

Applying Dual Angle System / Sweet Spot

Angle Sum Variance: +/- 30° for elite bowlers +/- 20° for good bowlers +/- 10° for average bowlers

1) Determine the Sum of angles by analyzing bowler's ball speed & rev rate.

Rev Dominant use higher angle sums – start around 120°

Speed Dominant use smaller angle sums – start around 80°

Speed = Revs use medium angle sums – start around 100°

2) Determine the angle ratio by analyzing the bowler's axis rotation and tilt.

Axis tilt over 17° use lower ratios (1:2 - 1:3) & longer Pin to PAP (over 4")*

Axis rotation over 75° use lower ratios (1:2 - 1:3)

Axis tilt under 16° use larger ratios (2:1 - 3:1) & shorter Pin to PAP (under 4")*

Axis rotation under 45° use higher ratios (2:1 - 3:1)

(*Pin distances for asymmetrical balls. See "retaining / burning off axis tilt" for more info)

3) Drilling Angle, Sum of Angles, & Ratio Adjustments

Make adjustments based on bowler specs that are extremes

(Normal Axis Rotation: 30° - 60° Normal Axis Tilt: 13° - 15°)

Use lower drilling **angles** for high Axis Rotation

(this may reduce the ratio & sum of angles)

Use lower **ratios** for high Axis Rotation in conjunction with low Axis Tilt

(helps smooth out breakpoint)

Lower drilling **sum** slightly for high Axis Tilt

Lower drilling **sum** more for high Axis Tilt & high Axis Rotation

(helps ball get into transition quicker)

4) Adjust the angles for the pattern the bowler wants to use the ball on.

Dry or short patterns use higher ratio

Wet or long patterns use lower ratio

5) Roll the ball, then use balance holes to fine tune reaction

Start with a smaller size hole ($\frac{3}{4}$ ") at least 2 $\frac{1}{2}$ " deep

P1 hole = Reduces drilled dynamics

P2 hole = Maintains drilled dynamics

P3 hole = Increases drilled dynamics some

P4 hole = Increases drilled dynamics more

(Please visit <http://www.morichbowling.com/Drilling/GradientLineBalanceHole/GradientLineBalanceHole.htm> for more detailed information.)

High tilt Bowlers: Pin to PAP distances of 4½" - 5¾" (Asymmetrical), 3" - 4" (Symmetrical)
4 ½" Pin to PAP distance will make the ball come off the spot hard (more angular)
5 ¾" Pin to PAP distance will make the ball roll forward sooner

Asymmetrical Balls exhibit most flare at Pin to PAP distances of 2¾" to 6¼"
Symmetrical Balls exhibit most flare with Pin to PAP distances of 3" to 4"

If the ball design creates a later, sharp break point, use lower ratio (lower drilling angle to VAL)
If the ball design creates a sooner, forward rolling ball, use more ratio (higher drilling angle to VAL)

After Drilling: With a symmetrical ball use Pin to center of thumbhole for measuring layout! The Mass Bias is near the thumbhole when no balance hole is present and moves towards balance hole when present.

Retaining Axis Rotation & Axis Tilt: To retain Axis Rotation and Axis Tilt in SYMMETRICAL equipment, we would tend towards longer pin-pap (> 4") distances, while ASYMMETRICAL equipment we use shorter pin-pap distances (< 3"). We would also chose higher angle ratios (2:1 - 3:1) to promote a longer first transition to make the most of what Axis Rotation and Axis Tilt is available at release.

Burning Off Axis Rotation & Axis Tilt: To burn off Axis Rotation and Axis Tilt quicker in SYMMETRICAL equipment, we would tend toward Max flare pin positions (3" - 4"), while longer pin distances (4"+) in ASYMMETRICAL equipment. We would also chose lower angle rations (1:1 - 1:2) to get the ball to reach the first transition sooner, while trying to eliminate jumpy back end reaction that tends to accompany high Axis Rotation and Axis Tilt.

