The **Truth** about **Drilled Bowling Balls**

and **why** they react the way they do

A

MORICH

Production

presenter

Ho Pinel

Understanding Ball Motion

Three Phases of Ball Motion

ROLL

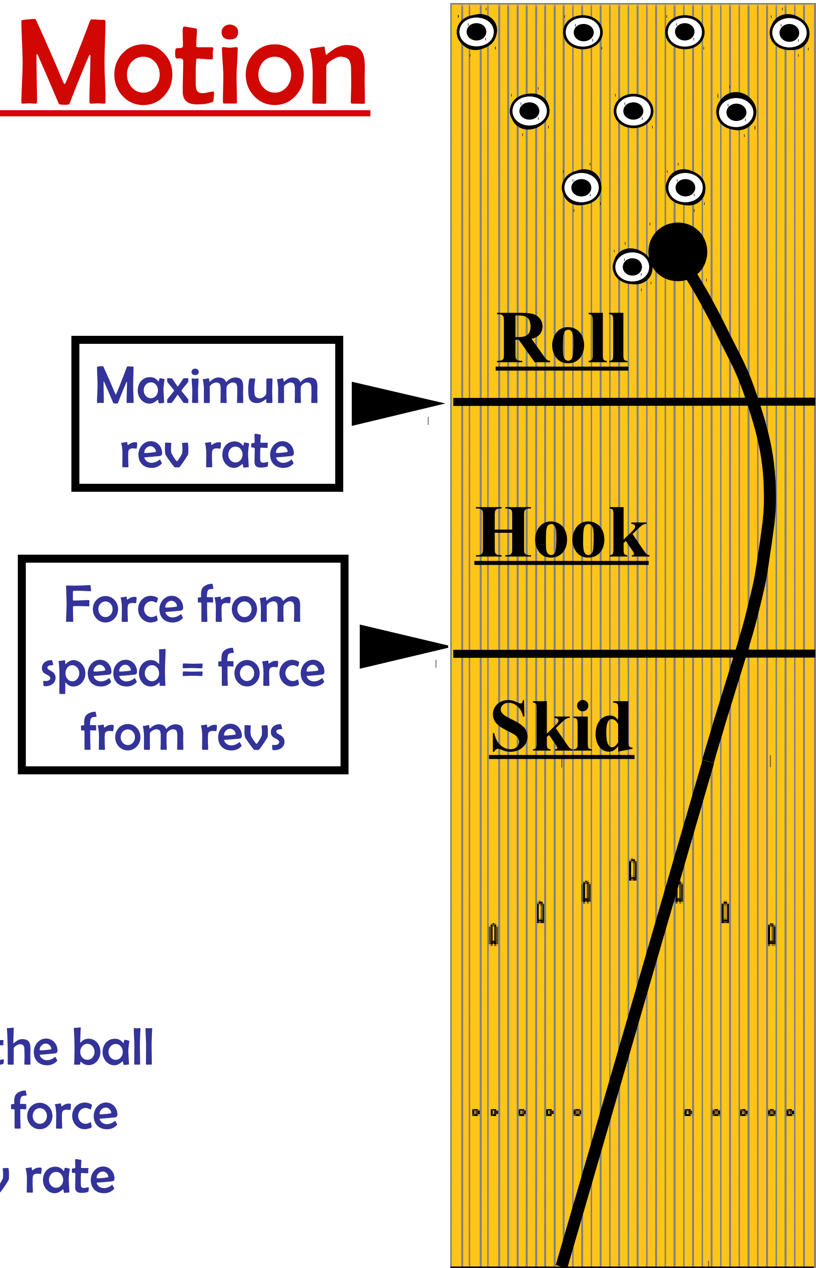
- Least ball speed
- Maximum rev rate
- Least axis rotation
- Most hitting power
- Axis rotation & tilt are minimal and equal

HOOK

- Less ball speed
- More rev rate
- Less axis rotation
- Force created by the rev rate exceeds the force created by the ball speed

SKID

- Highest Ball Speed
- Lowest Rev Rate
- Maximum Axis Rotation
- Force created by the ball speed exceeds the force created by the rev rate



