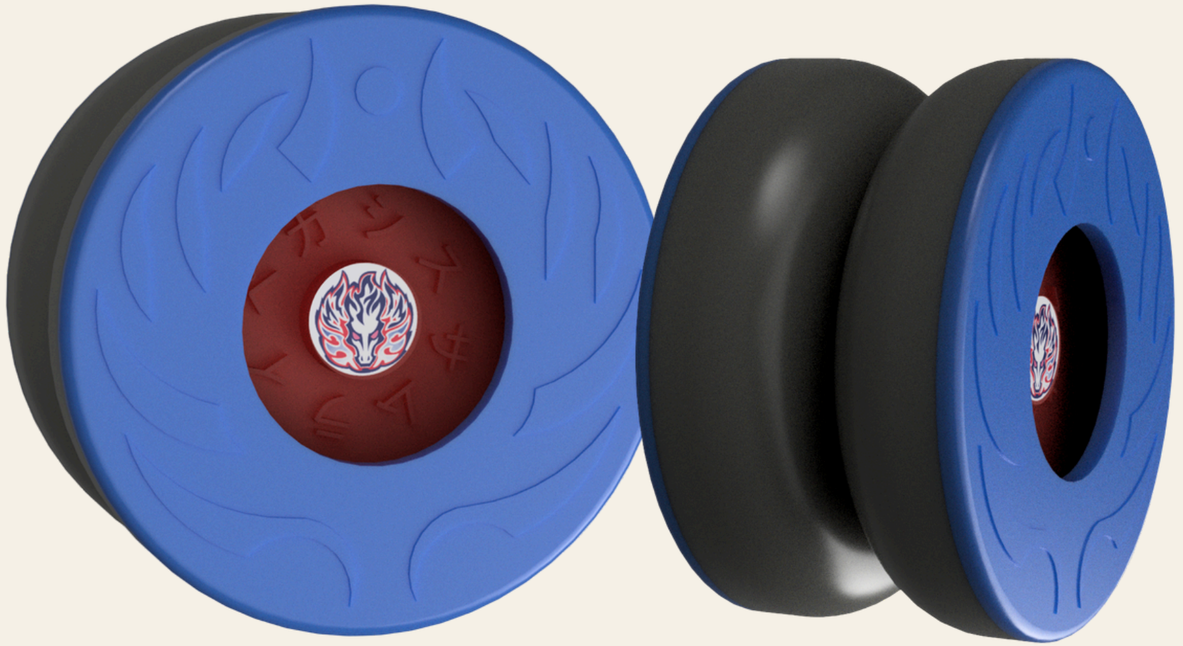


2-5/16” Diameter for Punch + Die Set

YO-YO CHECK

QUALITY INSPECTION



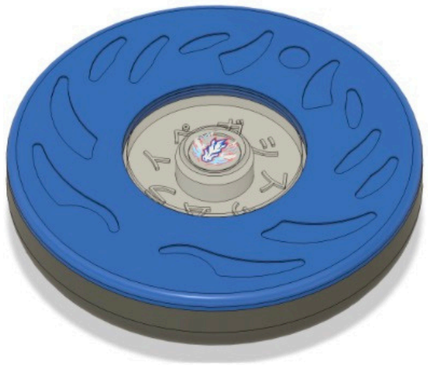


CHALLENGES AND LESSONS

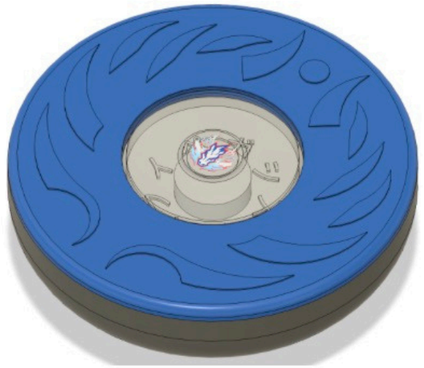
ITERATIONS



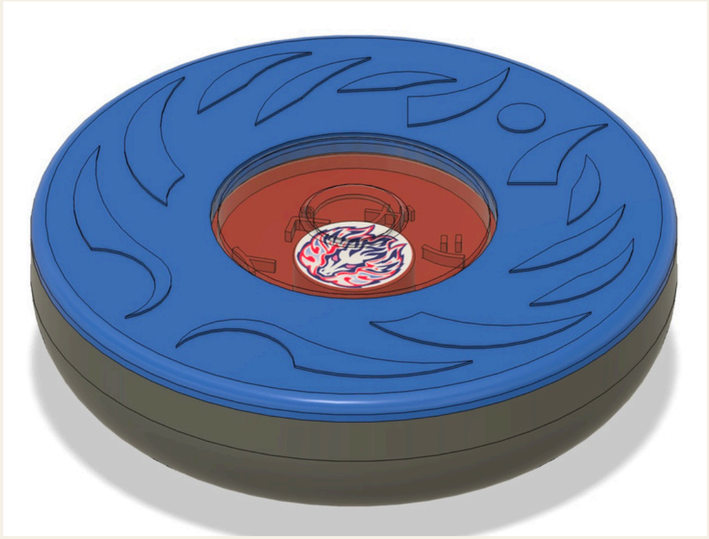
V11: Extruded Design



V61: Simplified Design



V73: Current Design





CHALLENGES

- **Expected Challenges**
  - Ring-body press fit shrinkage
  - Balancing bearing spin with separation force
  - Keeping as much detail on the ring as possible while meeting tooling constraints
- **Unexpected Challenges**
  - Consistent injection molding
    - Flash after 80 parts as mold heats
    - Color Consistency
  - Printing the small logo sticker
    - Image vectoring in Illustrator
  - Final assembly
    - What parts should be hot/cold
  - Engraving tool breakage



LESSONS AND ADVICE

- **Lesson #1**
  - Prioritize form over function
- **Lesson #2**
  - Take the time to properly review specifications and possible design constraints before settling on a design
- **Lesson #3**
  - Remain open to change, especially when considering what aspects of the yo-yo might need to be changed
- **Lesson #4**
  - Expect/look forward to failure

