The Truth about Drilled Bowling Balls and why they react the way they do
presenter

No 
Pine

©2010 Mo 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

\[ y = -0.2298x + 15.823 \]
\[ R^2 = 0.995 \]

\[ y = 0.0139x^2 - 0.8702x + 23.331 \]
\[ R^2 = 0.9983 \]

\[ y = 0.8662x - 29.686 \]
\[ R^2 = 0.9962 \]

The skid region or the region of ball motion where the ball has not encountered enough friction to begin its hook region.

The hook region or the region where friction is encountered and the ball goes from going in the negative direction to going towards the pins.

The roll region where the ball rolls on a constant path in regards to linearity.

1st trans. 2nd trans.
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

1. **Coverstock** (chemical composition and surface texture)
a Better Understanding of Coverstocks and Surface Preparation
Most Significant Variables — 18 Point Scale

- SR-Ra
- OH-Lane COF
- SR-RG
- Dry Lane COF
- Oil Absorption
- RG
- Total Differential
- Spin Time
- Diameter
- Side Weight
- Int-Crif
- Oil @ 32°
- Oil @ 68°
- Room Humidity
- Top Weight
- Room Temp.
- Fin/Th. Weight
- Lane Temp.
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)

Ra Values

Abralon Finish

©2008 USBC
Data courtesy of USBC
How Surface Changes affect $R_a$
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

©2010 Mo Pinel
Factors affecting the reaction of drilled Bowling Balls

1. **Coverstock** (chemical composition and surface texture)

2. **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 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
a study of Axis Migration Paths
the RG of the Migrating PAP

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

1. **Coverstock** (chemical composition and surface texture)

2. **Ratio** of Intermediate Differential to Total Differential (int. diff./total diff.) of the drilled ball

3. **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

©2010 Mo Pinel
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 = 0.33

RG of PAP = 2.567

©2010 Mo Pinel
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
**Un-Drilled Mass Properties**
- M = 15.25 lbs
- Low RG = 2.489
- Int Diff = 0.034
- Total Diff = 0.052
- 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 = 0.044
- Total Diff = 0.066
- Diff Ratio = 0.66

**RG of PAP** = 2.529
Combo Ball 10x4.25x20 BAL P4

Color Code
N’sane Blue
Mojave Orange
Frenzy Purple
Symmetrical Green

PAP at Release

©2010 Mo Pinel
## Mass Properties of Drilled Balls Summary

<table>
<thead>
<tr>
<th>Ball</th>
<th>Mass (lbs)</th>
<th>Low RG</th>
<th>Int Diff</th>
<th>Total Diff</th>
<th>Diff Ratio</th>
<th>RG of PAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Nsane LevRG</td>
<td>14.87</td>
<td>2.491</td>
<td>.044</td>
<td>.066</td>
<td>.66</td>
<td>2.529</td>
</tr>
<tr>
<td>Mojave</td>
<td>14.81</td>
<td>2.619</td>
<td>.017</td>
<td>.046</td>
<td>.38</td>
<td>2.648</td>
</tr>
<tr>
<td>Frenzy</td>
<td>14.85</td>
<td>2.528</td>
<td>.020</td>
<td>.061</td>
<td>.33</td>
<td>2.567</td>
</tr>
<tr>
<td>Symmetrical</td>
<td>14.83</td>
<td>2.502</td>
<td>.012</td>
<td>.066</td>
<td>.18</td>
<td>2.544</td>
</tr>
</tbody>
</table>

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

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

### MoRich RipR

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

### MoRich 'Nsane LevRG

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

©2010 Mo Pinel
Drilled MoRich LevRGs

<table>
<thead>
<tr>
<th>Name</th>
<th>Serial</th>
<th>Drilling Technique</th>
<th>Low RG Axis</th>
<th>Undrilled i-Diff</th>
<th>T-Diff</th>
</tr>
</thead>
<tbody>
<tr>
<td>LevRG</td>
<td>183</td>
<td>10° x 3 3/8” x 20°</td>
<td>2.485</td>
<td>0.035</td>
<td>0.049</td>
</tr>
<tr>
<td>LevRG</td>
<td>138</td>
<td>90° x 3 3/8” x 20°</td>
<td>2.484</td>
<td>0.034</td>
<td>0.049</td>
</tr>
<tr>
<td>LevRG</td>
<td>216</td>
<td>90° x 4 1/2” x 70°</td>
<td>2.483</td>
<td>0.034</td>
<td>0.050</td>
</tr>
<tr>
<td>LevRG</td>
<td>198</td>
<td>50° x 5” x 45°</td>
<td>2.481</td>
<td>0.034</td>
<td>0.053</td>
</tr>
</tbody>
</table>

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

©2010 Mo Pinel
### Drilled MoRich LevRGs

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

©2010 Mo Pinel
Factors affecting the reaction of drilled Bowling Balls

1. **Coverstock** (chemical composition and surface texture)

2. **Ratio** of Intermediate Differential to Total Differential (int. diff./total diff.) of the drilled ball

3. **Total Differential** of the drilled ball

4. **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.*
60 Degree Spin Time

Click to replay video

©2010 Mo Pinel
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!