GRAPHICAL ANALYSIS

USBC Ball Motion Study

Data provided by 23 sensor Super CATS lane

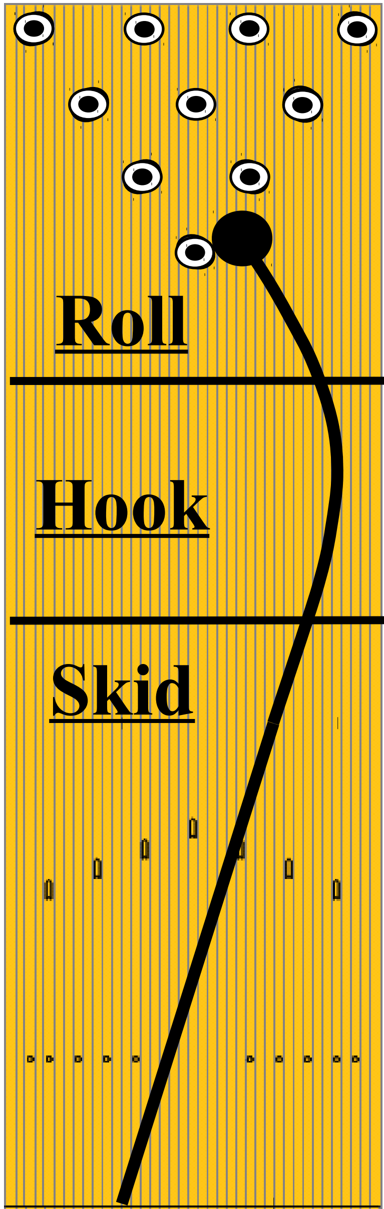
$$Y = mx + b \text{ (linear)}$$

2nd transition

$$Y = ax^2 + bx + c$$

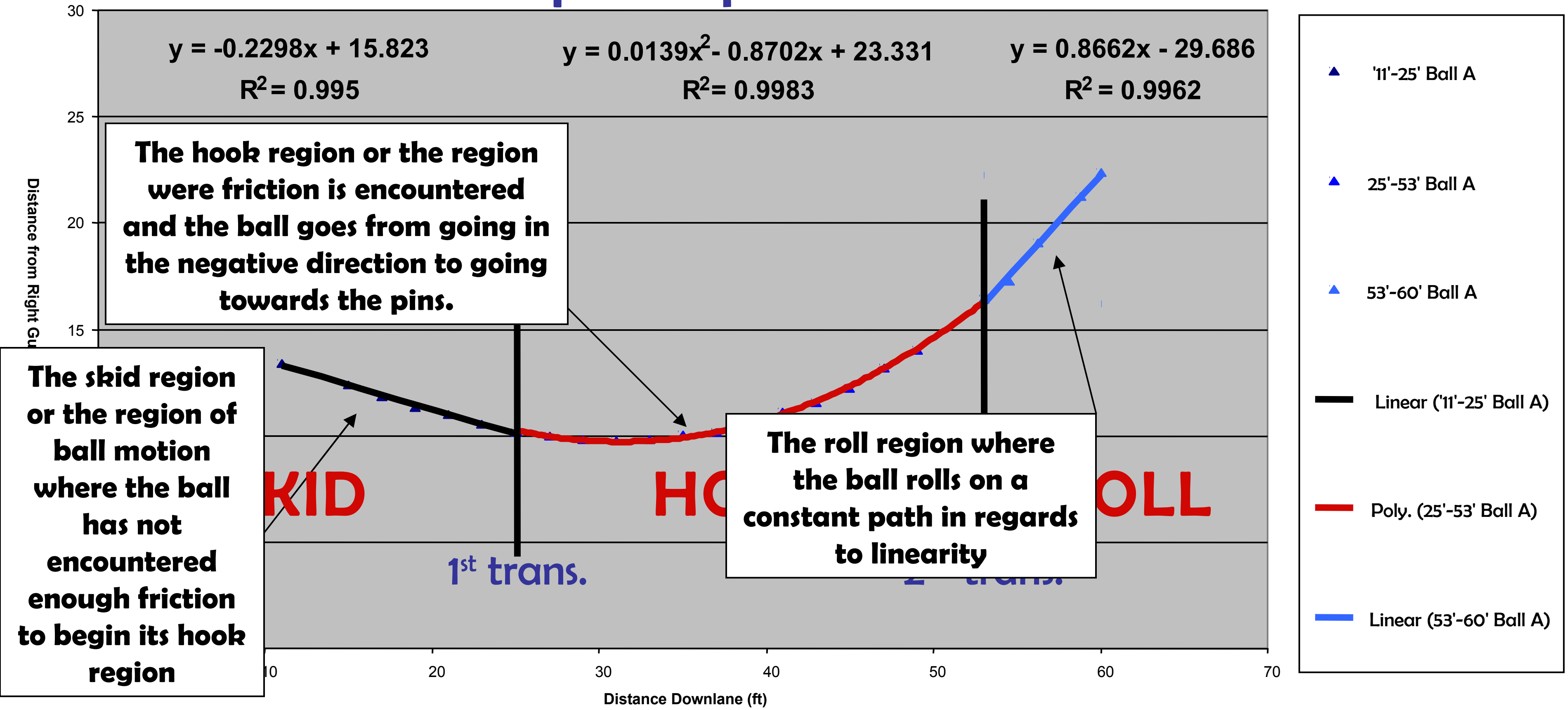
1st transition

$$Y = -mx + b \text{ (linear)}$$



Explaining the Phases of Ball Motion

Sample Equations

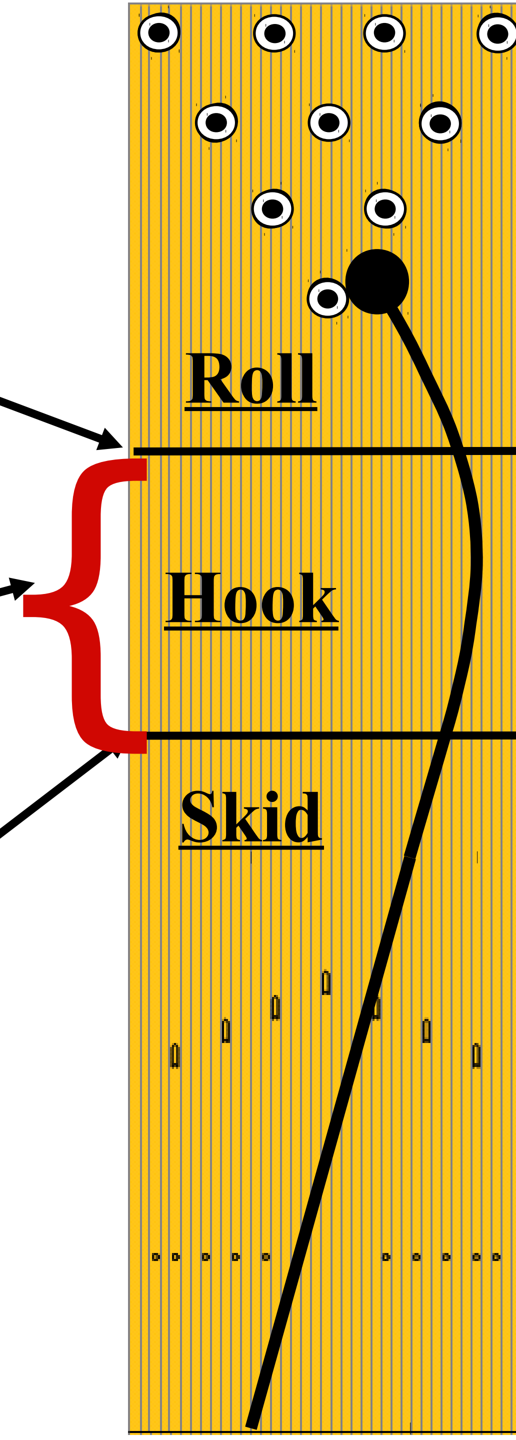


The Effects of Cores and Coverstocks on Ball Motion

This transition is dominated by the **mass properties** of the **drilled ball**.

The length of the hook zone is determined by the **spin time** of the drilled ball.

This transition is dominated by the **surface roughness** of the **coverstock**.



SYMMETRICAL

or

ASYMMETRICAL

Definition of an Asymmetrical Ball

An **asymmetrical** ball must display two characteristics. They are:

1. It must have a **PSA**.
2. It must have an **intermediate differential**.

All bowling balls that have a **PSA** and an **intermediate differential** must be asymmetrical by definition.

Definition of a Symmetrical Ball

A **symmetrical** ball does not have a **PSA** and has no **intermediate differential.**

All bowling balls that have no **PSA** and no **intermediate differential** must be symmetrical by definition.

All drilled bowling balls have a **PSA** and an **intermediate differential**.

Therefore, there is no such thing as a drilled symmetrical ball by definition.

All drilled balls are asymmetrical!

Drilled bowling balls have different degrees of asymmetry, but they are ALL asymmetrical.

Drilled Brunswick Mineralite

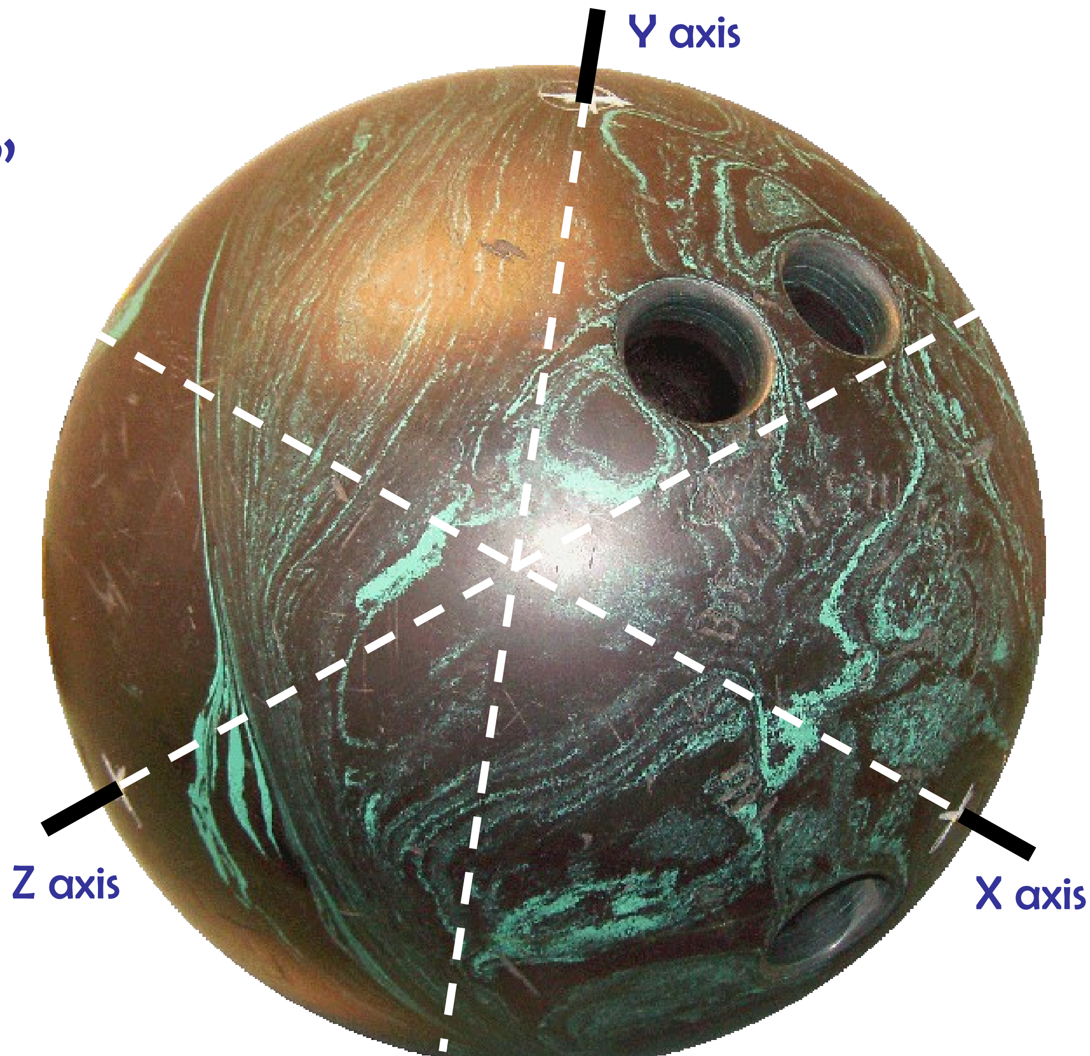
Serial # VL290

Manufactured in 1948

Low RG axis = 2.710"

Int. diff. = .010"

Total diff. = .015"



The drilled ball is asymmetrical by definition!

Mass Properties of a Bowling Ball

The mass properties measure the dynamic motion potential of a bowling ball.

The mass properties we are concerned with are the values of the **low RG** axis, the **high RG** axis, and the **intermediate RG** axis.

Using these values will allow us to calculate the **total differential** and the **intermediate differential** of the ball.

Necessary **Mass Properties** Specs.

It is necessary to specify three of the mass properties to define the dynamic potential of a bowling ball. The three **mass properties** necessary are:

1. The RG of the **low RG axis**
2. The **intermediate differential**
3. The **total differential**

The RG of the **high RG axis** = the RG of the **low RG axis** + the **total differential**
The RG of the **int. RG axis** = the RG of the **high RG axis** - the **int. differential**

Which RG really matters?

- Is it the **LOW RG** axis?
- Is it the **HIGH RG** axis?
- Is it the **INTERMEDIATE RG** axis?
- Is that of the **drilled** or **undrilled** ball?
- Is it the **RG** of the **PAP**?
  Obviously of the drilled ball!

The ANSWER

- The **RG** of the **PAP**
- The **RG value** of the **PAP** remains the same throughout the entire axis migration of the drilled ball.

