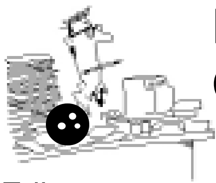

Editor's Corner:

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Well, here it is again guys. Print it out when you desire.

Place selected pages in a binder for your students. Use selected pages in your classes.

In this issue:
Advanced Lane Play:
Matching Up - The Ball to the Bowler

November Issue:
Matching Up - The Ball and Bowler to the Lane Conditions

The Coaching Eye

Volume #1 - Issue #4
October 2002

Matching Up - The Ball to the Bowler
Each part of each section (like a chapter) starts on a separate page. This allows you to cover a specific topic, one at a time with your student.

If you think of other topics pertaining to **Matching Up** and want to let other coaches know about them, please write it up, send it to me and I will review it and publish it with your name as the author. Send as a Microsoft Word file as an attachment to an e-mail to me. And, if you have other topics or ideas that would be of use to other coaches, please send them to me. Share those ideas and we will all grow as better coaches.

Note that each issue stands on it's own as a publication. Hence, some topics appear in multiple issues. (As my time permits and the demand requires, we also create a left handed bowler version of all back issues. They are available - free - upon request. Just e-mail us the request).

Each issue is designed to be a fund raising booklet for your local Youth Bowling Program. Excluding the cover page, make some clean copies and let the Youth Director sell them at the control desk or in the pro shop to raise money for the youth bowling program at your bowling center.

This issue is about 40 pages in length. Check your printer paper before printing it out. Please read it yourself before giving it to your students.

Matching Up
-
The Ball to the Bowler

by
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Bowling Terminology Definitions

Arc Point - The transition point where the ball changes it's rolling characteristics from sliding with little or no curve to the beginning of a pronounced curve.

AFR Number
The Actual Flare Realized Number is a product of the PTF Number and the DRG (the flare potential).

Axis Balance - The PIN of the bowling ball is positioned on the bowler's axis point with respect to the initial rolling track of the ball.

Axis Drilling
The bowling ball is drilled so that the initial axis of rotation is on or very close to the PIN of the weight block. Since the ball starts out at or very near one of the two stable rotational modes, the ball has a very stable and very smooth arcing rolling path.

Positive Axis of Rotation - The center of the bowling ball opposite to the bowler's initial rolling track on the ball on the same side as the gripping holes. This is also called the Positive Axis Point (PAP).

Axis Point - The point on the surface of the ball at the end of the Positive Axis of Rotation.

Backend - The rear part of the lane surface, usually categorized as the part of the lane where little or no lane conditioner has been applied. Depending on the bowling center, the backend can be the last 15 to 25 feet of the lane surface.

Backend Potential - This is a parameter that is sometimes used to compare the amounts of reaction on a drier backend bowling lane surface for bowling balls of a single manufacturer. Note that the backend potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Balance Hole - An extra hole positioned so as to statically balance and finalize the reaction characteristics of the ball. ABC limits the size of a balance hole to diameter of less than 1 1/4".

Ball Rolling Track - The circular region on a bowler's bowling ball where it makes contact with the lane surface. The initial rolling track is usually the most visible because it is usually the wettest.

Borden Number
It's a number that can be used to compare bowling balls of the same manufacturer or different manufacturers because, it only uses real numbers that describe the bowling balls. The best results come from comparing balls of the same type and manufacturer.

Break - The movement of the bowling ball laterally across the lane surface.

Center of Gravity (CG) - The location on the surface of the bowling ball where gravity acts straight down from the center of all of the weight of the ball. Manufacturers float a newly manufactured bowling ball on a cushion of air. Once the ball stops moving, the very center of the bottom of the ball is marked as the Center of Gravity (CG).

Core - The inner portion of a three (or more) piece bowling ball consisting of lighter weight filler material just between the cover stock and a heavier and very hard center material.

Coverstock - The outside material of a bowling ball. It can be as thin as about 1/4” to 1 1/2” thick and be made of various materials such as rubber, polyester, urethane and some exotic new reactive or composite materials.

Differential of Radius of Gyration - Radius of Gyration is measured with respect to the “Z” axis which is defined as the direction the PIN points outward from the surface of the ball from the center of the ball. The two other directions are perpendicular to that direction and the Radius of Gyration for those two axes can also be measured. The difference between the Radius of Gyration measured at any two of the three axes is defined as the Differential Radius of Gyration. (The largest is listed as the DRG).

Dynamic Balance - Drilling the bowling ball in such a position as to cause a specific ball reaction during the rolling path of the ball.

Dull Surface - A bowling ball surface that has not been polished so as to allow the ball to exhibit it’s porosity characteristics. A bowling ball that has been sanded at the factory with a specific lower grit numbered sandpaper leaves a dull finish on the surface of the ball. Using a ball spinner and the appropriate sandpaper, the surface dullness can be adjusted to fit the desire of the bowler.

Final Rolling Track (FRT)
The final rolling track on the ball surface. It is usually associated with the desired “over the PIN” orientation after flaring is completed.

Flare - A measure of how much the track changes position during the roll of the ball. It is caused by the bowling ball changing it’s axis of rotation during the roll of the ball.

Flaring Potential - This is a parameter that is sometimes used to compare the amounts of track flare for bowling balls of a single manufacturer. The track flare potential is measured in inches, so all of the manufacturer’s can reasonably be compared with each other.

Forward Roll Axis - The axis of rotation for the movement of the ball down the lane surface toward the pin deck. If you hold your right hand out with the palm facing downward and your fingers representing the direction of the top surface of the bowling ball, your thumb represents the axis of rotation of the forward roll of the ball.

Friction - The interaction between the lane surface and the bowling ball surface which causes the ball to slow down as it rolls farther down the lane after leaving the oil conditioned frontend of the lane.

Heads - The front portion of the lane surface, usually about 20 feet. When they say that they are re-oiling the heads, they usually mean that only that first 20 feet or so is being oiled.

Hook Potential - This is a parameter that is sometimes used to compare the amounts of hook for bowling balls of a single manufacturer. Note that the hook potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Initial Rolling Track (IRT)
The initial rolling track on the ball surface. It is usually the wettest track on the ball.

Label Balance - Drilling a bowling ball so that the CG is near the center of the gripping area of the ball.

Layout Instability
The range of the Layout Instability is from zero to one. For stacked leverage, the Layout Instability Number has a value of one. For a layout with the Pin on the PAP and the Mass Bias Point located on the initial rolling track (axis drill layout) has a value of zero.

Length Potential - This is a parameter that is sometimes used to compare the amount of delay a bowling ball can have before arcing. Note that the length potential ratings for one manufacturer are not necessarily the same scale as for another manufacturer.

Leverage Drilling - The bowling ball is drilled so that the maximum instability from the initial rolling track to the final rolling track is attained. The theoretical location for the PIN is 3 3/8th inches from the initial axis of rotation of the ball.

Leverage Line - An imaginary circle on the bowling ball located 3 3/8” from the current positive axis of rotation. When the PIN of the ball is located on the Leverage Line in the upper right quadrant, the greatest potential for the maximum break possible is realized.

Moment of Inertia - It is the resistance to change in angular velocity of the bowling ball. A bowling ball with a low moment of inertia will be easier to spin up to a high rotational velocity. And conversely, a ball with a high moment of inertia will not spin up easily. It’s related to the Radius of Gyration (RG) of the ball.

Mo Number
Mass bias is a measure of how the weight block is shaped. The more that the weight block is protruding to one side, the more mass bias it has.

PIN - The point on the surface of a bowling ball that represents the balance point of the symmetrical internal weight block of a bowling ball. It can be thought of as extending from the exact center of a symmetrical weight block. If you were to have the symmetrical weight block by itself, you could turn it over and stand it on the PIN point on the weight block.

Positive Axis Point - It is the center of the hemisphere on the ball defined by the initial rolling track of the ball. With the fingers at the top of the ball and the track to the left of the fingers and thumb, the Positive Axis Point is at the right at the center of that hemisphere. (Same side as the gripping holes).

Preferred Spin Axis - The rolling axis which the bowling ball searches to reach by flaring the rolling track. One preferred spin axis is at the PIN of a symmetrical weight block (spinning the ball about the PIN of the ball). The other two preferred axes are perpendicular to the PIN axis at the center of the ball (the PIN would be right on the rolling track of the ball).

PTF Number
The PTF Number is the rotational speed times the instability of the layout.

Radius of Gyration - The relationship between the moment of inertia and the mass of a bowling ball. A bowling ball with a higher radius of gyration has it's overall mass shape located further away from the center of the ball. A low radius of gyration ball has most of the mass near the center. A low RG ball is easier to "rev up."

Reactive Resin - A coverstock material which is usually a blend of urethane with different additives. It has the property of reacting violently on the drier backend portion of the lane surface. It has higher friction on a dry surface.

Revolutions (Revs) - The number of times a bowling ball makes a complete rotation about it's axis of rotation as it rolls from the foul line to the head pin.

Rev Rate - The rotational speed of the ball can measured in revolutions per second although it can be stated as revolutions per minute (RPM). And since that's a much higher number and much more impressive, that's the number you will usually see in the literature.

Rudy Numbers
Release strength is related to the Rave Rate and the Radius of Gyration. It takes more strength in a release to get a high Rev Rate. It also takes more strength in a release to rotate a higher RG ball.

Sideways Roll Axis - The axis of rotation for the movement of the ball across the lane surface. If you hold your hand up and face the palm to the left with your fingers curled, your fingers represent the moving top surface of the ball and your thumb represents the direction of the sideways roll axis pointing to the rear.

Three Piece Construction Bowling Ball - A bowling ball with a dense inner core, a filler material and a dense coverstock.

Two Piece Construction Bowling Ball - A bowling ball with an inner weight block and an outer shell.

Weight Block - The custom shaped inner mass of a bowling ball.

Bowling Ball Ratings Supplied by Manufacturers (Fudgable Numbers)

The Hook Potential
This rating is a number related to how much the ball could possibly hook.

The Length Potential
This rating is a number related to how long the ball will travel down the lane before it begins to hook across the lane.

Back End Potential
This rating is a number related to how aggressive the ball is on the back end compared to the front end of the lane surface.

Flare Potential
This rating is a number related to how far the ball may flare around the surface of the ball.

Ball Manufacturer Real Numbers
These are real numbers, not some evaluation by some 7 foot tall white rabbit with a bad fitting ball.

RG - Radius of Gyration
This parameter is related to how much of the mass of the ball is toward the surface of the ball. The higher the RG, the greater the percentage of the mass is located farther away from the center of the ball. Since the RG is measured about three axes X, Y and Z, there are three RG values. The average RG is usually what is listed, but usually stated in some easier to read scale.

Remember, low RG balls are easier to rev up to a high rotational energy state and just as easily release their rotational energy quickly. Your hand inputs the energy and the dry lane at the back end takes it away as the ball breaks toward the pocket.

DRG - Differential Radius of Gyration
This parameter is related to the shape of the total mass distribution inside a bowling ball. It is mostly related to the shape of the weight block. The highest difference between the RG values is what's generally stated as the DRG for a bowling ball. It is also usually stated in an easier to read scale.

Remember that the DRG is directly proportional to the flare distance, The higher the DRG, the higher the flare distance.

Grit Number - Surface Texture Roughness
This number is usually the out of box surface texture that the ball was processed to at the final stage before packing. The Grit Number is an inversely stated number. The higher the number is, the smoother the surface is. So, a 400 grit is much rougher than 2000 grit surface.

So, What are the Bowling Ball Design Characteristics to Look For?

The greater the reactive surface usually is, the greater the listed hook potential is.

The softer the surface, the greater the hook potential is.

The greater the porosity (and Coefficient of Friction), the greater the ball will hook early in the roll of the ball.

The lower the Radius of Gyration, the easier you will be able to "rev" the ball up to a higher rotational velocity, but the easier it will spin down after it comes off the front end oil. The lower RG ball will be more "snappy".

The higher the Radius of Gyration, the harder you will be able to "rev" the ball up, but the ball will maintain the rotational velocity longer in the roll of the ball. The higher RG ball will be more "arcy."

The greater the Differential Radius of Gyration, the greater the flaring distance is on the surface of the ball.

The harder the central core of the ball, the higher the Coefficient of Restitution will be and correspondingly, the more energy will be available to be imparted to the pins by the ball.