Drilling Angle: Smaller drilling angles are used to shorten the length of the 1st transition (skid to hook) because the PAP is closer to the Pin to Spin Line. Larger drilling angles increase the length of the 1st transition because the PAP is farther away from the Pin to Spin Line.

Angle Sum: Angle sum is the sum of the drilling and VAL angles. The main components that will affect this are ball speed and rev rate. An example of a well matched bowler would be 18mph speed and 300rpm (off the hand). For each 1mph increase or decrease in speed, a corresponding increase or decrease of about 50rpm would stay matched. Bowlers whose ball speed and rev rate are well matched will match up best with angle sums of 100° ± 30°. In general, the ± 30° will stay the same, and the 100° will shift. For bowlers that are speed dominant, you would want to lower the center of the range, to a minimum of 60° ± 30°. For bowlers who are rev dominant, you would want to raise the center of the range, up to a maximum of 130° ± 30°.

Pin-PAP Distance: Note that the following ranges refer to asymmetrical cores, which have different properties at longer pin-PAP distances than do symmetrical cores. Bowlers with medium tilt will match up best with pin-PAP distances in the 4" - 5" range. Bowlers with higher tilt would want to use slightly longer distances, while bowlers with lower tilt would want to use shorter pin-PAP distances.

Angle Ratio: Angle ratio is the ratio of drilling angle to VAL angle. Acceptable ratios range from 1:3 to 3:1. The range used by a bowler is dependent on axis tilt and axis rotation. The more axis tilt and/or axis rotation a bowler has, the lower the angle ratios the bowler should use. A bowler with 30° degrees of axis rotation and 15° of axis tilt would do best between 1:1 and 2:1. A bowler with 75° axis rotation and < 10° axis tilt, would do best between 1:3 and 1:1.

Bowler Example 1 – Speed Equals Revs, Average Tilt & Rotation

Speed: 17 - 18mph
Rev Rate: ~350°
Axis Tilt: ~15°
Axis Rotation: 50° - 70°

Sweet Spot Estimate: 100°
Range Of Angles: 80° to 120°
Ratios: 1:1 – 3:1

For Asymmetrical balls

Long and strong: 90° x 3" x 30°, P3 hole
Completely strong: "Double Thumb"
Strong midlane: 45° x 4" x 25°, P4 hole
Control: 70° x 4½" x 50°, P1 or P2 hole, if necessary
Mania for Nationals: 55° x 3¼" x 35°, P3 hole

Bowler Example 2 – Rev Dominant, Low Speed

Right Handed
Speed - 15-16 MPH (at release)
Revs - 325 (290 min and 355 max)
Axis Tilt - 13° (can vary from 7° to 15°)
Axis Rotation - 45° (approx)

Sweet Spot Estimate: 130°
Range Of Angles: 100° to 150°
Ratios: 1:1 – 2:1

For Asymmetrical balls:

Long and Strong - 90° x 3" x 25°
Heavy Oil - 50° x 3 1/4" x 45°
Very Dry - 90° x 1 3/4" x 55° with a P1 hole
Control - 90° x 2 1/4" x 65°

For Symmetrical balls:

Long and Strong - 90° x 3 1/4" x 25°
Heavy Oil - 50° x 3 1/4" x 45°
Very Dry - 90° x 5 1/2" x 55° with a P1 hole
Control - 90° x 5" x 65°

Bowler Example 3 – Speed Dominant, Higher Axis Tilt

Speed: ~18.3 to 18.8 mph off hand
Rev Rate: 285 to 300 rpm
Axis Rotation: ~60°
Axis Tilt: 20°

Sweet Spot Estimate: 80°
Range Of Angles: 60° to 100°
Ratios: 1:1 – 1:2

For Asymmetrical balls:

FRENZY: 45° x 4 ½" x 50° with a P2 hole
Craze: 40° x 4 ¼" x 40° with a P3 hole
Mania: 25° x 4" x 25° with a P3.5 hole

Mo Says:

"The key number is 20° of axis tilt. If there's oil at the back of the pattern, or carry down, the ball has a tendency to "skip out" on him, plus with the speed domination to go with the tilt, we have to guard against a "wet/dry" reaction. Basically, the combination of speed dominant and excess tilt needs the ball to start transitioning earlier and smoother."