Essential Elements to scoring

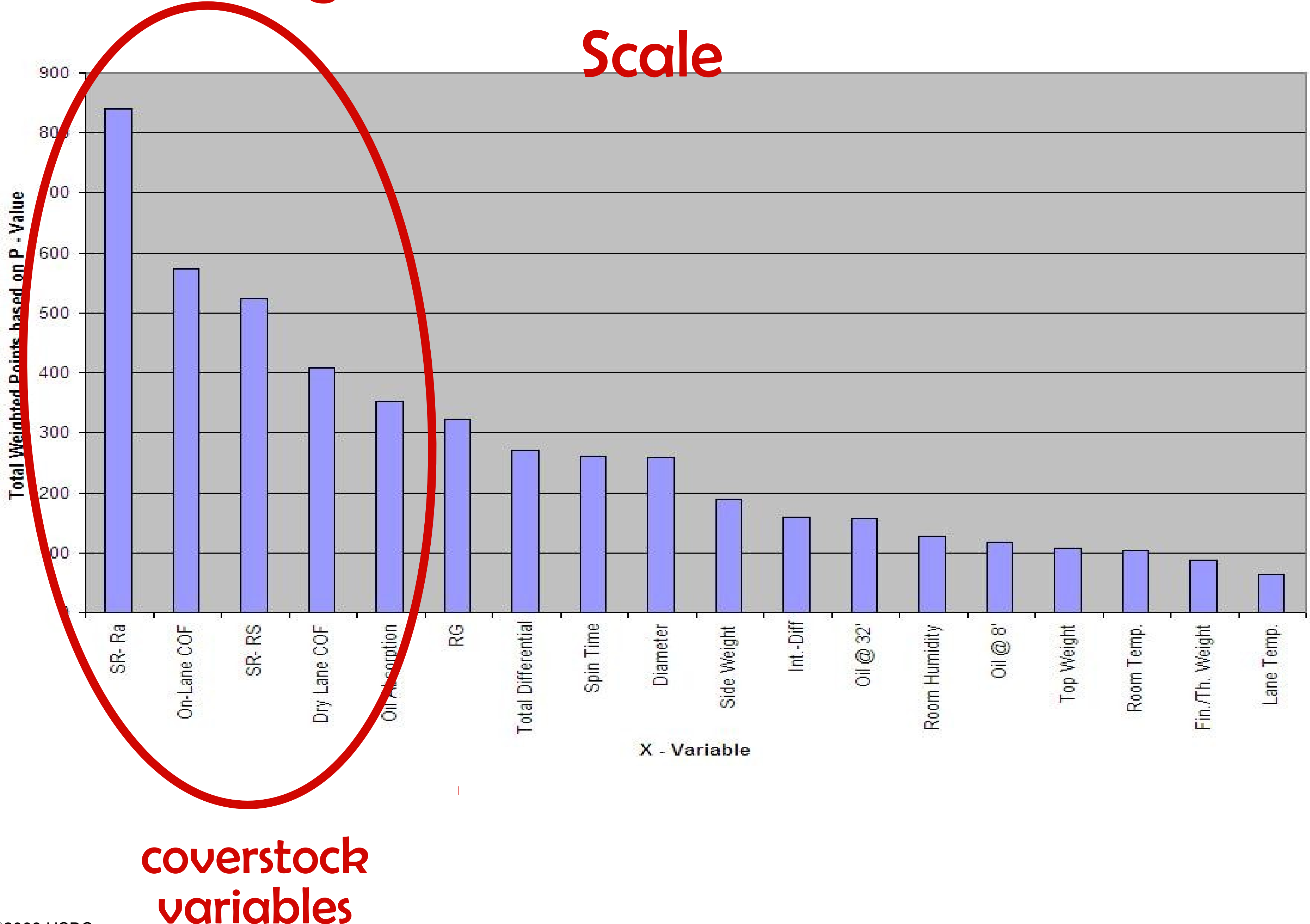
1. Proper **execution** during the delivery.
2. Determine the **shape** of the ball motion that will score.
3. Let the lane tell you where to put your **feet.**

Factors affecting the reaction of drilled Bowling Balls

- **Coverstock** (chemical composition and surface texture)

a Better Understanding of Coverstocks and Surface Preparation

Most Significant Variables – 18 Point Scale

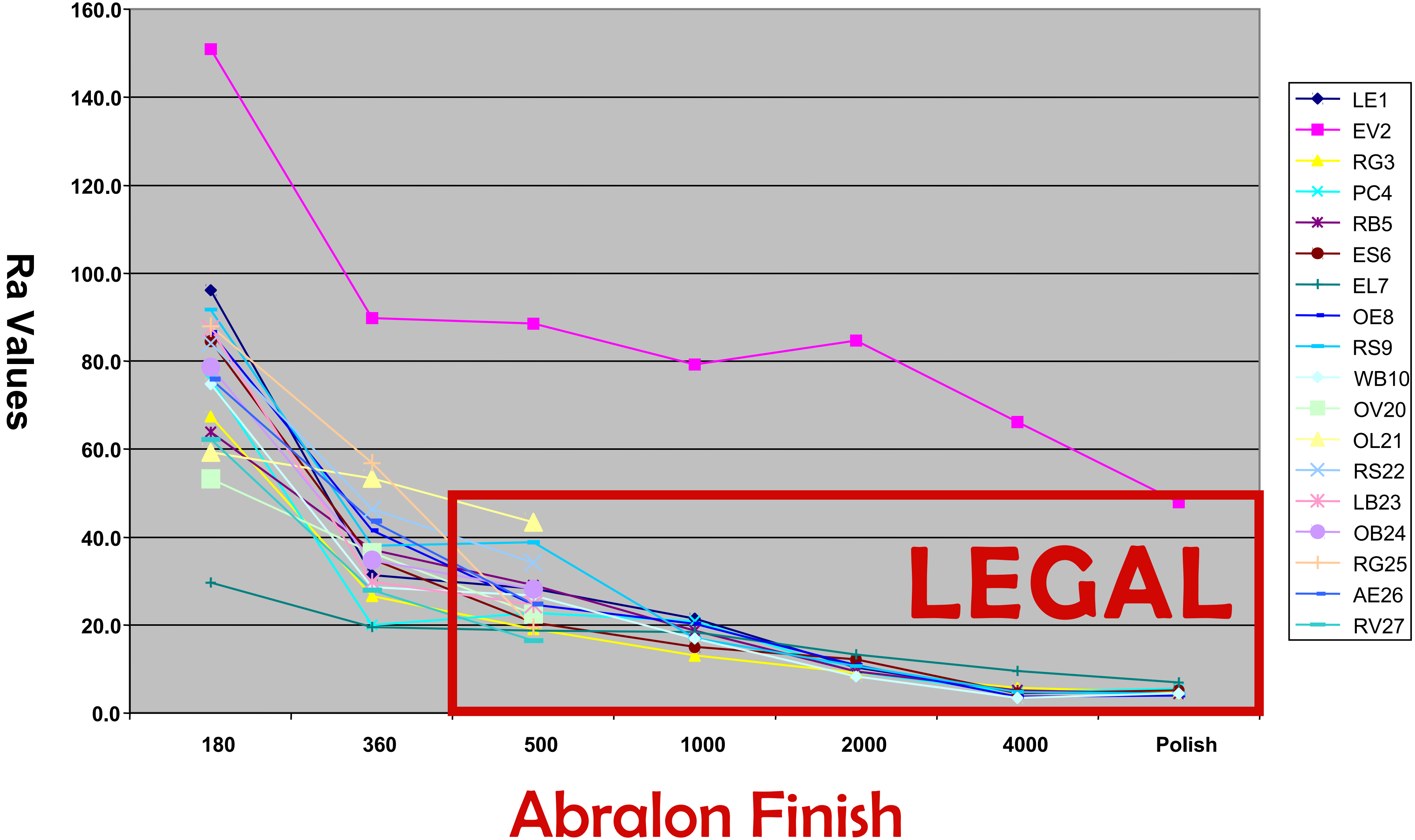


Understanding Ra

Ra is defined as the **height** of the **micro-spikes** of the coverstock when it is measured scientifically.

Surface Roughness Ra - 18 Samples

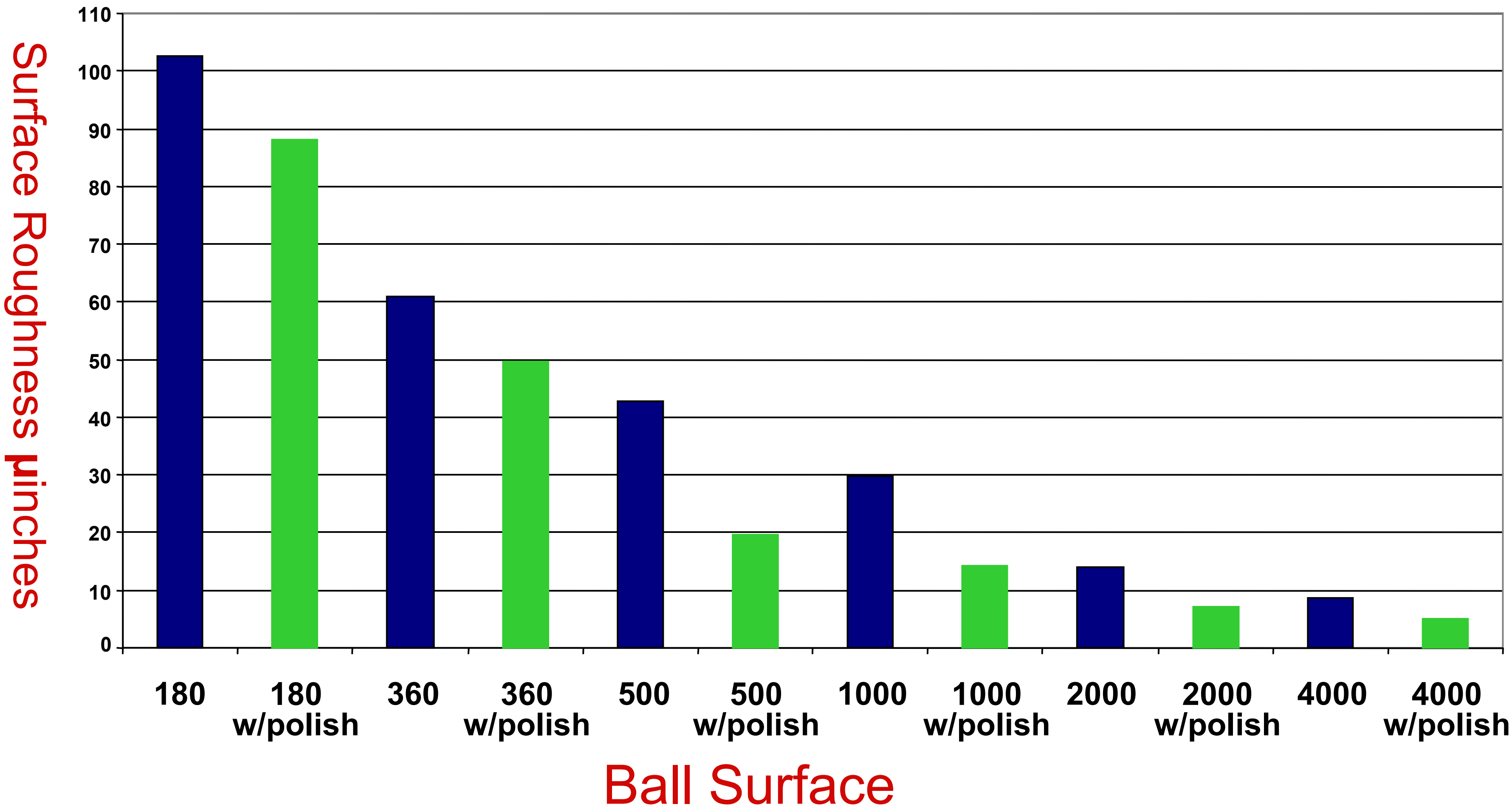
(Range of Balls on Market)