Influences on Matching Up - The Equipment

How the Weight of the Ball Affects the Roll of the Ball
Weight affects the deflection angle of the ball. Generally, the deflection angle that the ball has after impacting a pin decreases as the weight increases. (Lighter weight balls deflect more).

How the Static Weight Balance of the Ball Affects the Roll of the Ball
The static weight imbalance has a small affect on the rolling path characteristic of the ball compared to the dynamic and surface effects of the ball. To a small degree the more side weight, the greater the break will be. Also to a small degree, the greater the finger weight and top weight, the greater the length of the delay of the break across the lane surface will be.

How the Radius of Gyration Affects the Roll of the Ball
The smaller the radius of gyration, the easier it is to impart rotational energy into the ball. Generally, the easier it is to rev the ball up. And, conversely, the higher the RG, the harder the ball is to rev up. For that reason low RG balls usually have oil tracks closer together than high RG balls.

How the Differential Radius of Gyration Affects the Roll of the Ball
The greater the Differential Radius of Gyration, the longer the flaring is on the surface of the ball.

How the Surface Reactivity Affects the Roll of the Ball
An increased surface reactivity increases the break across the lane at the backend of the lane. Usually, highly reactive bowling balls are smooth surfaced and do not react well with the surface during the roll of the ball at the frontend of the lane where the lane conditioner is applied heavily.

How the Surface Porosity and Hardness Affects the Roll of the Ball
As the porosity increases and hardness decreases, the break increases.

How the Surface Bumpiness (Surface Roughness) Affects the Roll of the Ball
As the surface bumpiness increases, the overall amount of break usually increases. This is most easily seen as the sanding state of the surface of the ball. As the sanding grit number decreases, the overall amount of break increases. In the published ball guides, balls are sometimes listed with ratings for both the smooth and sanded state. The sanded state “almost always” has more hook potential.

There are exceptions, however. When a bowling ball has too much roughness (traction), it will do well in the early part of the oil but may not get enough friction (rubbing) at the rear part of the lane. The result is that the sanded ball actually breaks less than the smooth surface ball of the same type. This is especially true of an aggressive reactive resin ball. That type ball does extremely well on the dry back end. And, it is mostly because of friction, not traction. If you sand the ball, you decrease the total surface of the ball that makes contact with the lane surface. Hence, the ball will break less, not more.

The Hardness of the Inner Core of the Bowling Ball
Some bowling balls have a super hard inner core. The newest balls have either a ceramic or a titanium inner core. It is very lightweight, so it doesn’t add that much weight to the ball and it is

extremely hard, so it doesn't deform very much when impacted or when it impacts something else (like a bowling pin for example).

You want a bowling ball to act like a spring, not like a shock absorber. Damping (the shock absorber effect) is the primary effect that is changed by the super hard core. The less spongy the core is, the less it absorbs impacts. Ceramic and Titanium are less spongy than normal core material. They act as a better spring. Because the inner core absorbs shocks less easily, the energy exchange in an impact is greater. That means that the ball delivers energy to the pins better. (It hits harder).

When a bowling ball impacts a pin, both the pin and the ball are affected. If there is a sound made during the impact, and there always is, the energy to make that sound is taken away from the available kinetic energy of the ball. If the ball becomes deformed during the impact, and it always does, the internal materials are very slightly heated up. The creation of a slightly hotter bowling ball results in still more energy taken away from the kinetic energy of the bowling ball. The parameter that ABC specifies for governing the design of bowling balls with respect to their energy loss due to impacts is called the Coefficient of Restitution.

The limits that ABC specifies for the Coefficient of Restitution is between .65 and .78 . A ball that has a higher Coefficient of Restitution loses less energy during the impacts with the pins. A harder central core, like ceramic or titanium tends to make the ball have a Coefficient of Restitution at the higher end of the range of values that are legal, closer to the .78 value.

As a bowling ball travels through a rack of pins, each impact that the ball makes with the pins releases some of the energy of the ball into the impacted pins. So, after the first impact, the ball has a little less energy and it slows down. After the second impact the ball has even less energy and it slows down further. Successive impacts causes the ball to go slower and slower. You cannot design a ball that doesn't release part of it's energy at the impacts.

If the ball is going to lose energy as it travels through the pins, and it always will, the higher Coefficient of Restitution ball will lose less kinetic energy and will have greater kinetic energy longer for those later impacts.

Surface Parameters

The surface of the bowling ball affects the scoring more than anything else. At present the only limitation is that the hardness be not less than 72 on a Durometer "D" hardness meter. Bowling ball manufacturers have produced new bowling balls that are smooth or porous or reactive resin or very rough at the surface. Some have the ability to curve even on slick or "oily" lane conditions. For oily conditions you would most likely choose a porous surface ball or a rough surface ball. For dry (little or no oil) conditions you would most likely choose a smooth reactive resin surface ball.

Surface Reaction

Most bowling balls are manufactured with a reactive resin as the outer surface. The reactive resin ball will slide through the oil and when it starts to roll over the dry area, it reacts for a greater curve at the end of the roll of the ball. Since it adheres to the lane in the pin deck area, it drives through the pin deck with a more powerful reaction. The reactive resin ball grips the lane better in the dry areas of the lanes.

If you take one of the reactive resin balls and heat it, the surface will become sticky. When the reactive resin ball rolls out of the oil and begins to roll on the higher friction dryer surface, the area of the ball making contact with the lane is slightly heated due to the increased friction. The reactive resin at the surface changes it's characteristics in the same way as described, it becomes sticky and adheres to the lane better. The result is that the ball violently curves into the set of pins and continues to drive through the set of pins while still on the pin deck.

Particle Ball Reaction

The newest addition to the surface reaction bowling ball arsenal available is a surface with spikes sticking out. Particles are imbedded into the material that is used to make the cover stock. The result is a bowling ball that adheres better in the transitional area of the oil. The spikes are actually pieces of "mica" or some other hard material.

Depending on how many particles (the loading), how far they stick out (the size) and how rigid the spikes are (their hardness), the ball may exhibit both good traction and friction characteristics during the entire roll of the ball. This type ball probably has the greatest overall hook potential .

Influences on Matching Up - The Bowler

Age, Size and Strength
Since a bowler's size and strength usually changes as the bowler's age changes, all three of these influences are related.

Historical General Rule:
The weight of the ball should be no more than 10% of the bowler's body weight.
(No that does not mean that a 200 pound adult can bowl with a 20 pound bowling ball). It means that within the legal limits set by ABC rules, about 10% of the bowler's body weight is about right for a very young child. It's simply a starting point when there is nothing else to use as a weight determining factor.

Tiny Little Boys and Teenie Tiny Little Girls
However, that rule does not work as well for little boys as it does for little girls because of the difference in the manner that boys and girls are created. The boys usually have greater upper body strength. Therefore, for little boys, the rule is adjusted a little. For little boys, a maximum of 1 or 2 pounds may be added based on the ability of the child to handle the weight.

A young child may begin bowling even when holes cannot be drilled for them. In fact not drilling holes for a small 60 pound child (6 pound ball) is recommended. The first type of release that a young beginner utilizes is a two hand delivery, so there's not a need for drilling holes.

Determining When to Drill Holes for Little Boys and Little Girls:
As soon as the child can handle the weight, have the ball fit properly at a certified PBPSI Pro Shop. Have the ball drilled with a conventional grip if the young person is at the beginner stage with very little experience and skill.

"Handle the weight" is a very ambiguous term. The bowler should pass the following test.
1. Have the bowler pick a ball off the shelf of a PBPSI Certified Pro Shop until they find a weight that feels "heavy". To do that, have them hold the ball with both hands at their side just as if they were ready to roll the ball. Have them adjust the ball position vertically (still using both hands at the side) at least 3 times. If the ball feels "heavy", it probably is too heavy.
2. Once they have determined that that ball is too heavy, choose the next lowest weight ball available.
3. To confirm that the estimated ball weight is about right, have the bowler find a house ball with the estimated weight that fits them reasonably well. After at least 2 games with that practice ball, make sure that the bowler is not too tired. If they aren't, the estimated weight is probably a good choice.

The reason for all of this caution is to avoid any possible strain on the young child's arm. Make sure that you perform the tests above.

Larger, Older and more Muscular People
If a person (young or old) is well developed with greater strength, have the ball drilled with fingertip grips. The sooner a bowler gets to the fingertip grip, the sooner the bowler will compete better against the bowlers of their age that already have the fingertip grips. But as before, caution must be used, especially with young people with marginal strength.

Do not under any circumstances drill the ball for fingertip gripping and not use the fingertip grips. Absolutely use the softest fingertip grips available. Several grip manufacturers advertise which of their grips are the softer ones. "Vice Inserts ®" goes by a color scheme. The darker the color, the softer the grip. So, their black colored grips are the softest. Regardless of the manufacturer, use the softest available.

Your PBPSI Certified Pro Shop should be able to tell you which are the softest of the grips.

When all else fails, feel the grips yourself. The more you are able to "squeeze" the grip, the softer the grip usually is for gripping purposes. Find one that fits your finger (probably your index finger), push the grip against a hard surface like the edge of a counter. The only way to determine the softest is to test several types of grips on the recommendation of your pro shop operator. So, compare several different types.

The Senior Bowler

If a senior bowler is purchasing their first bowling ball, the procedure for the choice of ball weight is the same as for any other person and just as described as above. But . . there is one very important difference. Remember that the senior bowler most likely will be reducing the weight of the ball when they purchase their next ball (young people will usually be adding weight for their next ball choice). For that reason, make sure that you are very conservative in their ball weight recommendation. Using the tests described above, choose a ball that is two pounds lower than the one that feels heavy.

If a senior bowler complains that a ball doesn't fit right anymore; it may be more than just changing the fit. They may need to go down in ball weight by a pound. Try to observe them during league and check whether or not they are working hard to swing the ball consistently. If they are, a lighter weight ball might be in order.

Ball Speed

Ball speed is the single most influential factor of a bowler's style. As the speed goes up, the ability for the ball surface to interact with the lane surface decreases. For that reason, matching the surface of the ball to the ball speed is the first parameter to explore when considering a specific ball.

In the same manner, the slower the speed, the less aggressive the surface needs to be. But there are exceptions.

Arm and Wrist Strength and Bowling Gloves

The stronger a bowler's arm and wrist, the more likelihood that the bowler will impart a higher rev rate into the ball during the release of the ball.

More than 50% of the energy imparted to the ball comes from the bowler's arm and wrist strength. The magnitude of the energy comes from the bowler's arm strength. The ability to transfer the energy into a higher rev rate upon release comes from the bowler's wrist strength.

Bowling gloves with wrist stiffeners add to the ability of a bowler to transfer the magnitude of the energy in their arm into energy into their release as a higher rev rate. The wrist stiffener prevents the wrist from bending back as the ball is being released. The more the wrist is prevented from bending back, the longer the fingers stay in the ball after the thumb has exited the ball. That equates into a higher rev rate at the release of the ball.

Experience and Bowling Education and Performance Potential
That very small computer we all have between our ears allows us to remember many things about what has worked for us in the past with respect to bowling. It is called learning the game. And, the more we know about the game, the better chance we have to perform better.

Desire, Opportunity and Ability to Learn and Perform Better
One of the real driving forces to having a high performnce potential is the desire to learn.

Okay . . . . time for a pop test!

Who do you think should has the greater desire to learn more about the sport of bowling, a high average bowler of a low average bowler?

The answer is probably not what you expect. It's the high average bowler. That high average bowler has spent much time getting to that level of competition and they don't want to give it up. They want more. They want to find out everything that they can about the game and how to perform better. They are always looking for anything that will give them an edge.

There are a few low average bowlers that are absolutely totally consumed by the game. These bowlers are most likely the bowlers that will improve rapidly and become high average bowlers very quickly. But they are unique.

In general, as a bowler does gradually improve their average, their desire to learn more about the game increases. The opportunity to learn more about the game is mostly connected to the access the bowler has to better learning materials and qualified coaching. So as you might expect, money comes into play. He who gets the most coaching and one-on-one help usually has the best chance to improve.