Bowler Example 4 – Speed Dominant, Low Revs, Very High Axis Tilt

Speed: 17 (off hand)
Rev Rate: 220
Axis Tilt: 30°
Axis Rotation: 45°
Speed Dominant

Sweet Spot: 60°
Range of Angles 50° - 80°
Ratio: 1:2 – 1:3

Symmetrical: 10° x 3" x 35° with a P4 hole. Use a low top ball with the pin out 4+."

Asymmetrical: 20° x 5" x 40° with a P4 hole. Use a low top ball with the pin out 4++"

Bowler Example 5: Very Low Axis Rotation, Low Axis Tilt, Low Revs

Speed: 15 mph off hand
Rev Rate: 200
Initial Axis Rotation: 7°
Initial Axis Tilt: 10°
Synthetic Lanes on THS
Speed = Revs but with low revs

Sweet Spot: 110°
Range of Angles: 90° - 130°
Ratio: 2:1 - 3:1

Benchmark: 85° x 3¼" x 25° (symmetrical & asymmetrical)

This layout is for a low Axis Rotation, low Axis Tilt, low Speed, low Rev bowler and will get max flare with the 3¼" Pin and a chance to preserve the Axis Rotation / Axis Tilt with the dual angle layout.

If I have a low Axis Rotation, low Axis Tilt, High Speed, High Rev bowler I could use a similar Drill Angle & Vertical Angle, but adjust the PIN towards 1¾" for Asymmetrical balls and towards 5" for Symmetrical balls to actually control/reduce the flare, but still help preserve the Axis Rotation and Axis Tilt.

Bowler Example 6: Slightly Rev Dominant, Slightly High Axis Tilt

Speed: 16mph off hand
Rev rate: 250 - 300 rpm (best guess by comparison)
Rotation: 40° - 50° (best guess)
Tilt: 17°
Surface: deteriorating Guardian for 1st 30 feet, pine in rear 30 feet.
Oil: Medium-heavy oil (my best guess) to begin, transitioning to medium-light rapidly
Slightly Rev Dominant

Sweet Spot is 105°
Range of Angles: 85° - 125°
Ratio: 2:1 - 1:1

Benchmark: 60° x 4" x 45° (symmetrical & asymmetrical)

For Bad Guardian: 90° x 5" x 35° (symmetrical)
90° x 2½" x 35° (asymmetrical)
Use the balance hole and the surface to tweak the reaction

Bowler Example 7: Speed Equals Revs, Very Low Axis Tilt

Ball Speed: 18.5 mph (in the heads)

Rev Rate: 450 rpm

PAP: 4 7/8 over 1/2 up

Axis Rotation: 45°

Axis Tilt: 3°

Sweet Spot: 110°

Range of Angles: 90° - 130°

Ratio: 1:1 – 3:1

Asymmetrical: 75° x 3" x 40° with a P2 hole (on medium ball for medium oil)

60° x 3¼" x 30° with a P3 hole (on strong ball for heavy oil)

Bowler Example 8: Rev Dominant, Low Speed, Very High Axis Rotation

Speed: 12mph – 13mph (max) at end of lane

Rev Rate: 300 - 350

Initial Axis Rotation: 70° - 90°

Initial Axis Tilt: 13°

Bowl mostly on drier THS, and Kegel # 6, synthetic lanes

Totally rev dominant

Sweet Spot: 130°

Range of Angles: 100° - 160°

Ratio: 2:1 – 1:2

Asymmetrical: 80° x 5" x 60°

Symmetrical: 90° x 2 ¼" x 50°

Mo Says:

"Slightly different angles are used because symmetrical cored balls lose axis tilt faster than asymmetrical cored balls. The bowlers' axis tilt is medium but ball speed is very low, so we need to retain axis tilt for as long as possible."