Data courtesy of USBC

How Surface Changes affect R_a

R_a – Average Surface Test



Surface Texture

Wet sanded with 320 to 400 grit paper

Scuffed with a good burgundy pad

Sanded with 600 grit paper

Scuffed with a grey pad

Wet sanded with 1000 grit paper

Wet sanded with 2000 grit paper

Wet sanded with 4000 grit paper

Polished with compound

Polished with ball polish

Polished with ball polish containing a slip agent

earliest breakpoint

latest breakpoint

Factors affecting the reaction of drilled Bowling Balls

- **Coverstock** (chemical composition and surface texture)
- **Ratio** of Intermediate Differential to Total Differential (int. diff./total diff.) of the drilled ball

Differential Ratio

The differential ratio is defined as intermediate differential divided by the total differential

(Int. Diff. / Total Diff.)

the Effect of Diff. Ratio

An indicator of the sharpness of the break point. The larger the diff. ratio, the sharper the break point.

Diff. Ratios < .25 yield a smoother, more continuous, break point.

Diff. Ratios of .25 to .45 yield a medium break point.

Diff. Ratios > .45 yield sharper, more angular break points.

RG Contours

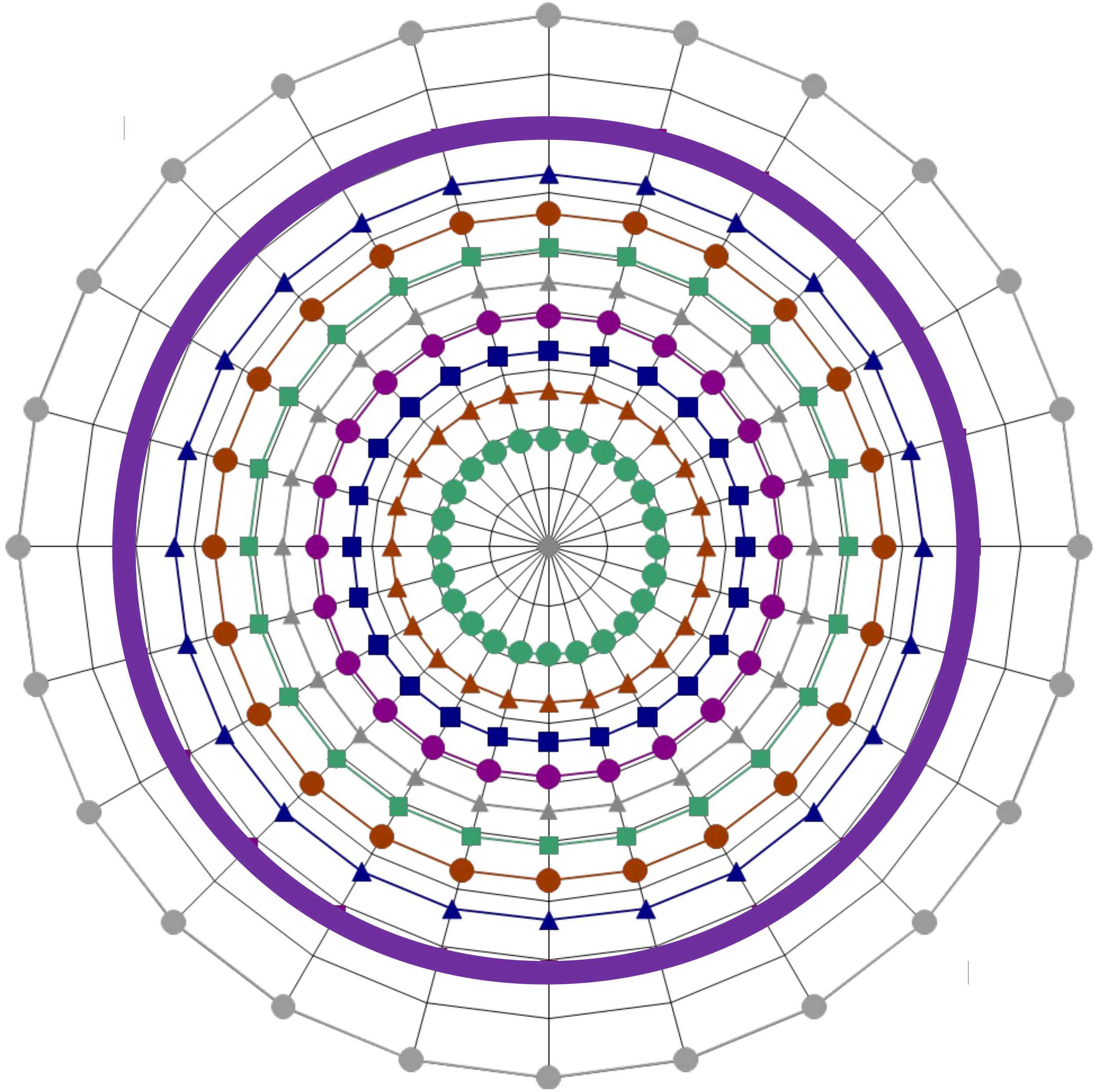
RG contours

are all the points on the surface of the ball that have the same **RG** value.

RG contours are important because the migrating **PAP** will follow the **RG contour** as the ball flares. That means that the **RG** of the **PAP** will remain the same during the ball's entire path down the lane. The bowler will dictate the initial **PAP**, but the **RG contour** of the ball dictates the path of the migrating axis.