The ability to learn is a physcological thing. It's related to how much a bowler will accept the recommendations given by a coach or some literature. It's also tied to how well the bowler understands and pays attention as instruction is given. This attribute is why it is more difficult to teach very young people for long periods of time. Their attention spans are very short. Because of that, their lessons should be very short and limited in scope.

Seniors are also in that category. Don't try to teach the too much at a time. The ole computer ain't what it use to be. And, yes senior moments do indeed occur.
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-
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What were we talking about . . . .
-
-
-
The ability to perform better is almost directly tied to the physical conditioning of the bowler. There are many many different ways to bowl and bowl very well. The really high average bowlers that consistently perform well are almost all in great physical shape. They regularly work out and they bowl many many games each and every week.

What differeniates the very high average bowler from the average bowler is the ability to get all of the fundamentals correct even after bowling 12 games in a short period of time. Their knee bend is still about what it was at the first frame of the first game that day. (These are the young professionals).

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Oh to be flexible again!

But you don't need to be a professional to perform over a short period of time. If a bowler stays in reasonable shape, they can perform in an excellent manner over a period of 3 games in league play.

Committment to Make a Change

In most cases the commitment to make a change is tied to reason why the bowler is seeking to improve their game. It's best shown by comparing three different types of students, the Good, the Bad and the Ugly.

The Good student will listen attentively, try their best to follow the instruction as described by the coach and usually is easy to coach.

The Bad student is out on cloud nine during the instruction. They don't or can't pay attention to what's being said by the coach.

The Ugly student doesn't even want to be there. His parents forced him to take lessons and he knows it all anyway.

It' fairly easy to see that the Good student will have a better committment to making a change.

The Numbers Game

Speed Calculation
Layout Instability Number
Release Rev Rate Calculation
Normalized DRG Number (DRGN)
Permission to Flare Number
Actual Flare Realized Number
Release Strength and Energy Comparison - The Rudy Numbers
Ball Snappiness Comparison - The Borden Number
Mass Bias Comparison - The MO Number

Speed Calculation

The speed the bowler rolls the ball can be easily calculated in the standard units (miles per hour - mph).

Ball Speed = BS (some bowlers have too much BS).

Since distance equals velocity multiplied by time,

d = v * t

So,
v = d / t

So,

BS = d / t

d = 60 feet = (60 / 5280) miles

d (in miles) = d (in feet) divided by 5280

t = seconds = minutes * 60 = hours * 60 * 60 = hours * 3600

t (in hours) = t (in seconds) divided by 3600

Since 60 times 3600 divided by 5280 equals 40.9, the equation for BS is:

$$BS = \frac{40.9}{t}$$

(where t is measured in seconds)

So, if t is about 2 second, the average speed is about 20 mph
and if t is about 3 seconds, the average speed is about 14 mph

The easiest way to measure your ball speed is to simply have someone time the number of seconds from the instant the ball impacts the lane surface until it impacts the head pin.

Layout Instability Number

The range of the Layout Instability Number is from zero to one. For a stacked leverage layout, the Layout Instability Number has a value of one. For a layout with the Pin on the PAP and the Mass Bias Point located on the initial rolling track (axis drill layout) the Layout Instability Number has a value of zero. If the Pin is on the initial track and the MBP is at the PAP, the Layout Instability Number is also zero. All of the other layouts have an Layout Instability Number between 1 and 0. So the maximum value of the Layout Instability Number is 1.

Release Rev Rate Calculation

The determination of the Rev Rate for the bowler is a little more difficult. Here's how to do it.

Take a piece of white tape and stick it to the ball with one end at the PAP for the bowler, The tape should be pointed along a line that intersects the initial rolling track, perpendicular to that rolling track. When the ball is initially rolled, that piece of tape will act as a spoke does on a wheel and you will be able to count the number of revolutions that the ball makes during the time it takes for the ball to get to the arrows on the lane surface. That will be used to approximate the rev rate at the release.

You will probably need a digital camcorder to perform the rev rate computation properly. But as long as you have single frame playback, you should be able to do it with just about any camcorder and then play it back in the single frame mode.

Stand directly behind the direction that the bowler will release the ball.

Videotape the ball as it is released. Make sure that you can see the tape revolving about the initial axis of rotation, the PAP.

Now take the tape, rewind it and play it back in the single frame mode.

To measure the rotational speed of the ball, the Rev Rate, you must be able to compute the number of frames of the videotape it took for the tape to make one complete revolution.

Each frame takes 1/30th of a second. The ball takes a certain number of frames to make one complete revolution. You count those frames.

Rev Rate = The number of revolutions divided by the time it takes to make those revolutions. Since the speed of the camera is in frames per second, and the desired rev rate speed is revolutions per minute, the time must be divided by 60 to get minutes.

$$\mathrm{Re}\,vRate = \frac{\mathrm{Re}\,volutions}{\dfrac{Frames * (1/30)}{60}}$$

Simplified the equation is:

$$\mathrm{Re}\,vRate = \frac{\mathrm{Re}\,volutions * 900}{Frames}$$

$$\text{Re}vRate = \frac{\text{Re}volutions * 900}{Frames}$$

So, if the bowler gets "1" revolution in "1" frame. That means that the Rev Rate is 900 rpm. That is of course impossible for humans. (and it wouldn't do the lane surface any good either).

If the bowler (a real human being this time) gets 1 revolution in 3 frames, their Rev Rate is 300 rpm.

What is an average Rev Rate? Around 250 rpm is an average Rev rate for adults. Above 300 is high.

Estimating the Rev Rate
You can estimate the Rev Rate without using a camcorder. It requires that you measure the time it takes for the ball to travel a specific distance down the lane. For the best estimate a shorter distance is best but is hardest to measure. So measure the time it takes to travel the full 60 feet and the number of revolutions that were rotated in that 60 feet again using the white tape attached ot the ball.

The raw equation form the Rev Rate is:

Raw Rev Rate = Revolutions / time

Since you will be measuring the time in seconds, you must multiply the Raw Rev Rate by 60 to get revolutions per minute.

$\text{Re}vRateEstimate = \frac{\text{Re}vs * 60}{t}$, where t is measured in seconds.

If you get 10 revolutions in 2 seconds of ball travel, your average Rev Rate is 300 rpm.
If you get 7 revolutions in 3 seconds, the Rev rate is 140 rpm.
If you get 15 revolutions in 2 seconds, the Rev rate is 450 rpm. (Good job Rudy!)

If you can measue the time it takes to get the ball to the arrows, the Rev Rate calculated is more accurate. You must also measure the revolutions attained in that same distance and at the same time. I suggest a couple of helpers if you try the shorter distance.

The Normalized DRG Number (DRGN) and Normalized RG Number RGN
The range of the values for the possible DRG values is limited by ABC rules as 0.000 to .080.

The Range of the DRG can be "normalized" to a range of 10. Here's how it works. The lower value set by ABC is assigned the value "one." The top value set by ABC is assigned a value of "ten." All the values in between are computed in a linear scale of 1 to 10. So the middle value is a DRG of "5."

The actual computation is as follows:

The Normalized DRG Number (DRGN)

$$DRGN = \frac{10 * ActualDRG}{.08}$$

In simpler terms,

$$DRGN = 125 * ActualDRG$$

So if the Actual RG of your ball is .040, the normalized DRGN = 125 * .040 = 5

The Permission to Flare Number (PTF)
The PTF Number is the rotational speed times the instability of the layout.

PTF Number = Rev Rate * Layout Instability

If both the Rev Rate and the Layout Instability are high, the permission to flare is high.

The Acrual Flare Realized (AFR Number)
The Actual Flare Realized Number is a product of the PTF Number and the DRG (the flare potential).

AFR Number = PTF * DRGN

So, another definition for the Actual Flare Realized Number is:

AFR Number = Rev Rate * Layout Instability * DRGN

Note again that if any one of the terms are essentially zero, it doesn't matter what the other two terms are, the Actual Flare Realized (AFR) is essentially zero also.

If the AFR Number is too high, the flaring distance will exceed the manufacturers specification for flare potential (their pronouncement of flare potential was for a “medium” rev rate release).

The range of the rev rate starts at zero corresponding to zero revolutions per minute as rotational energy (chunking the ball).

For purposes of incuding all possible humans, humanoids, androids and clones of Rudy Revs, we will set the limit for rev rate at 500 rpm's. That means that the upper limit for the Permission to Flare Number (PTF) is 500. It also means that the range for the AFR Number is zero to 5000.

Normalized AFR Number = AFRN = Rev Rate * Layout Instability * DRGN * 10 / 5000

So, the range for the AFRN is between zero and 10.

$$AFRN = \frac{RevRate * LayoutInstability * DRGN}{500}$$

An average release has an AFRN of about 5. As the AFRN inbcreases above 5, the danger of over flaring increases.

Release Strength and Release Energy - The Rudy Numbers
Release strength is related to the Rev Rate and the Radius of Gyration. It takes more strength in a release to get a high Rev Rate. It also takes more strength in a release to rotate a higher RG ball. So, the Rudy Strength Number is:

$$RudyStrength = \frac{RevRate * RGN}{500}$$

The Rudy Strength Number ranges from zero to 10.

The Rudy Energy Number is related to the total energy given to the ball by the bowler during the release.

$$RudyEnergy = \frac{RevRate * RGN * BS}{500}$$

The Rudy Energy Number ranges from zero to about 250
(assuming there is someone out there that rolls the ball at 25 mph). I saw a guy do that one night. He was so out of control that the ball went straight at the 7 pin. It then got hit again by the ball and the 7 pin took out the 10 pin . . . . . . on the first ball. He converted the 7-10 split on the first ball. He had a very high Rudy Strength and Rudy Energy Number but no control.

The Borden Number

Snappy versus Arcy
The most basic of all choices that a bowler will make about a bowling ball is the shape of the ball path. Some bowlers want a ball that has a nice “arc” to it, a banana type ball path shape. Other bowlers want a “snap hook” type ball path shape similar to a hockey stick. It is mostly a mental comfort thing.

Generally, the snap hook path is better for reserving energy for the impact with the pins but is less controllable. The arc ball path is more controllable but generally eats up more energy earlier in the path of the ball.

The three real number parameters RG, DRG and Grit Number can be used to form a number that is related to how snappy the ball is. It’s called The Borden Number.

It’s a number that can be used to compare bowling balls of the same manufacturer or different manufacturers because, it only uses real numbers that describe the bowling balls. The best results come from comparing balls of the same type and manufacturer.

Note that the number does not relate in any way to how the ball was drilled, who tested it, what the lane conditions were, how fast the ball was rolled or what the rev rate of the release was. (Most and sometimes all of those parameters are mysteriously missing in the manufacturers and the ratings by the magazines. . . .).

Is the Borden Number exact? No. Very few things are exact these days. But it’s very useful in comparing two possible choices for a bowling ball purchase. If they are about the same type of ball, the one with the highest Borden Number will most likely be the snappiest.

The Borden Number Definition
The Borden Number is defined as BN = Grit * DRG / RG
(BN = Grit multiplied by the DRG and then divided by the RG)

As the Grit Number increases, the smoothness of the ball increases which aids the ball in getting farther down the lane and thereby increasing the distance before the ball reacts to the drier lane surface. So, as the Grit Number increases, BN increases.

As the DRG increases, the Flare Distance increases which aids the ball in being able to still flare after it is in the drier end portion of the lane surface. So, as the DRG increases, BN increases.

As the RG increases, the ability to rev up the ball as well as the ability of the ball to release it's energy quickly is decreased. (Higher RG react slower to the surface). Hence, as RG increases, the BN decreases.

So, you can classify all balls with this number because it is a real number.

But most importantly, you can take any two balls and compare their Borden Numbers. The one that is the highest will most likely tend to snap more. Old ball, new balls, it doesn't make a difference, you can still compare the Borden Numbers.