Bowler Example 9: Speed Equals Revs, Low Axis Tilt, Very High Axis Rotation

Ball Speed: 16mph (off my hand)

Rev Rate: 240

Initial Axis Rotation: 75° - 80°

Initial Axis Tilt: 7°

Sweet Spot: 80°

Range of Angles: 55° - 95°

Ratio: 2:1 – 1:2

Symmetrical: 50° x 3¼" x 30°

Asymmetrical: 50° x 4½" x 30°

Mo Says:

"Most of my requests seem to involve low tilt players looking for continuation. I wanted a sum of 80° with a 1.7:1 ratio to control the snap...if he had less rotation, I would have gone with a larger angle ratio between 2 and 3 to 1. The 3¼" pin to PAP distance will help retain axis rotation and tilt and help him cover more boards. I was keying in on the low tilt."

Bowler Example 10: Rev Dominant

Speed: 17.5 off hand

Rev Rate 500

Initial Axis Rotation: 55°

Initial Axis Tilt: 15°

Dry THS and Dry versions of PBA patterns, Synthetic HPL Heads, Murray last 40

Rev Dominate

Sweet Spot: 120°

Range of Angles: 90° - 150°

Ratio: 3:2 – 2:1

Benchmark Layout

Symmetrical: 80° x 4.5" x 45°

Asymmetrical: 75° x 2.5" x 45°

Bowler Example 11: Slightly Rev Dominant, Lower Axis Tilt

Ball Speed: 17mph (off hand)

Rev Rate: 360

Initial Axis Rotation: 45° - 60°

Initial Axis Tilt: 10°

Sweet Spot: 110°

Range of Angles: 90° - 120°

Ratio: 1:1 – 3:1

Asymmetrical: 75° x 3½" x 25° with a P3 hole (strong ball on heavy oil)

Symmetrical: 80° x 4½" x 25° with a P3 hole

Bowler Example 12: Slightly Rev Dominant, Very Low Axis Tilt

Ball Speed: 18.5mph (off hand)

Rev Rate: 450

Initial Axis Rotation: 45°

Initial Axis Tilt: 3°

Slightly Rev Dominant

Sweet Spot: 110°

Range: 80° - 140°

Ratio: 1:1 - 3:1

Hyroad (benchmark): 70° x 4½" x 40°, P2 hole, sanded 4000

Reign of Fire (heavy oil): "Double Thumb" sanded 1000

Mania (heavy+ oil): 60° x 3¼" x 30°, P3 hole

Natural: 60° x 4" x 35°, P2 hole

Craze: 75° x 3" x 40°, P2 hole

Bedlam: 60° x 3½" x 40°, P3 hole, sanded 2000

Blast Zone: 65° x 3¼" x 25°, P3 hole

Bowler Example 13: Speed Dominant, Low Axis Tilt, Lower Axis Rotation

Ball Speed: 19mph
Rev Rate: 350 - 375
Initial Axis Tilt: 7°
Initial Axis Rotation 30°
Speed dominant

Sweet Spot: 110°
Range: 80° - 140°
Ratio: 1:1 – 2:1

Benchmark (THS): 65° x 5" x 45°
Natural (medium oil): 55° x 4" x 45°
Mania (heavy / long oil): 60° x 4" x 30° Double Thumb
Jigsaw Corner (heavy / long oil): 60° x 4" x 30° Double Thumb
Evil Siege (heavy / long oil): 55° x 3¼" x 25°, P3 hole

Bowler Example 14: Slightly Rev Dominant, Low Tilt, Low Axis Rotation

Speed: 15 - 16 mph off hand
Revs: 350 rpm
Initial Axis Tilt: 7°
Initial Axis Rotation: 30° - 35°

Sweet spot: 115°
Range: 95° - 135°
Ratio: 3:1 – 2:1

Benchmark layout:
80° x 3" x 35° (asymmetrical)
85° x 4" x 35° (symmetrical)

Mania (heavy oil): 60° x 3¼" x 35°, P3 hole
Siege or Invasion (heavy oil): 65° x 3¼" x 30°, P3 hole