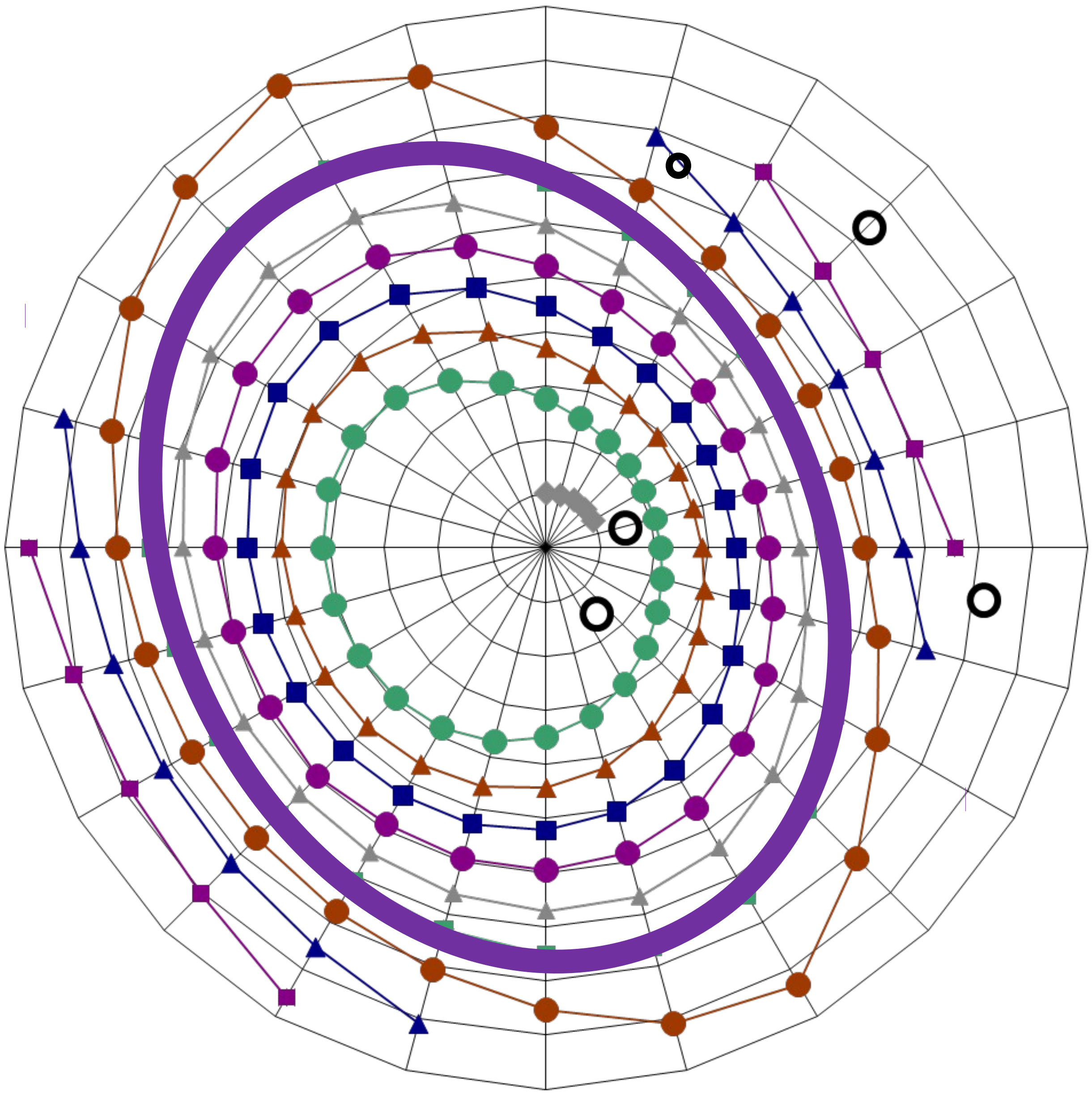
RG Contour of a Symmetrical Ball

Diff Ratio 0.00

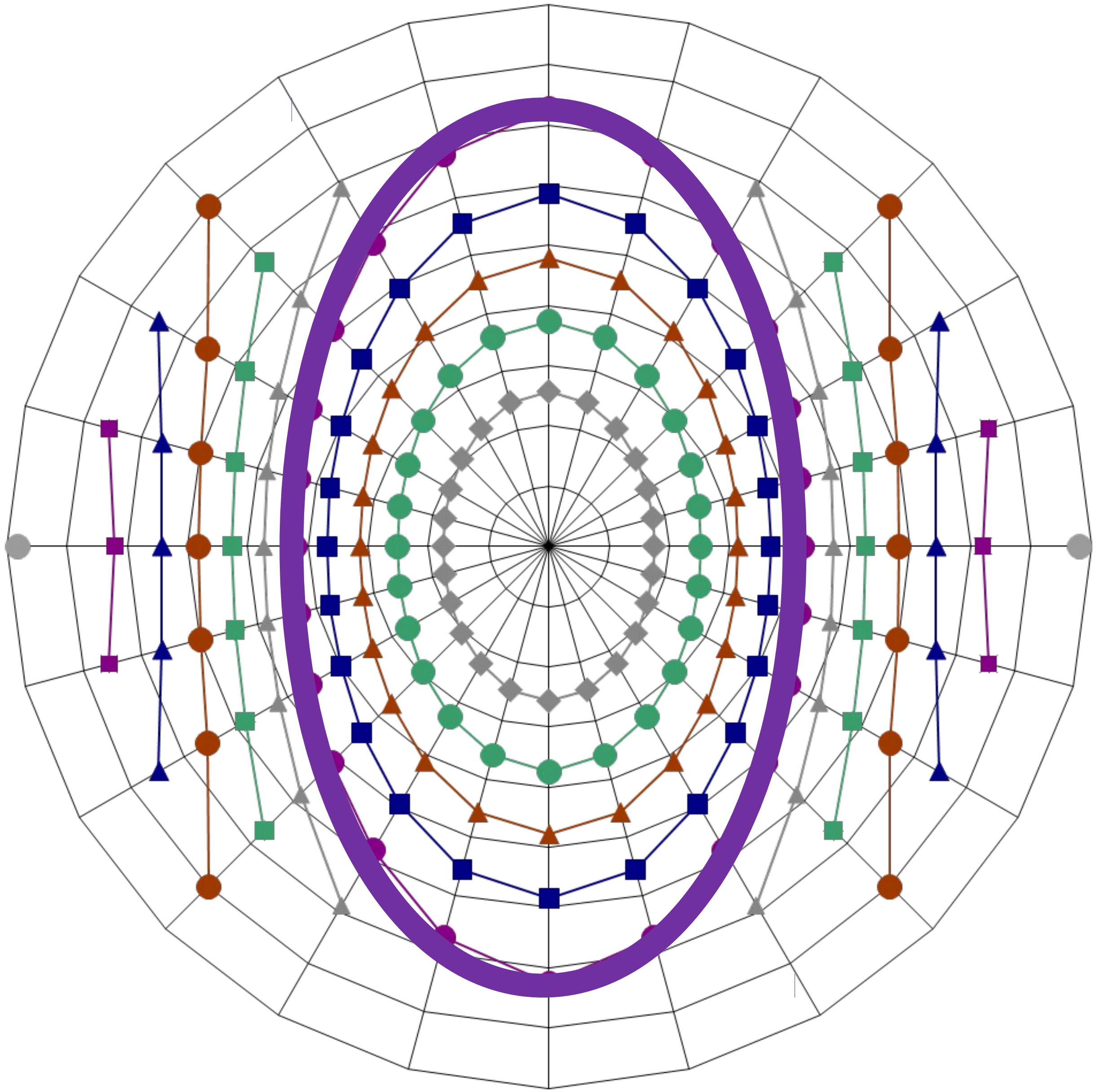


RG Contours of Asymmetrical Balls

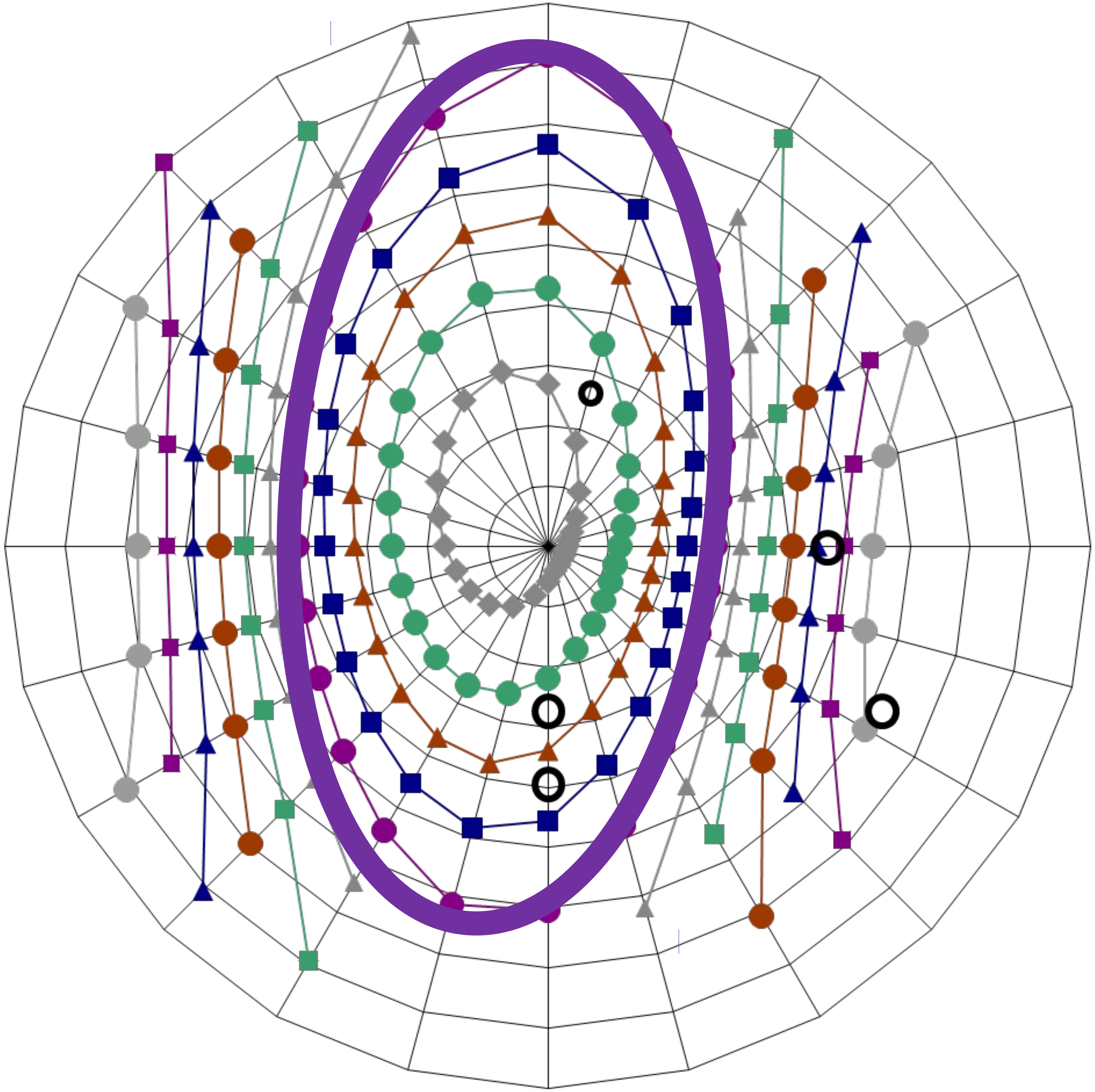
Diff Ratio 0.30



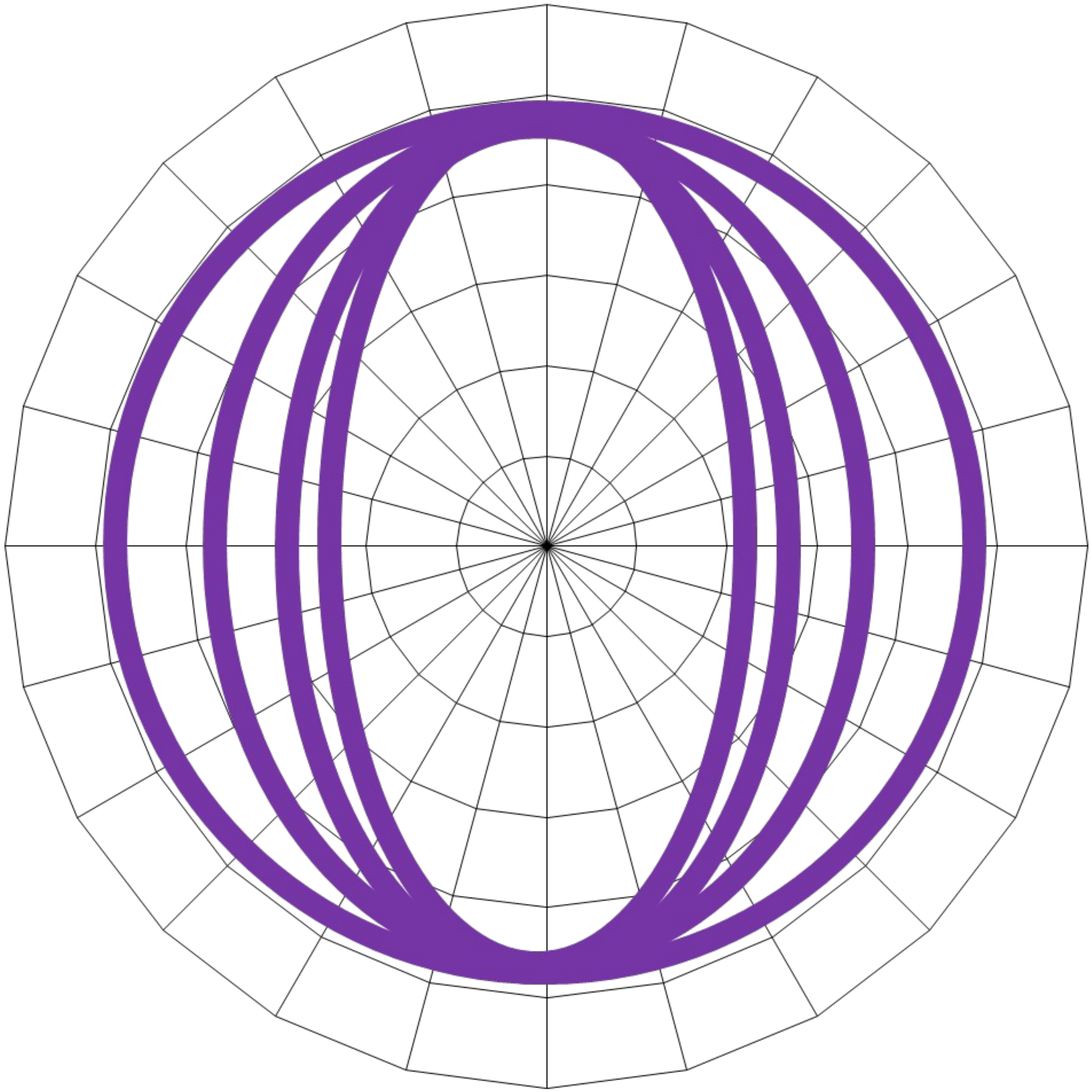
Diff Ratio 0.50



Diff Ratio 0.65



RG Contour Comparison



a study of

Axis Migration Paths

Remember, the RG of the Migrating PAP remains the same during the entire migration of the PAP.

The **shape** of the axis migration path results from the **differential ratio** of the drilled ball.

The **length** of the axis migration path results from the **total differential** of the drilled ball.

Factors affecting the reaction of drilled Bowling Balls