The Mo Number

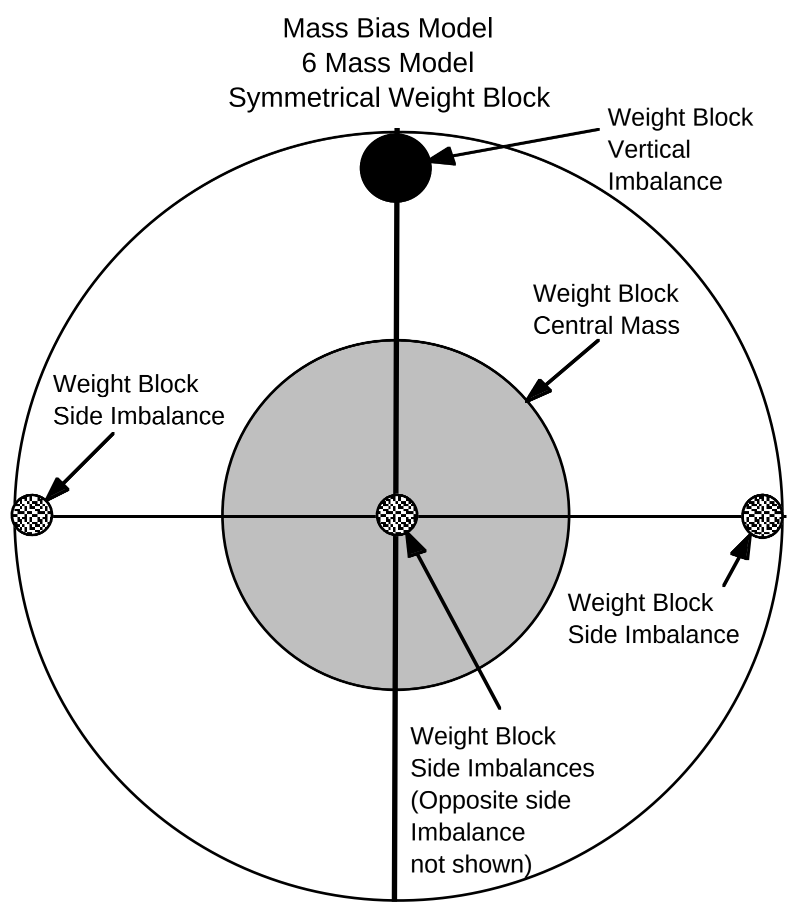
The concet of Mass Bias is difficult to understand. It's a term that is new compared to most of the other bowling ball terminology. Mass bias is a measure of how the weight block is shaped. The more that the weight block is protruding to one side, the more mass bias it has.

For some balls mass bias is simply a manifestation of the location of where the weight block is closest to the surface of the ball, but in some ball designs, it is the actual location of an extra mass that makes up part of the weight block. It's that extra mass farther out to one side that gives a bowling ball a stronger action at the end of the lane. The stronger the mass bias, the stronger the possible finish of the ball.

The "shape" of the weight block is modelled with 5 masses. The total of all of the individual masses representing the ball must equal to the actual total mass of the ball. It's the location and relative size of those masses away from the center mass that gives the ball it's shape and dynamic characteristics.

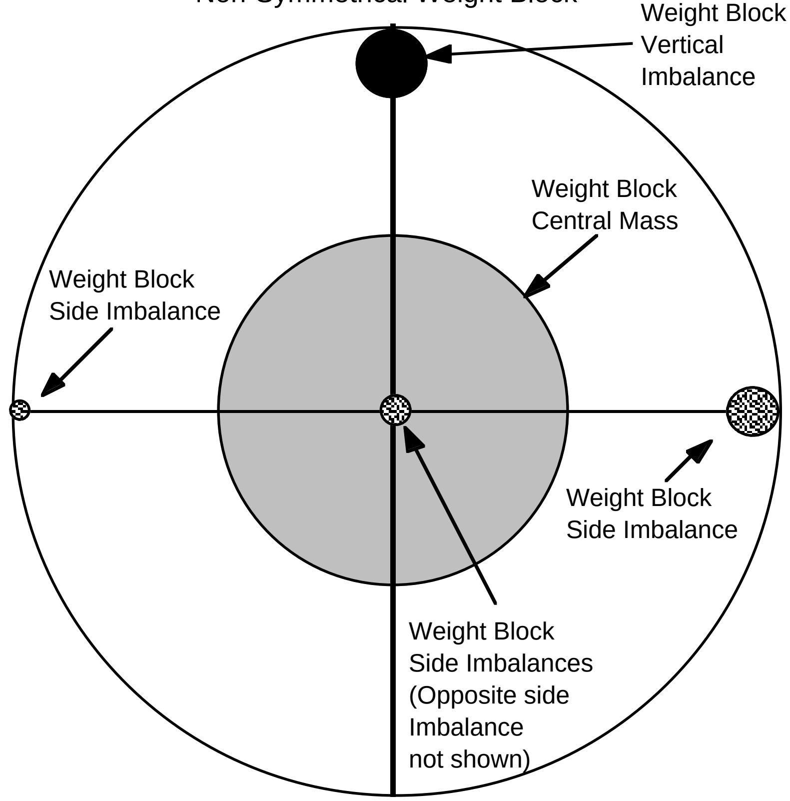
Note that no ball is made and looks like this. This is just a model to show how mass bias is designed into a ball to give dynamic effects.

Most of the mass of the ball is represented as the center mass of the ball. And, for a symmetrical shaped weight block centered in the ball, the ball has no mass bias. The graphic shown below shows a symmetrical weight block ball with zero mass bias. The side imbalance masses are equal.



When the weight block is designed with more mass to one side, the mass distribution is changed. Since more mass is to one side the static balance is changed and the dynamic characteristics are also changed. The greater the "offset" mass to one side, the greater the mass bias.

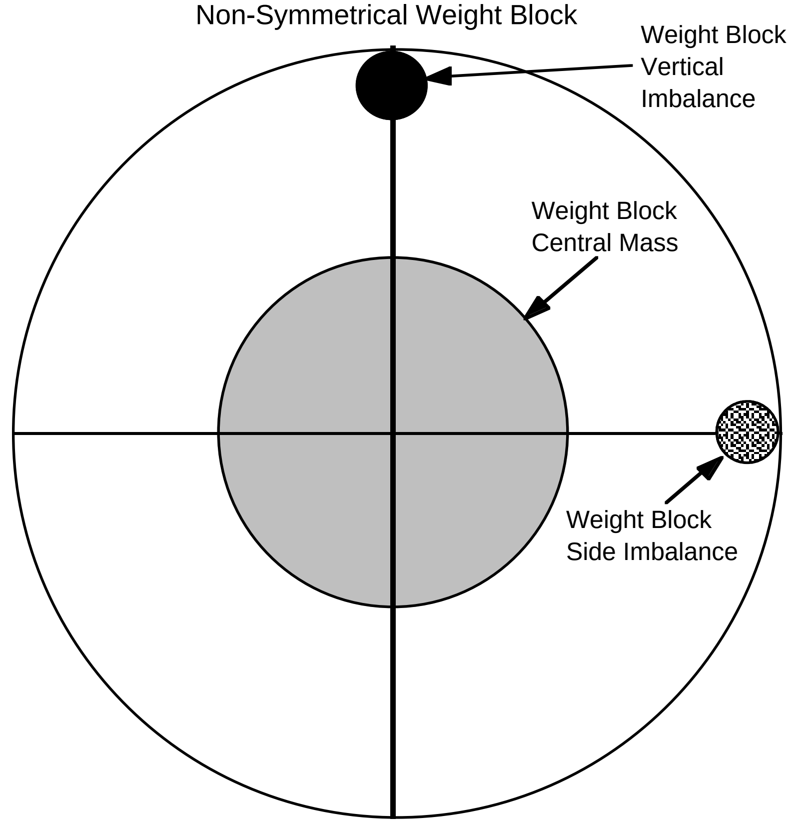
Mass Bias Model
6 Mass Model
Non-Symmetrical Weight Block



Symmetrical Shaped Weight Block Centered in the ball.

As the design of the weight block shifts the weight to the side, more mass bias is created. The model can then be changed to a 3 mass model. The center mass is still as before. The weight block vertical imbalance is as before. All of the sideways imbalance is modelled at one side. You will be able to see this effect in real weight blocks where the weight block very preferentially shaped in one direction.

Mass Bias Model
3 Mass Model
Non-Symmetrical Weight Block

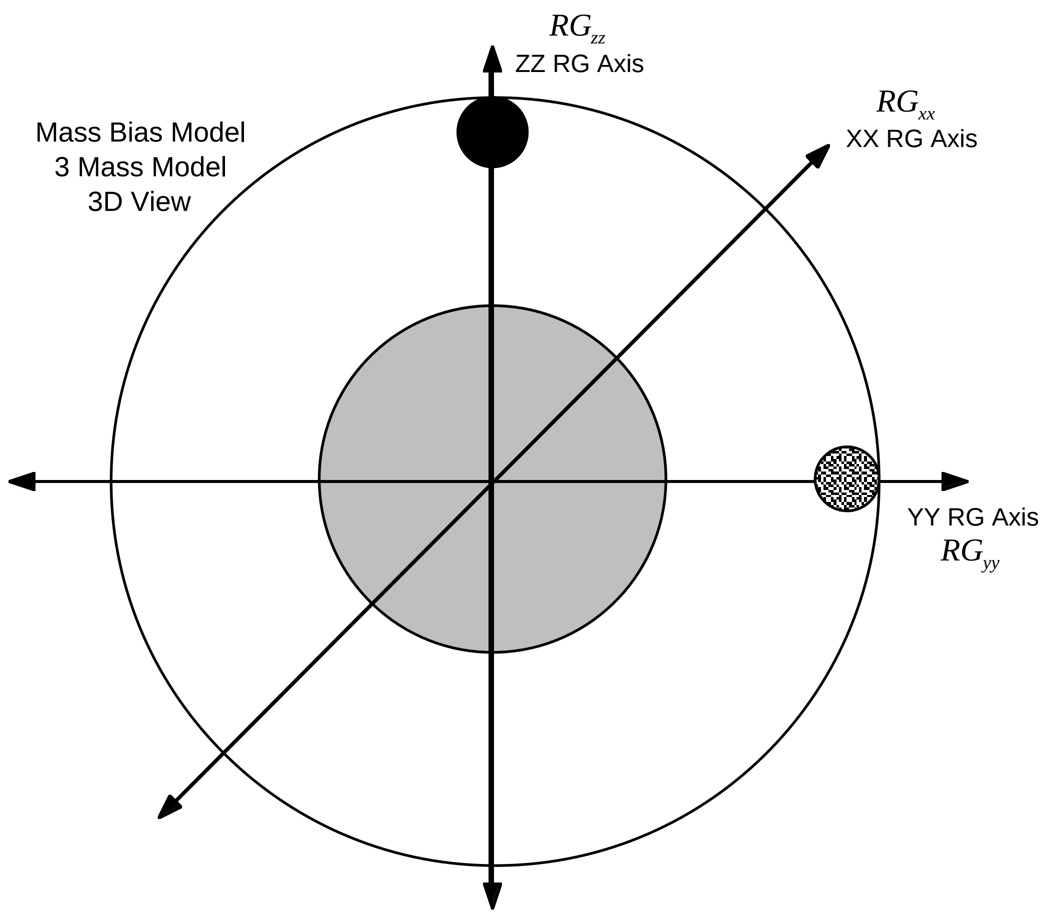


Non-symmetrical Shaped Weight Block Centered in the ball.

Shown below is a 3D model of a ball with a weight block that is designed with a large mass bias.

The Radius of Gyration (RG) is measured at each of the three axes. So there are three separate RG values.

The MO Number is a number related to the distribution of those masses. It is defined in terms of the three known RG values as specified by ABC.



$$MO = \frac{RG_{xx} + RG_{zz}}{RG_{yy}}$$

As the equation shows, the larger the values of RG measured about the XX axis and ZZ axis are and the smaller the value of RG measured about the YY axis is, the larger the MO Number is. And, since that's the way that mass bias is affected by different vales of RG, the MO Number is related to the actual mass bias effect that the weight block has.