Craze (medium oil): 85° x 2¾" x 30°, P3 hole
Evil Siege (medium oil): 80° x 2¾" x 35°, P3 hole
Furious (medium oil): 90° x 4" x 30°, P3 hole

FRENZY (light oil): 90° x 2¼" x 45°, P1 hole if necessary
Rattler or Dark Star (light oil): 90° x 5" x 45°, P1 hole if necessary

Bowler Example 15: Slightly Rev Dominant, Medium - High Tilt

Speed: ~ 18 mph
Rev Rate: ~ 375 - 400rpm
Initial Axis Rotation: ~ 45° - 50°
Initial Axis Tilt: 15° - 20°
Normally bowl on a medium THS

Sweet Spot: 105°
Range: 85° - 125°
Ratio: 3:2 - 2:3

Benchmark layout (Asymmetrical): 55° x 4½" x 50°
Benchmark layout (Symmetrical): 55° x 4" x 50°

Heavy Oil layout (Asymmetrical): 50° x 4" x 35°
Heavy Oil layout (Symmetrical): 50° x 3½" x 35°

Dry layout (Asymmetrical): 65° x 5" x 60°
Dry layout (Symmetrical): 65° x 4½" x 60°

Angular medium layout (Asymmetrical): 65° x 4" x 40°
Angular medium layout (Symmetrical): 65° x 3½" x 40°

Bowler Example 16: Speed Dominant, High Tilt

Speed: 18mph (off hand)
Revs: 250
Initial Axis Tilt: 23°
Initial Axis Rotation: 45°

Sweet Spot: 70°
Range: 50° - 90°
Ratio: 3:2 - 2:3

Pin to PAP distances from 4" to 5½" on asymmetrical
Pin to PAP Distances from 3" to 4" on symmetrical
Balance holes from P2 (control only) to P4

Asymmetrical Benchmark: 30° x 4.5 x 40
Symmetrical Benchmark: 30° x 3¼" x 40

Invasion (heavy oil): 40° x 4½" x 30°
Response: 40° x 4¼" 30°, P4 Hole
Mojave: 40° x 4¼" x 25°
Hyroad (wet-dry): 35° x 3" x 45°

Bowler Example 17: Slightly Rev Dominant, Very Low Tilt, Higher Axis Rotation

Speed: 15 - 16 mph
Revs: 260 - 280 rpm
Initial Axis Rotation: 75°
Initial Axis Tilt: 0° – 3°

Sweet Spot: 95°
Range: 70° - 120°
Ratio: 1:1 – 1.5:1

Benchmark: 55° x 4" x 40°

Mo Says:

"I would not exceed an angle ratio of 1.5:1 for you. I'd use 1:1 for wet dry conditions to make sure you could control the break point more easily.

We're using a sweet spot for you of 95° +/- 25° because of the variety of lane conditions on which you bowl. Use pin to PAP distances of 3" to 4¾". Your benchmark layout should be 55° x 4" x 40°. On more challenging patterns, use a ratio of 1.5:1. On THS (easier and more wet/dry patterns), use a ratio of 1:1. On synthetics or longer patterns, use a smaller sum of the angles. On Guardian (which is like bowling on a gum eraser), use max. sum of angles (125°). On wood lanes or shorter patterns use a larger sum of angles. Use balance hole size and location to fine tune the reaction after bowling with the drilled ball with the chosen surface."

Benchmark Layouts for walled-up THS

Bowler A: Tons of hand, not enough lane
Bowler B: Normal revs, balanced with speed, likes playing 2 arrow
Bowler C: Weak wrist, rev challenged, break point at 7-8 board

Bowler A: Angle Sum - 145° to 160°
Bowler B: Angle Sum - 115° to 130°
Bowler C: Angle Sum - 85° to 100°

Bowler A: Pin to PAP - Asymmetrical = 1½"	Symmetrical = 5¼"
Bowler B: Pin to PAP - Asymmetrical = 2"	Symmetrical = 4¾"
Bowler C: Pin to PAP - Asymmetrical = 2½"	Symmetrical = 4¼"