- **Coverstock** (chemical composition and surface texture)
- **Ratio** of Intermediate Differential to Total Differential (int. diff./total diff.) of the drilled ball
- **Total Differential** of the drilled ball

Symmetrical 10x4.25x20 BAL P4

Un-Drilled Mass Properties

M=15.25 lbs

Low RG 2.501

Int Diff .000

Total Diff .050

Diff Ratio 0.00

TW 2.61 oz.

Pin Out 4.51 in.

Drilled Mass Properties

M=14.83 lbs

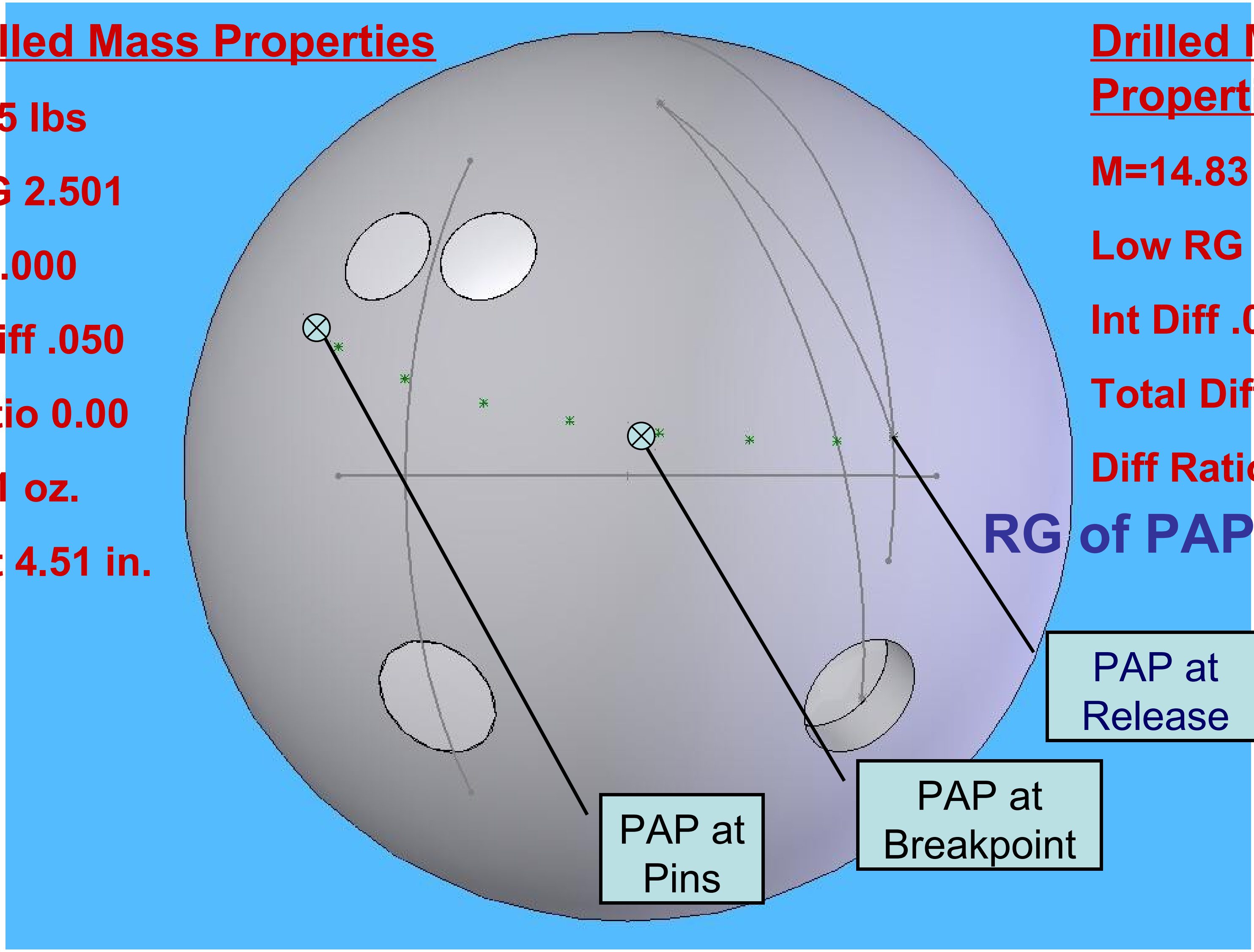
Low RG 2.502

Int Diff .012

Total Diff .066

Diff Ratio .18

RG of PAP 2.544



FRENZY 10x4.25x20 BAL P4

Un-Drilled Mass Properties

M=15.25 lbs

Low RG 2.527

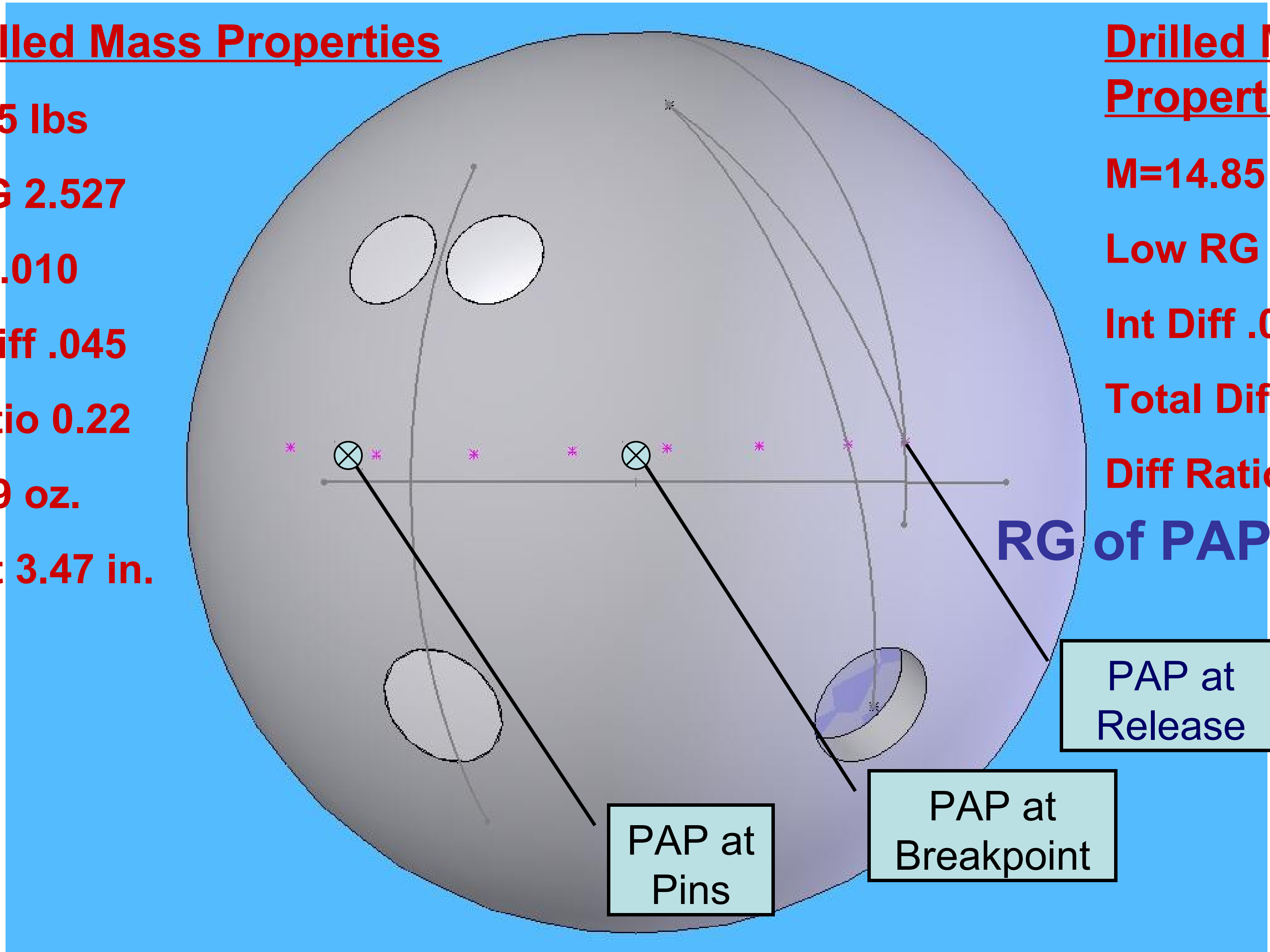
Int Diff .010

Total Diff .045

Diff Ratio 0.22

TW 2.19 oz.