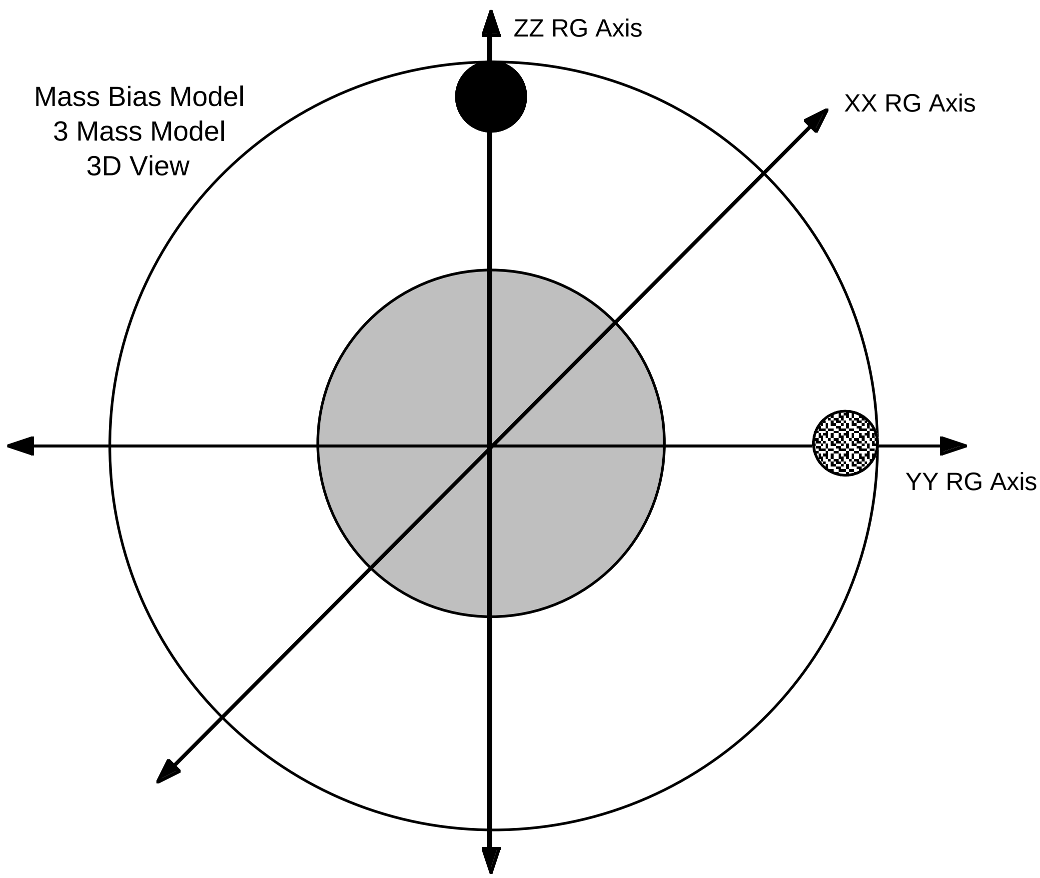
That's all pretty neat except that the manufacturers don't really publicize all three of the measured RG values. What is published in a lot of cases is the Max and Min and Average values of RG. For that reason, the MO Number is usually stated in terms of those published values.

The higher the MO Number, the better chance the ball has to react more aggressively at the back end.

$$RG_{xx} = RG_{Max}$$

$$RG_{zz} = RG_{Min}$$

$$RG_{ave} = \frac{RG_{xx} + RG_{yy} + RG_{zz}}{3} \longrightarrow RG_{yy} = 3 * RG_{ave} - RG_{xx} - RG_{zz}$$



$$MO = \frac{RG_{Max} + RG_{Min}}{3 * RG_{ave} - RG_{Max} - RG_{Min}}$$

Graphics Modelling

Drilling Layout - The Taylor Diagram

At an instant of time during the roll of the ball, the axis of rotation at that instant of time has an associated leverage line (3-3/8 " from the current axis of rotation).

To determine the dynamic characteristics of a bowling ball, look where each of the respective parts of the imbalances are located with respect to the three leverage lines.

If all three imbalances are located close to the initial leverage line, then the ball has maximum flare early in the roll of the ball and the maximum flare distance.

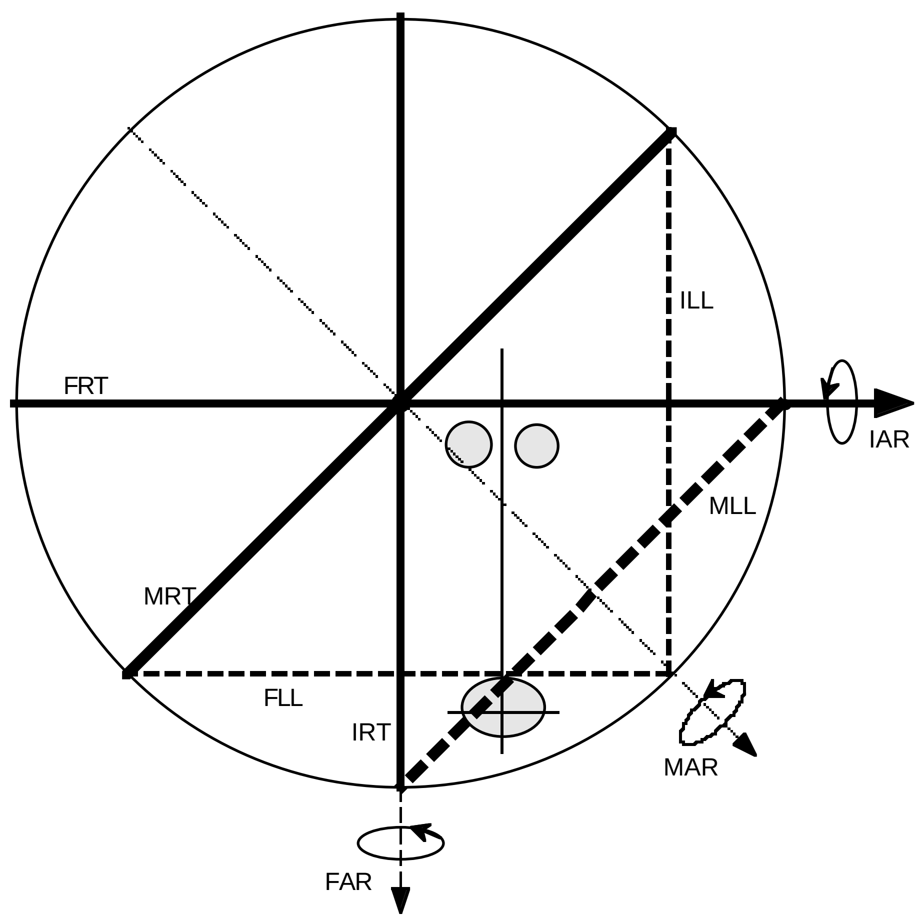
If most of the imbalances are closer to the final leverage line, then the ball will tend to hook more at the end of the roll of the ball.

If most of the imbalances are near the mid-flare leverage line, then the ball will tend to hook more in the midlane area. That will usually cause the ball to arc more than snap.

Note:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

The Taylor Ball Dynamics Diagram

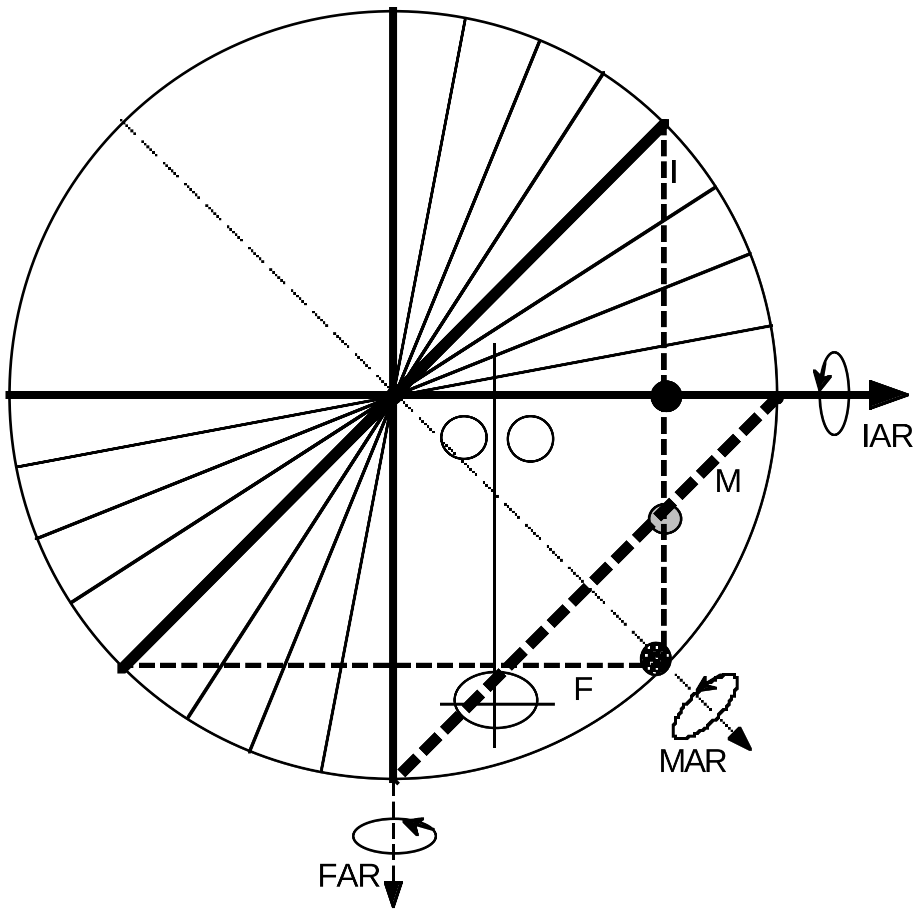
By definition, the Taylor Diagram is drawn from the Flare Axis Point (FAP = bow tie) view. That defines that the Pin is on the PAP-FAP line (because that's how the FAP location is essentially defined).



Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
Leverage Pin Position
6-3/4" Flare Potential
3-3/8" Pin/Mass Bias Line



Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Note #2:
Bowlers with a strong release (hi rev rate) should probably not use this layout. The ball might flare completely around the ball. For the rest of us, it is a great layout.

Layout Instability Number
LSN = 1

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**I**). With all three of the imbalances on the initial leverage line, the maximum flare rate is just as the ball is released. This layout will expose the maximum flare distance on the surface of the ball.

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**M**). The Pin is above the Mid-Flare leverage line and the Mass Bias Point is below the Mid-Flare leverage line. So the total influence is a little reduced.

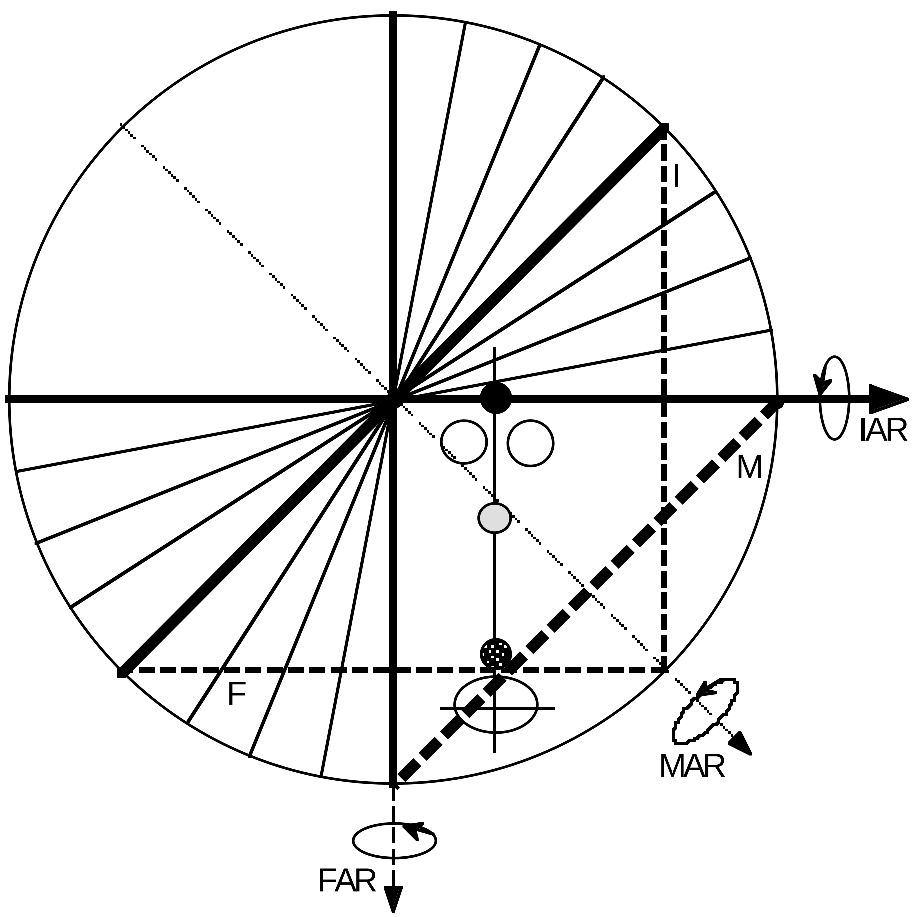
Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**F**). The Mass Bias Point is the only imbalance near the Final leverage line. The influence depend on how "strong" the mass bias is. Balls with a strong mass bias will have a greater reaction at the end of the lane.