Pin Out 3.47 in.



Drilled Mass Properties

M=14.85 lbs

Low RG 2.528

Int Diff .020

Total Diff .061

Diff Ratio .33

RG of PAP 2.567

Mojave 10x4.25x20 BAL P4

Un-Drilled Mass Properties

M=15.19 lbs

Low RG 2.619

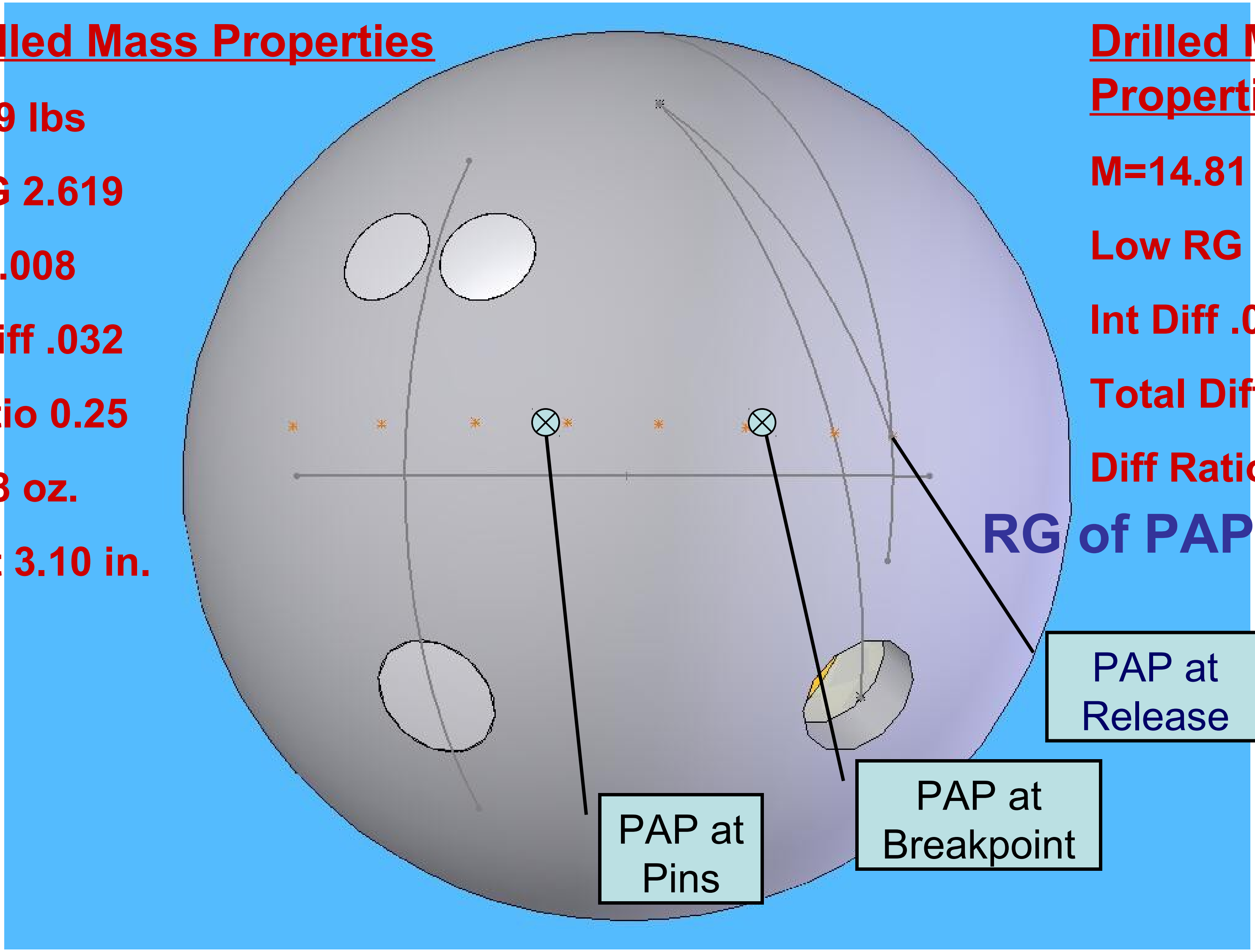
Int Diff .008

Total Diff .032

Diff Ratio 0.25

TW 2.58 oz.

Pin Out 3.10 in.



Drilled Mass Properties

M=14.81 lbs

Low RG 2.619

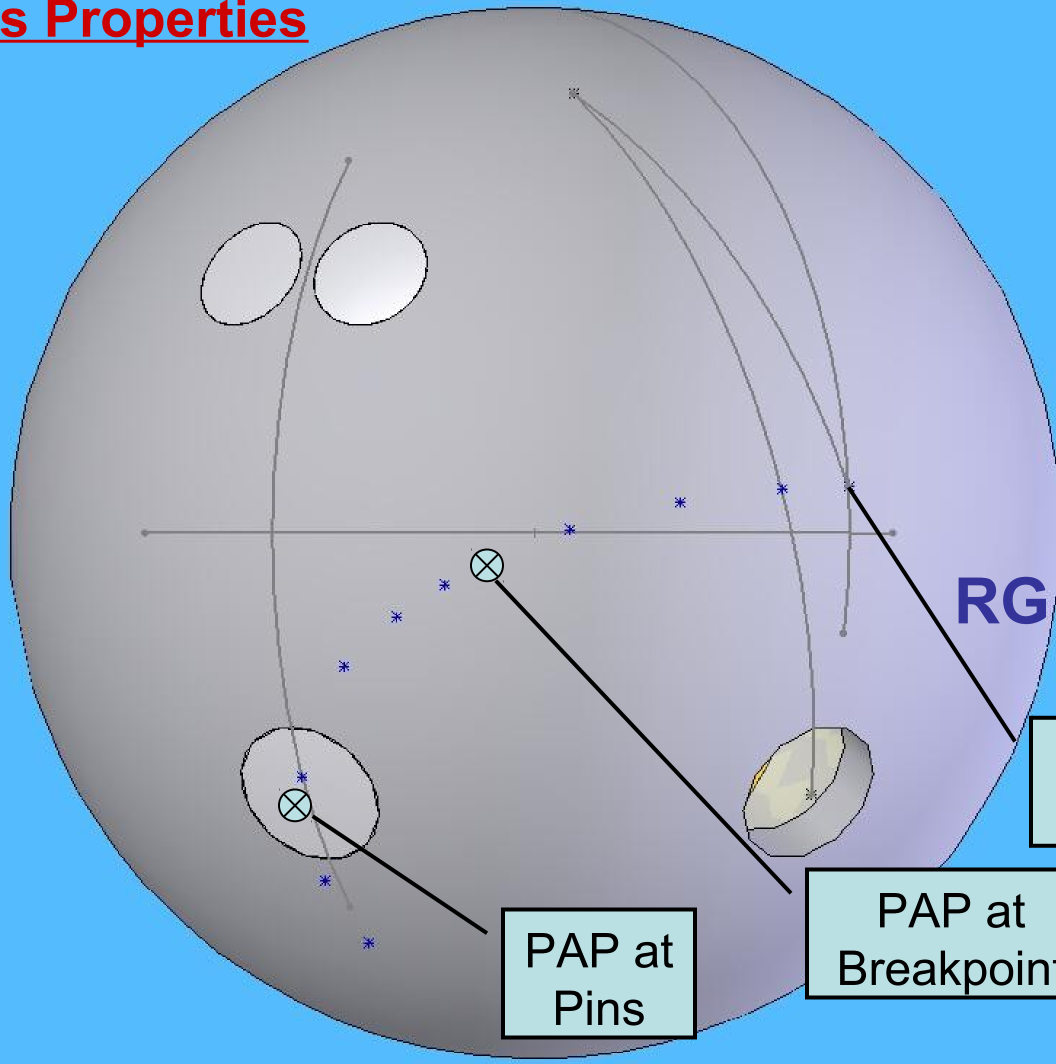
Int Diff .017

Total Diff .046

Diff Ratio .38

RG of PAP 2.647

N'sane Lev RG 10x4.25x20 BAL P4



Un-Drilled Mass Properties

M=15.25 lbs

Low RG 2.489

Int Diff .034

Total Diff .052

Diff Ratio 0.66

TW 3.25 oz.

Pin Out 3.18 in.

Drilled Mass Properties

M=14.87 lbs

Low RG 2.491

Int Diff .044

Total Diff .066

Diff Ratio .66

RG of PAP 2.529

Combo Ball 10x4.25x20 BAL P4

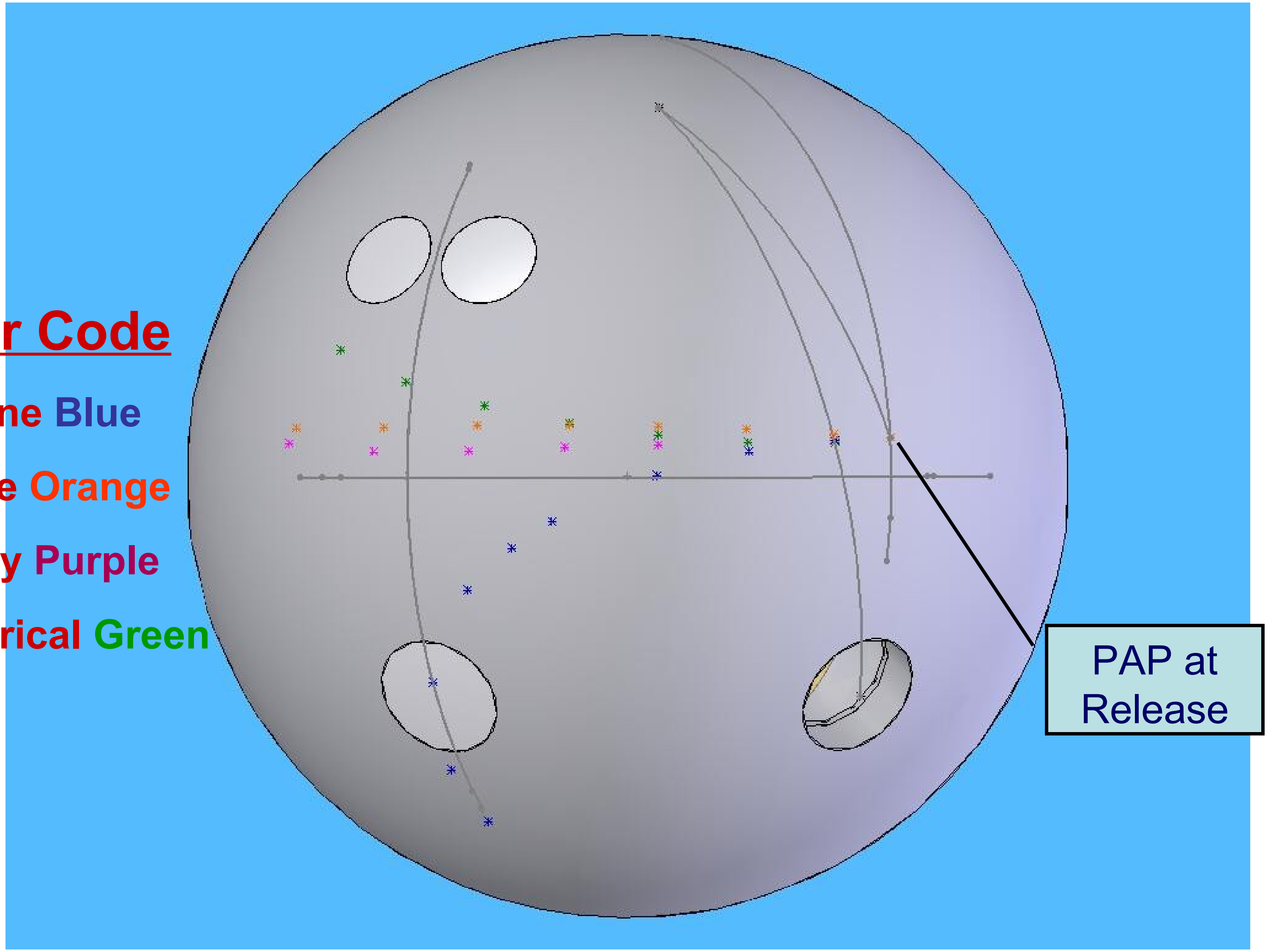
Color Code

N'sane Blue

Mojave Orange

Frenzy Purple

Symmetrical Green



Mass Properties of Drilled Balls Summary

Ball	Mass (lbs)	Low RG	Int Diff	Total Diff	Diff Ratio	RG of PAP
'Nsane LevRG	14.87	2.491	.044	.066	.66	2.529
Mojave	14.81	2.619	.017	.046	.38	2.648
Frenzy	14.85	2.528	.020	.061	.33	2.567
Symmetrical	14.83	2.502	.012	.066	.18	2.544

Drilling: 10° X 4.25" x 20° with a P4 hole

By choosing a **drilling technique**, the location and the size of the **balance hole**, a ball driller can now **reduce** the strength of the drilled ball's **reaction** by as much as **29%** or **increase** it by as much as **55%** using current USBC specifications.

To learn about more about effective drilling techniques, read "**Dual Angle Layouts with Gradient Line Balance Hole Placements**" at www.morichbowling.com, or visit **forum.bowlingchat.net** where all the issues of bowling technology are discussed on a daily basis, especially the "**Mo and Friends**" forum.

Summary of Drillings for Freshour, RipR and Nsane

Symmetrical Ball with Freshour Core

Mass	Drilling	Low RG	Diff	Int Diff	Ratio	RG of PAP	Pin Out	Top Wt.
16.06	Undrilled	2.496	0.047	0.000	0.00		3.2 in	2.6 oz
15.59	10x4.25x20 P4	2.500	0.063	0.013	0.20	2.540		
15.59	30x4.25x20 BAL P4	2.501	0.066	0.020	0.30	2.536		
15.60	65x4x30 BAL P4	2.502	0.061	0.020	0.32	2.535		
15.56	70x5x45 BAL P2	2.508	0.054	0.016	0.29	2.551		
15.82	80x2.25x50 NO BAL Hole	2.501	0.049	0.006	0.12	2.507		
15.52	80x2.25x50 BAL P1	2.519	0.035	0.003	0.09	2.530		

MoRich RipR

Mass	Drilling	Low RG	Diff	Int Diff	Ratio	RG of PAP	Pin Out	Top Wt.
16.08	Undrilled	2.533	0.042	0.013	0.32		3.2 in	2.9 oz
15.58	10x4.25x20 P4	2.537	0.061	0.027	0.44	2.576		
15.58	30x4.25x20 BAL P4	2.537	0.065	0.036	0.55	2.569		
15.54	65x4x30 BAL Dbl-Thm	2.540	0.063	0.039	0.62	2.564		
15.51	70x5x45 BAL P2	2.547	0.050	0.029	0.59	2.575		
15.84	80x2.25x50 NO BAL Hole	2.536	0.046	0.018	0.40	2.539		
15.56	80x2.25x50 BAL P1	2.554	0.031	0.014	0.46	2.561		

MoRich 'Nsane LevRG

Mass	Drilling	Low RG	Diff	Int Diff	Ratio	RG of PAP	Pin Out	Top Wt.
16.06	Undrilled	2.471	0.052	0.036	0.70		3.5 in	2.6 oz
15.65	10x4.25x20 P4	2.472	0.067	0.045	0.68	2.512		
15.66	30x4.25x20 BAL P4	2.472	0.070	0.053	0.76	2.502		
15.56	65x4x30 BAL Dbl-Thm	2.480	0.067	0.057	0.85	2.496		
15.52	70x5x45 BAL P2	2.485	0.057	0.047	0.82	2.505		
15.82	80x2.25x50 NO BAL Hole	2.475	0.055	0.040	0.72	2.475		
15.53	80x2.25x50 BAL P1	2.492	0.041	0.035	0.86	2.497		

Drilled MoRich LevRGs

Name	Serial	Drilling Technique	Low RG Axis	Undrilled I-Diff	T-Diff
LevRG	183	10° x 3 3/8" x 20°	2.485	**0.035**	**0.049**
LevRG	138	90° x 3 3/8" x 20°	2.484	**0.034**	**0.049**
LevRG	216	90° x 4 1/2" x 70°	2.483	**0.034**	**0.050**
LevRG	198	50° x 5" x 45°	2.481	**0.034**	**0.053**

Name	Serial	Drilling Technique After Drilling	RG of the PAP	Top	Side	Finger
LevRG	183	12° x 3 5/8" x 17°	**2.514**	-0.75	0.75	0.675
LevRG	138	78° x 2 1/4" x 3°	**2.496**	-0.75	-0.25	0.75
LevRG	216	90° x 2 3/8" x 70°	**2.488**	-0.50	0.50	-0.375
LevRG	198	50° x 5" x 45°	**2.509**	0.375	0.625	0.50

Drilled MoRich LevRGs

Name	Serial	Drilling Technique After Drilling	Sum of the Angles	RG of the PAP	1st trans	2nd trans	Hook Zone Length	A Score	Break point	Frictional Efficiency
LevRG	183	**12°** x 3 5/8" x 17°	**29**	**2.514**	25	**41**	16	0.0177	32.12	0.1309
LevRG	138	**78°** x 2 1/4" x 3°	**81**	**2.496**	29	**43**	14	0.0162	34.10	0.1175
LevRG	216	**90°** x 2 3/8" x 70°	**160**	**2.488**	29	**49**	20	0.0165	34.56	0.1194
LevRG	198	**50°** x 5" x 45°	**95**	**2.509**	27	**47**	20	0.0153	31.95	0.1133

Factors affecting the reaction of drilled Bowling Balls

- **Coverstock** (chemical composition and surface texture)
- **Ratio** of Intermediate Differential to Total Differential (int. diff./total diff.) of the drilled ball
- **Total Differential** of the drilled ball
- **RG** of the **PAP**

Ball surface, RGs, and the **total differential**, have similar effects on ball motion. They will all affect the **rate** at which the ball transitions. **Differential ratio** has the greatest effect on the **shape** of the ball motion. **Pin to PAP distance** affects the **rate** that the ball transitions by affecting flare, as well as the **shape** of the ball motion.

The SPIN TIME of the Drilled Ball

The **spin time** of the **drilled ball** measures the complex relationship between the **ratio** of intermediate diff. to the total diff., the **total diff.**,and the **RG** of the **PAP.**

Learn how to accurately analyze bowling balls for yourself by using the "**USBC Ball Analysis Form**" at **bowl.com.**

IBPSIA Advanced HOTS is held annually in conjunction with BOWL EXPO. For more info about this and others educational classes contact IBPSIA.

THANX

for attending

MO

and

All the people at MoRich!