Conclusion:
The ball desires to react during the entire path.

Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
5 1/2" Pin Position
6-3/4" Flare Potential
3-3/8" Pin/Mass Bias Line



Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Note #2:
Balls with a low RG value enhance this layout. That will amplify the snappiness of the dynamics of the ball.

Note #3:
Balls with a "strong" mass bias enhance the desires of this layout.

Layout Instability Number
LSN = .25

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**I**). All three of the imbalances are away from the initial leverage line. Only a small influence is felt.

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**M**). Only the Mass bias is close to the midflare leverage line. If the mass bias is "strong", the flaring rate will increase in the midlane area. This causes a greater influence depending on the mass bias strength.

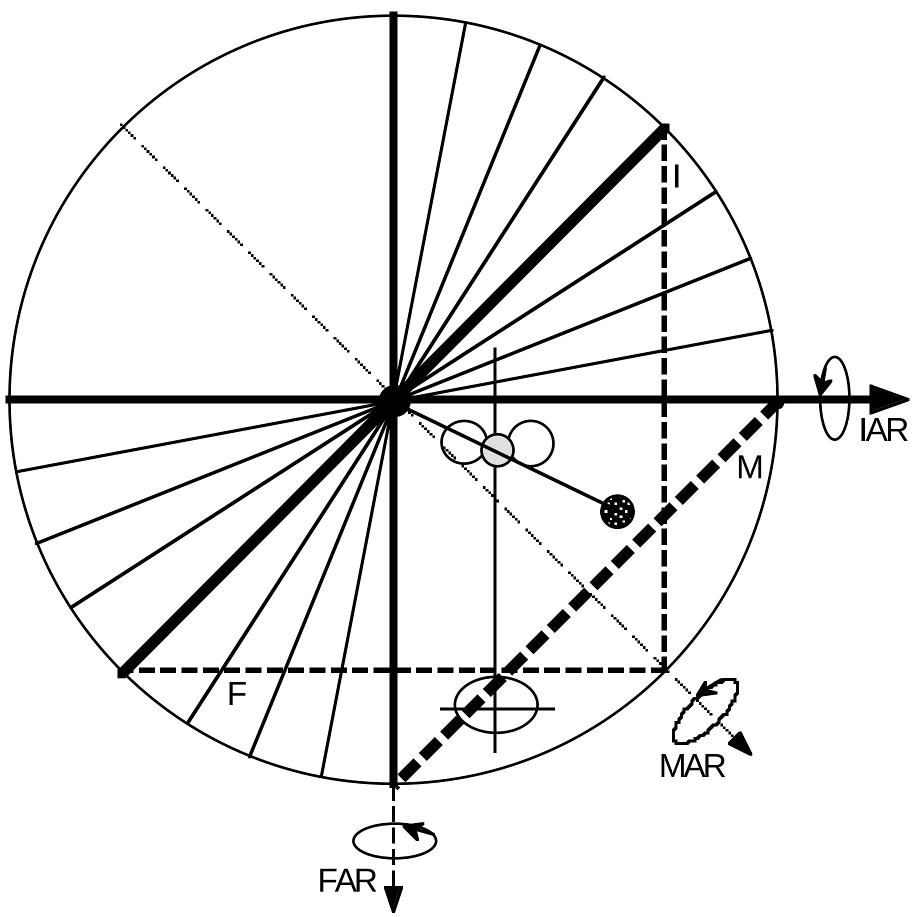
Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**F**). As before, only the Mass bias is close to the final leverage line. If the mass bias is "strong", the flaring rate will increase in the backend area. This causes a greater influence depending on the mass bias strength.

Conclusion:
The ball desires to go a little longer before reacting. It will tend to be snappy.

Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
Initial Track Pin Position
6-3/4” Flare Potential
3-3/8” Pin/Mass Bias Line



Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction “allows” the ball to do.

Layout Instability Number
LSN = ,1

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**I**). Only the mass bias point is near the initial leverage line. But the Pin is at one of the two stable imbalance positions.

So whether or not the ball flares at all will depend upon the strength of the mass bias point. If it is, the effect wil be very small.

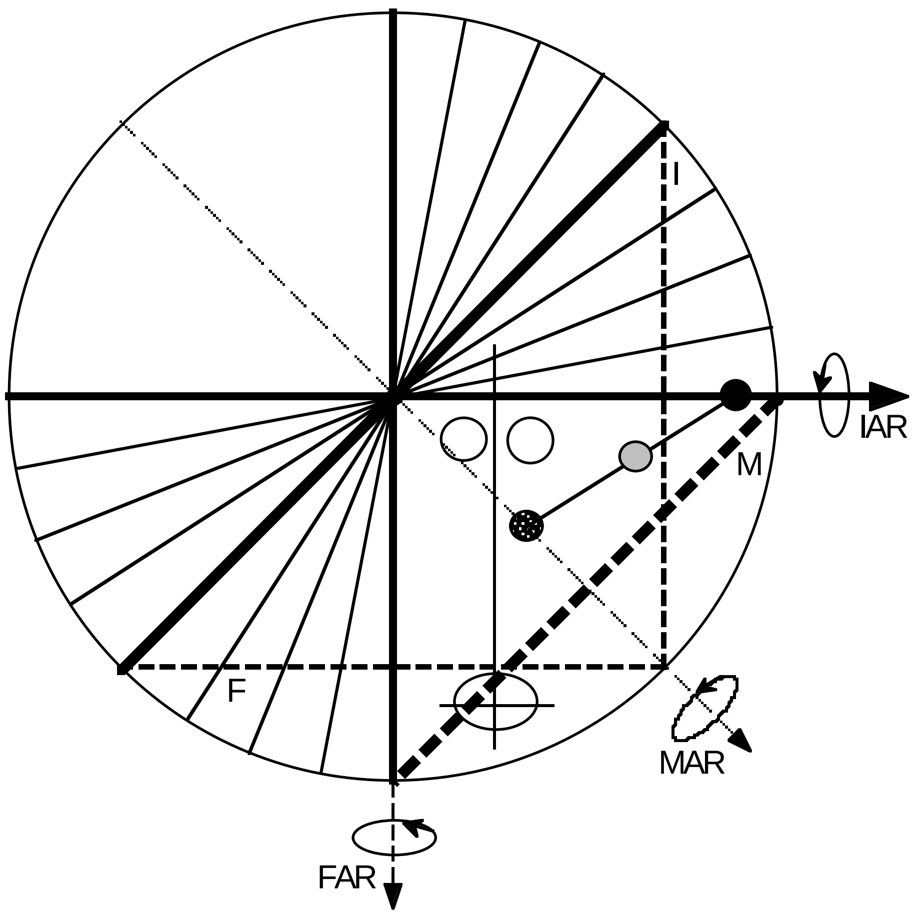
Conclusion:
This is also one of the most stable layouts. Little or no dynamic effects will cause flaring.

Note that although the flaring potential is 6-3/4 inches, there are little or no dynamic forces to make it happen.

Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
1-1/2" Pin Position
6-3/4" Flare Potential
3-3/8" Pin/Mass Bias Line



Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Layout Instability Number
LSN = .2

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**I**). The CG is the only imbalance that is close to the initial leverage line. Both the Pin and the mass bias point are away from the initial leverage line. Only a small flaring force is caused by the imbalances.

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**M**). All three imbalances are located close to the midflare leverage line. So, the most flare will usually occur in the midlane area.

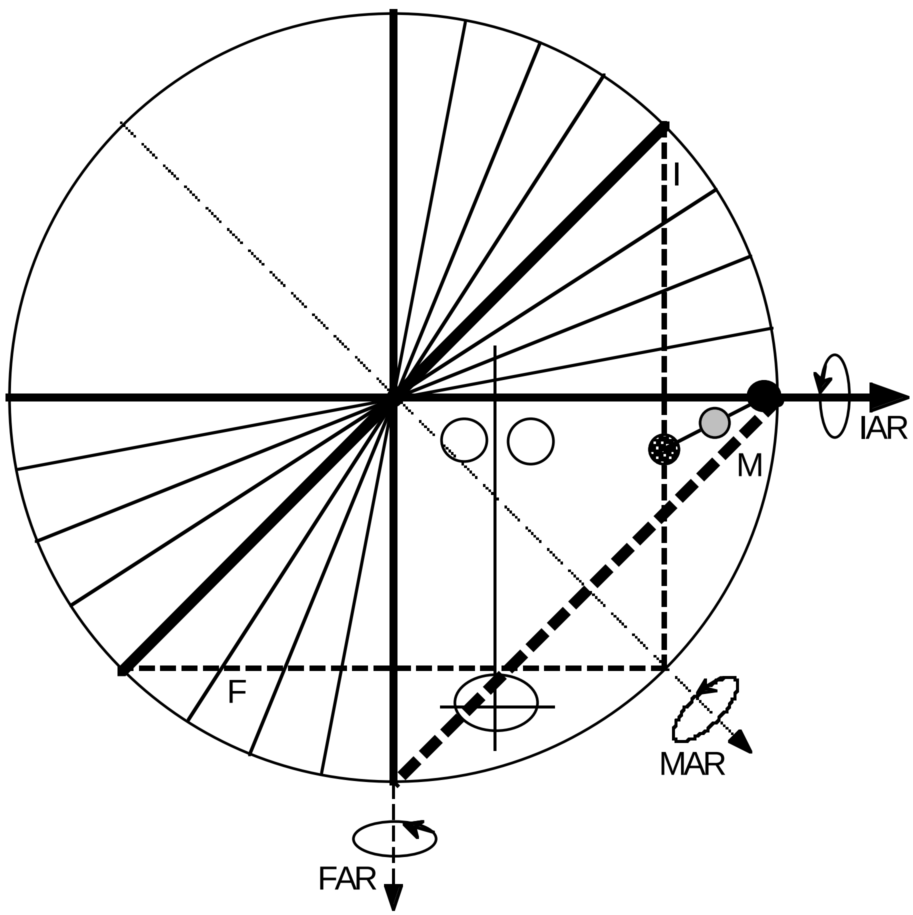
Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**F**). The mass bias point is the closest to the final leverage line.

Conclusion:
The ball desires to arc. It is an early rolling layout.

Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
Axis Pin Position
6-3/4" Flare Potential
3-3/8" Pin/Mass Bias Line



Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Note #1:
This layout actually works better for a longer Pin-CG-MBP line or a smaller flaring potential.. The problem is finding a location for drilling a balance hole.

Layout Instability Number
LSN = .1

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**I**). Only the MBP is close to the initial leverage line.

The Pin is at the PAP and commands the dynamic effects to be very small. It wants to stay right there. Little or no flaring occurs because the Pin placement at the PAP controls the flaring force to be minimal.

But, if the mass bias is strong enough, it may overpower the stability of the Pin at the PAP and cause some flaring.

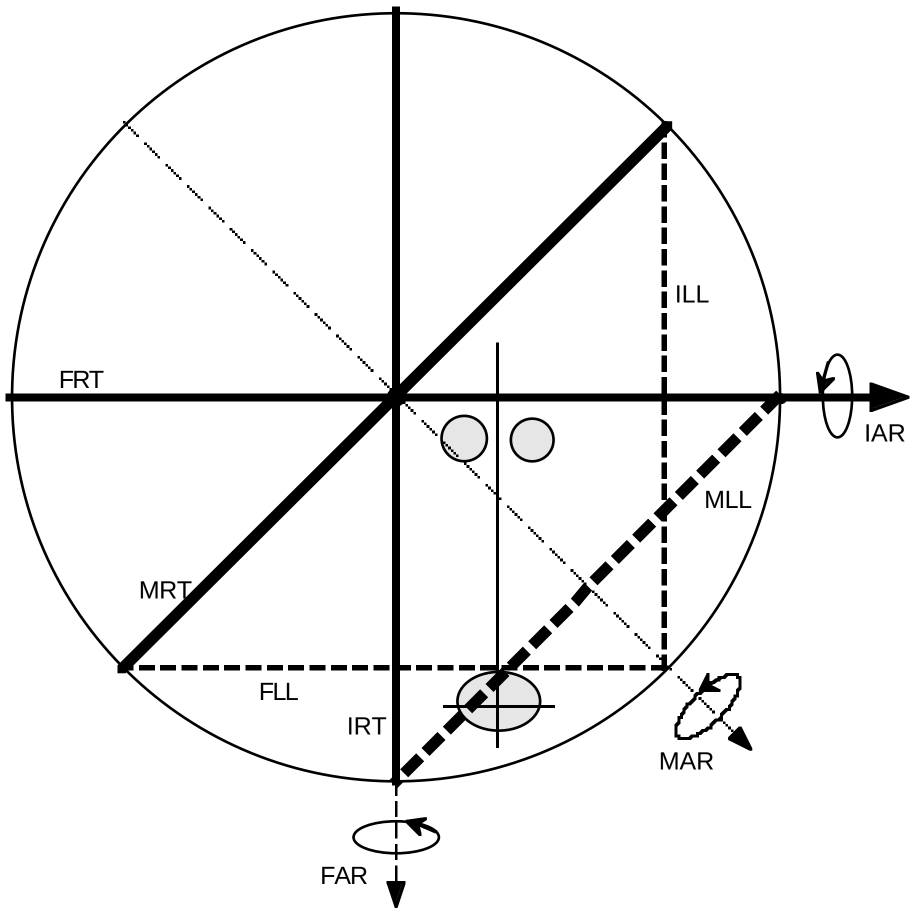
Conclusion:
The ball desires not to flare at all. Flaring will depend upon the strength of the mass bias

Note that although the flaring potential is 6-3/4 inches, there are little or no dynamic forces to make it happen.

Professional Bowling Pro Shops International

Taylor Diagram

3/4 Roller Release
__________ Layout
6-3/4" Flare Potential
_______ Pin/Mass Bias Line



IRT = Initial Rolling Track
MRT = Mid-Flare Rolling Track
FRT = Final Rolling Track
ILL = Initial Leverage Line
MLL = Mid-Flare Leverage Line
FLL = Final Leverage Line
IAR = Initial Axis of Rotation
MAR = Mid-Flare Axis of Rotation
PAP = Principal Axis Point
Pin = Pin of the Weight Block
CG = Center of Gravity
MBP = Mass Bias Point

Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**ILL**).

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**MLL**).

Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**FLL**).

Conclusion:
The ball desires to

Professional Bowling Pro Shops International

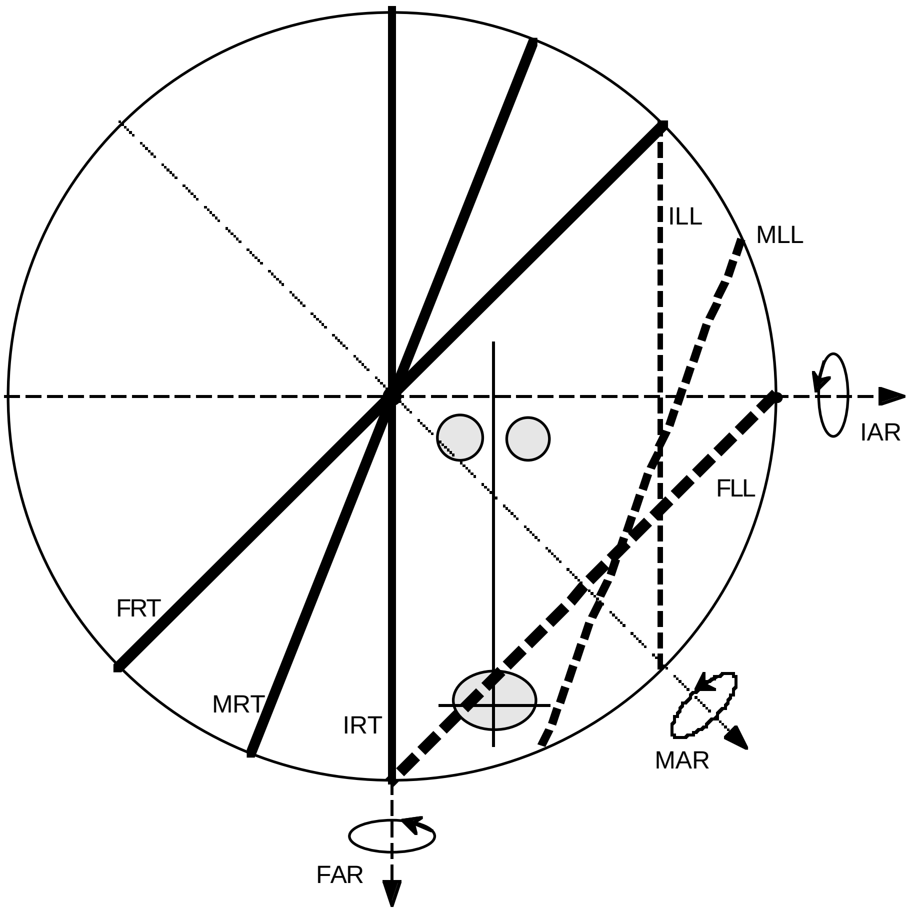
Taylor Diagram

3/4 Roller Release

__________ Layout

3-3/8" Flare Potential

_______ Pin/Mass Bias Line



IRT = Initial Rolling Track
MRT = Mid-Flare Rolling Track
FRT = Final Rolling Track
ILL = Initial Leverage Line
MLL = Mid-Flare Leverage Line
FLL = Final Leverage Line
IAR = Initial Axis of Rotation
MAR = Mid-Flare Axis of Rotation
PAP = Principal Axis Point
Pin = Pin of the Weight Block
CG = Center of Gravity
MBP = Mass Bias Point

Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**ILL**).

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**MLL**).

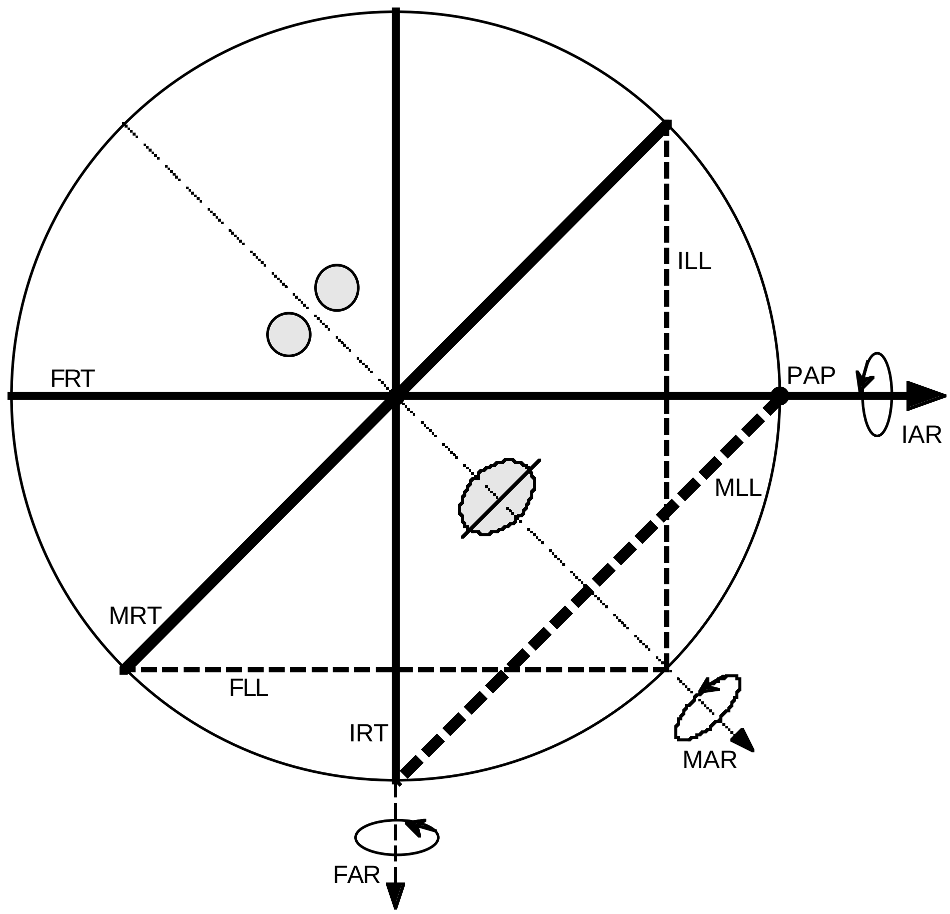
Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**FLL**).

Conclusion:
The ball desires to

Professional Bowling Pro Shops International

Taylor Diagram

Full Roller Release
__________ Layout
6-3/4" Flare Potential
_______ Pin/Mass Bias Line



IRT	=	Initial Rolling Track
MRT	=	Mid-Flare Rolling Track
FRT	=	Final Rolling Track
ILL	=	Initial Leverage Line
MLL	=	Mid-Flare Leverage Line
FLL	=	Final Leverage Line
IAR	=	Initial Axis of Rotation
MAR	=	Mid-Flare Axis of Rotation
PAP	=	Principal Axis Point
Pin	=	Pin of the Weight Block
CG	=	Center of Gravity
MBP	=	Mass Bias Point

Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**ILL**).

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**MLL**).

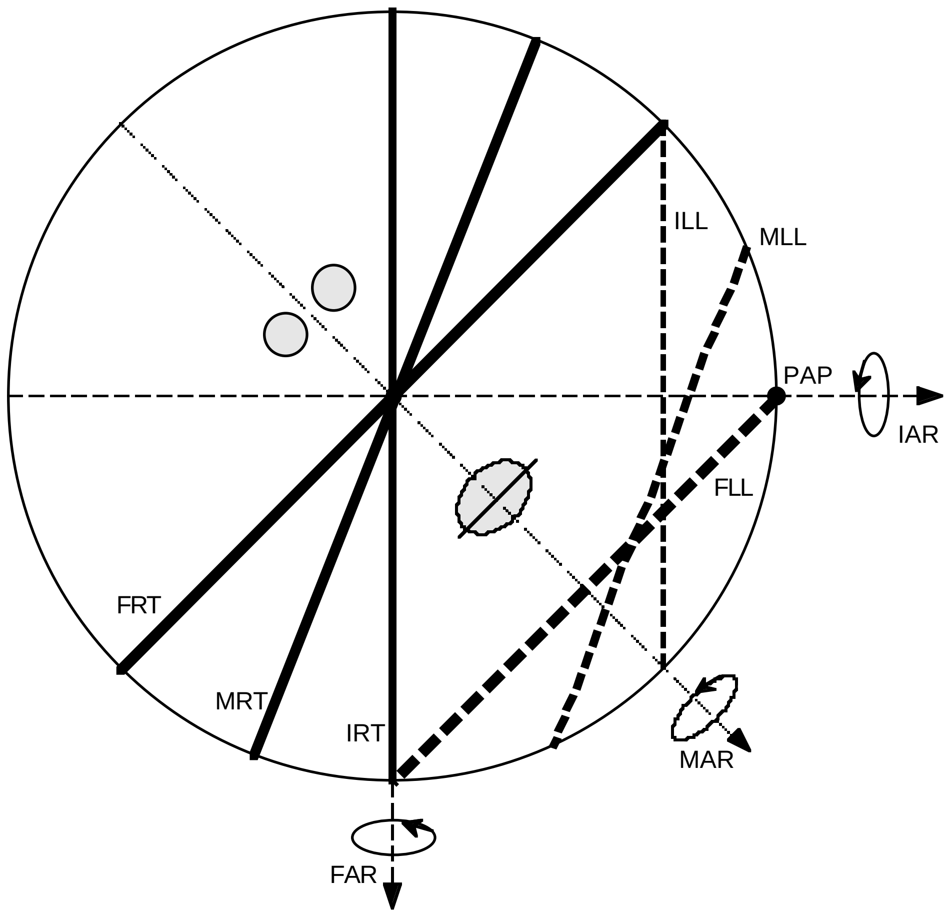
Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**FLL**).

Conclusion:
The ball desires to

Professional Bowling Pro Shops International

Taylor Diagram

Full Roller Release
__________ Layout
3-3/8" Flare Potential
_______ Pin/Mass Bias Line



IRT = Initial Rolling Track
MRT = Mid-Flare Rolling Track
FRT = Final Rolling Track
ILL = Initial Leverage Line
MLL = Mid-Flare Leverage Line
FLL = Final Leverage Line
IAR = Initial Axis of Rotation
MAR = Mid-Flare Axis of Rotation
PAP = Principal Axis Point
Pin = Pin of the Weight Block
CG = Center of Gravity
MBP = Mass Bias Point

Note #1:
These dynamic characteristics are a reflection of what the ball wants to do, not what the lane friction "allows" the ball to do.

Analysis:

Initial Leverage Line:
Look at where all three imbalances are with respect to the initial leverage line (**ILL**).

Mid-Flare Leverage Line:
Look at where all three imbalances are with respect to the midflare leverage line (**MLL**).

Final Leverage Line:
Look at where all three imbalances are with respect to the final leverage line (**FLL**).

Conclusion:
The ball desires to

What the Ball is Designed to Do

All Snappy Match

The ball should be drilled to match the inherent design of the ball. The Borden Number is a good reflection of the snappiness of the ball. In comparing two similar bowling balls, the one with the largest Borden Number will be the snappiest.

If the ball is designed as a snappy ball, it should be drilled as a snappy ball. It should be drilled to go long and allowed to snap toward the pocket. The best combination for a snappy ball is a ball with a low RG value and a high DRG value.

One good match is a snappy designed ball drilled to be a snappy ball for a lane condition that allows a bowling ball to go long and snap toward the pocket. That means sufficient oil in the heads and the transition area to allow the ball to go long and then be allowed to snap toward the pocket at the backend. That also means the backend is sufficiently clean, the lane surface is aggressive and no carry down interferes with the snap to the pocket.

The ball surface should be very smooth so that the ball can go long before reacting with the friction of the lane surface.

The bowler should have a large percentge of the release energy be imparted as forward roll of the ball. The bowler should have just enough sideways rotational energy so the the sideways rotational energy is dissipated an instant before the ball impacts the pins.

The best location for the bowler to roll the snappy ball is any location that will have sufficient oil length so that the ball is allowed to go long enough to satisfy the desire of the bowler (who apparently wants a snappy ball path) but far enough outside so that the ball just makes it up to the pocket for a strike.

So:
The ball wants to snap based on it's design (low RG and large DRG),
the ball surface is smooth so that it will go long before breaking inward,
the ball is drilled to go long and snap,
the bowler releases the ball with a greater percentge of forward roll enhancing the go long combintion,
the bowler rolls the ball in an area on the lane surface where there is an ample length of oil so that the ball can go long and at the correct location on the outside so that the ball just makes it back to the pocket.

All Arcy

When comparing two canidate balls, the one with the smaller Borden Number (less snappy) should be chosen because it is more arcy. Bowling balls with a high RG value are more arcy.

The ball surface should be dull enough to enhance the need for a ball that starts breaking early.

If the ball is designed as an arcy ball, it should be drilled as an arcy ball. It should be drilled to start breaking as early as possible. A stacked leverage layout will give the ball the best chance of breaking early.

One good match is a ball designed ball drilled to be a arcy ball for a lane condition that allows a bowling ball to break early toward the pocket. That means less oil in the heads and the transition area to allow the ball to start breaking early and then arc toward the pocket at the backend. That also means the backend is sufficiently clean, the lane surface is aggressive and no carry down interferes with the arc to the pocket.

The bowler should have just enough sideways rotational energy so the the sideways rotational energy is dissipated an instant before the ball impacts the pins.

The best location for the bowler to roll the arcy ball is any location that will allow the ball to start early enough to allow the ball to arc and far enough outside so that the ball just makes it up to the pocket for a strike.

So:
The ball wants to arc based on it’s design (high RG and large DRG),
the ball surface is dull so that it will start breaking inward as early as desired,
the ball is drilled to expose as much ball surface as possible to allow breaking as early as possible,
the bowler releases the ball with just enough sideways rotatioinal energy so that all of the sideways energy is exhausted just an instant before the ball impacts the pins.
the bowler rolls the ball in an area on the lane surface where the ball can start breaking early and at the correct location on the outside so that the ball just makes it back to the pocket.

The Ball and the Bowler

Type of Release - This defines where the initial axis or rotation will be located and proportions of the three rotations (forward, sideways and top spin). Examples are 3/4 roller, spinner, full roller, straight ball and backup ball. Remember, ideally the ball should only have enough sideways rotational energy to be able to move the ball laterally across the lane so that it just gets to the pocket as that sideways energy is expended. The rest of the rotational energy should be forward rotational energy. Forward rotational energy is what is seen as the "drive through the pocket." The greater the forward rotational energy at the instant of impact at the proper angle of attack into the rack of pins, the greater the drive into the pocket. Top spin is mostly a waste. However, in an effort to consciously decrease the sideways movement of the ball across the lane under dry conditions, an increased top spin rotational energy can decrease the sideways rotational energy (you increase one and the other is decreased).

Speed of Release - This defines the need for the ball to have a more or less shiny smooth surface. Friction between at the interface between the ball surface and the lane surface is what allows the sideways rotational energy to be expended. If there is little or no friction, the sideways rotational energy imparted to the ball at the release will never be tranformed into "work" as usually seen by moving the ball in a direction perpendicular to the then current direction of travel of the ball. Contrasting examples are very wet long oil lanes (little or no friction) versus very dry short oil lanes (large friction). A high speed release will require a very dull surface so that the reaction at the beginning of the end of the oil starts as quickly as possible. For insanely high speed (above 20 mph), it may take an insanely rough surface. Regardless of the speed and the surface, movement of the ball laterally across the lane surface still requires that the bowler impart some amount of sideways rotation into the ball during the release.

Strength of Release (The Rev Rate), Layout Instability and Flare Potential - This defines how the bowler "allows" flaring to occur. The Differential Radius of Gyration (DRG) defines how the ball is designed with respect to the proportion of the dynamic imbalances created by the weight block. The higher the rev rate at the release, the greater the centrifugal forces on the imbalances. That's what actually causes flaring to occur. The drilling layout defines how those dynamic imbalances are positioned during the release of the ball. Some drilling layouts enhance the flaring and some tend to delay or even prevent flaring to occur at all. The chosen drilling layout is in effect the "allowing" of the flaring potential to be realized. Contrasting examples are the "stacked leverge" layout and the "axis" layout. The stacked leverage layout maximizes the initial flaring rate and the axis layout minimizes the flaring rate.

If a bowler has a strong release (rev rate) a stacked leverage release may "allow" too much flaring to occur. The flaring may continue all the way around the surface of the ball. It may flare over both the finger and thumb holes. So, a strong release (high rev rate) and a stacked leverage layout is not a good combination.

But, that same layout may be perfect for a bowler with a weak release (low rev rate).

So, you can buy a ball with a tremendous flare potential let's assume 6 3/4" of flare. If the bowler doesn't impart a reasonable amount of rotational energy into the ball (bowler allowing the flaring to occur), flaring will not occur. And or if the driling layout does not position the dynamic imbalances in an initial position for flaring to occur (the layout allowing for the flaring to occur), flaring wil not occur. Remember when you took the steps to the foul line and just chunked the ball forward using both hand like the beginning bowlers do. When you do that there is little or no rotationl energy imparted to the ball and essentially no flaring will occur.

It's like multiplying the terms together to get flaring, If either one is small, flaring is small.

Bowler Speed and Ball Surface
The most dominant factor in a bowler's execution is the speed of the ball at release. It, more than anything else determines the needed aggressiveness and roughness of the coverstock surface.

As a bowler's speed increases, the needed aggressiveness increases. So, for a high speed ball release, the ball needs to be very aggressive to give the bowler a better chance to get the ball surface friction to interact with the lane surface friction at the backend. Depending on the oil pattern and the density of the oil where the ball is rolled, the surface may also need to be dull so that the ball friction has an earlier chance to interact with the lane friction.

There is a wide range of bowler ball speed. For adults the speed varies from about 10 mph to about 25 mph. The slower speeds usually come from seniors. Heh, all of us will eventually roll the ball at that speed. For the time being, we need to be able to recommend the proper ball for such a low speed.

For the same reason that a high speed bowler needs a very aggressive dull surface ball, a slow speed bowler usually needs to be less aggressive, a lot less. And, also for the same reason, the ball surface needs to be as smooth as possible. That will save as much energy as possible for the drier backend lane surface.

Rev Rate and the Drilling Pattern Another Dynamic Duo
Another Dynamic Duo is the bowler's rev rate and the drilling layout. This is related to the manner in which the ball is released and the strength of the bowlers wrist and grip,

A weak release has the fingers above the middle of the ball and far to the right of the center of the ball. A low rev rate is very noticable. The gripping holes can easily be seen rotating as the ball rolls down the lane. And in the same manner a strong release shows the gripping holes as a blur on the side of the ball.

The strong release (high rev rate) is the easiest to match. Regardless of the combinations that this bowler will try as a good match, the one that is likely to lead to more trouble is the choice of a very aggressive ball (Reactive surface) with a large flare distance (high DRG) and a drill layout for maximum flare (stacked leverage). The stacked leverage layout gives the highest starting flaring rate. It kick starts the flaring. Once that happens for a strong release, it's hard to stop. When a strong release bowler has this combination, there is a huge likelihood that the ball will not ever stop flaring. Those oil tracks will appear all round the ball. The ball may or may not roll over the fingers and or thumb holes. Yuck!

You may think that the bowler can move into the oil farther inside and curtail the problem, but that is not how flaring works. Flaring is induced by the imbalances caused by the drill layout and the rev rate (centrifugal forces). The higher the rev rate, the more likely the flaring will continue all around the ball.

For that reason a strong release should not be combined with a stacked leverage layout. The layout needs to be one that does not “kick start” the flaring quite as much.

A high rev rate does not necessarily mean a high speed ball, but that is usually the case. If that is the case, the recommendation for a high speed ball still holds. The layout must still be something other than a high flare inducing layout. And the surface must still be aggressive if the surface is an oily condition. The only option left is to make sure that the ball is, by dynamic design, a ball with less flaring potential (lower DRG).

The remaining ball parameter that is variable is the RG. The actual release rev rate will depend directly upon the RG. The highest rev rate will come from that person releasing a bowling ball with the smallest RG value. The lowest rev rate for that same bowler’s release will come from that person releasing a bowling ball with the highest RG value.

So, one method to curtail such a high rev rate at release is to choose a ball with a high RG value. That will automatically reduce the rev rate for the same release energy.

So, that means the best recommendation for a high rev rate high speed release is a ball with an aggressive dull surface, a low flare potential (low DRG), drilled for mellow flare (not stacked leverage) and a high RG.

If the rev rate is high but the speed is not excessive there is not a need for an aggressive surface. So, the recommendation is a for a high rev rate medium speed release is a ball with a mellow shiny surface, a low flare potential (low DRG), drilled for mellow flare (not stacked leverage) and a high RG.

You can see that the real difference is the state of the surface. The slower the speed, the shinier and less aggressive the surface.

Weak Release and Low Speed Another Dynamic Duo (Without Vitamins or Caffeine)
This is of course the opposite case and many of the recommendations are very different.

Using the same logic as before, weak release implies a very shiny surface. That makes sure that what ever minimal energy imparted to the ball by the bowler is not dissipated too early or too quickly after the end of the oil. The dynamics of the ball design and drill layout should be as aggressive as possible (stacked leverage) and the flare potential (DRG) should also be as high as possible. That will give the maximum potential of new surface being exposed to the lane surface after the ball reaches the end of the oil.

The RG recommendation is the hardest to accept. A weak release requires the highest RG possible. We want the bowler to reatin as much of the rev rate as possible. A high RG ball remember, retains most of the rotational energy as it goes down the lane. By design it is more difficult to change it’s rotational energy because of it’s high RG value.

Since the weak release bowler is usually connected with a low speed release, the recommendation of a shiny surface is valid. So, the recommendation for a weak release, low speed bowler is a shiny surface, very aggresssive design and drill layout (stacked leverage), high flare potential (high DRG) and high RG value.