

ENGINEERING REPORT

Subject: 3 oz. Static Wt. vs Balance Hole- Bowler #1

Date: 3/6/18

Place: International Training & Research Center

Present: Danny Speranza, test bowler

Purpose: Use ball with adjustable weights to study 3 oz. static weight in all directions vs. ball with balance hole.

Summary: This was a test to determine if increasing static weights to 3 oz. in all directions could hook more than a ball with a balance hole located to increase the differential RG and flare which results in increased hook. Using a special adjustable static weight ball with and without a balance hole, different combinations of static weight and balance hole were tested. It was determined that the added static weight did not perform better (hook more or greater entry angle) than a ball within existing static weight with a large weight hole to maximize the differential RG to create more flare. In many cases the balance hole ball out performed the added static weights.

Discussion: A 220+ average bowler was used for this test. We build two adjustable static weight balls with different weighted slugs using switch grips to allow different static weights in the same ball.

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Different inserts were weighted differently to change the static weight. Only 3 static weight adjusters were used in the ball to prevent the flaring ball track from rolling over the inserts. The inserts allowed for:

- Add positive side weight
- Add top weight
- Add thumb weight

These three were selected because these had the potential to increase the amount of hook and entry angle. We know negative side weight and bottom weight reduces hook. Finger weight might increase hook slightly but any insert to add finger weight would have been rolled over during track flare which we wanted to avoid.

A balance hole was added with an insert to allow the ball to return to the original differential RG (insert weight matched the ball material weight removed).

A research technician made the weight adjustments during the test without the bowler knowing what he was testing. The testing was conducted on a flat oil pattern. The goal was to hit the same 3 board area at the target and at the down lane marker and let the ball hook

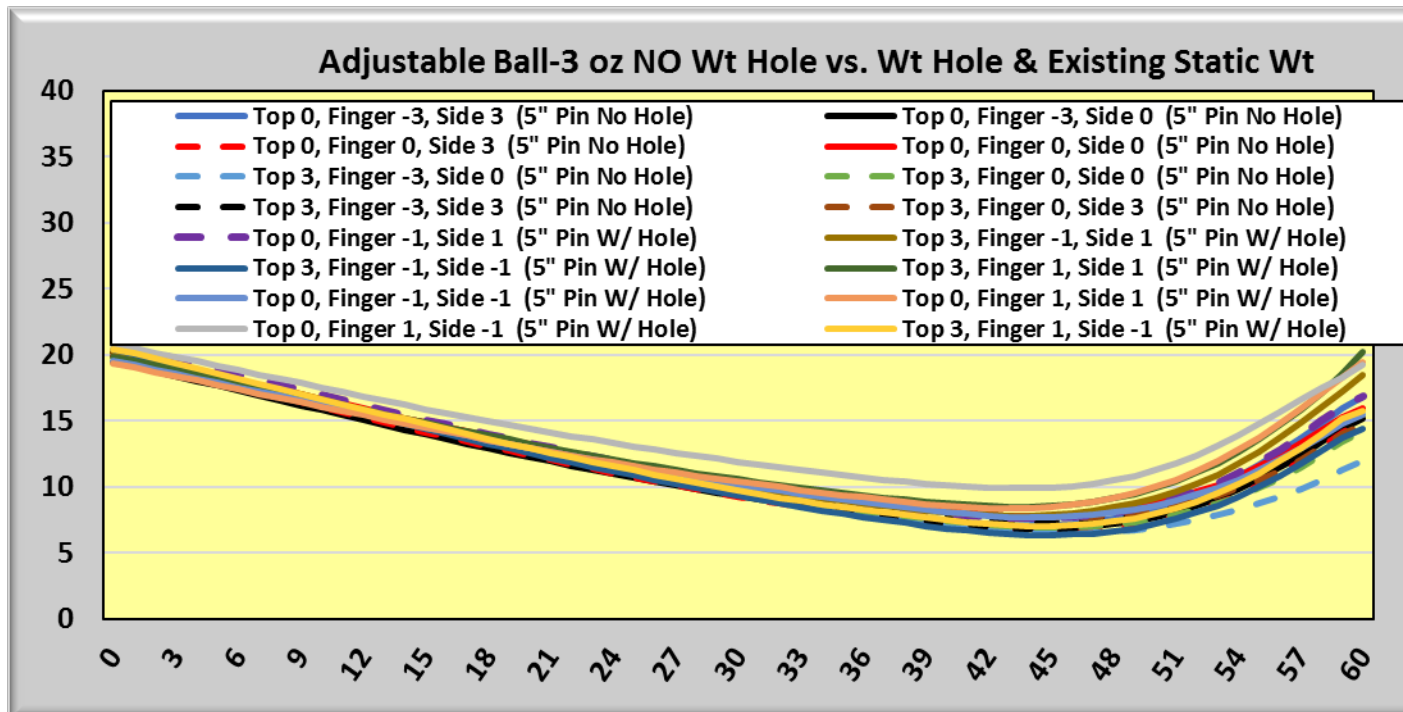
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wherever it would. The goal was also to throw 5 good shots in less than 15 shots to prevent the lane condition from changing during the test. Some test required 20 shots to get 5 good ones.

Test# 1 - Ball drilled with 5" pin to PAP and tested different 3 oz. static weight combinations vs. the same ball with a large weight hole to maximize the differential RG with existing static weights (3 oz. top, 1 oz. side, 1 oz. finger/thumb).

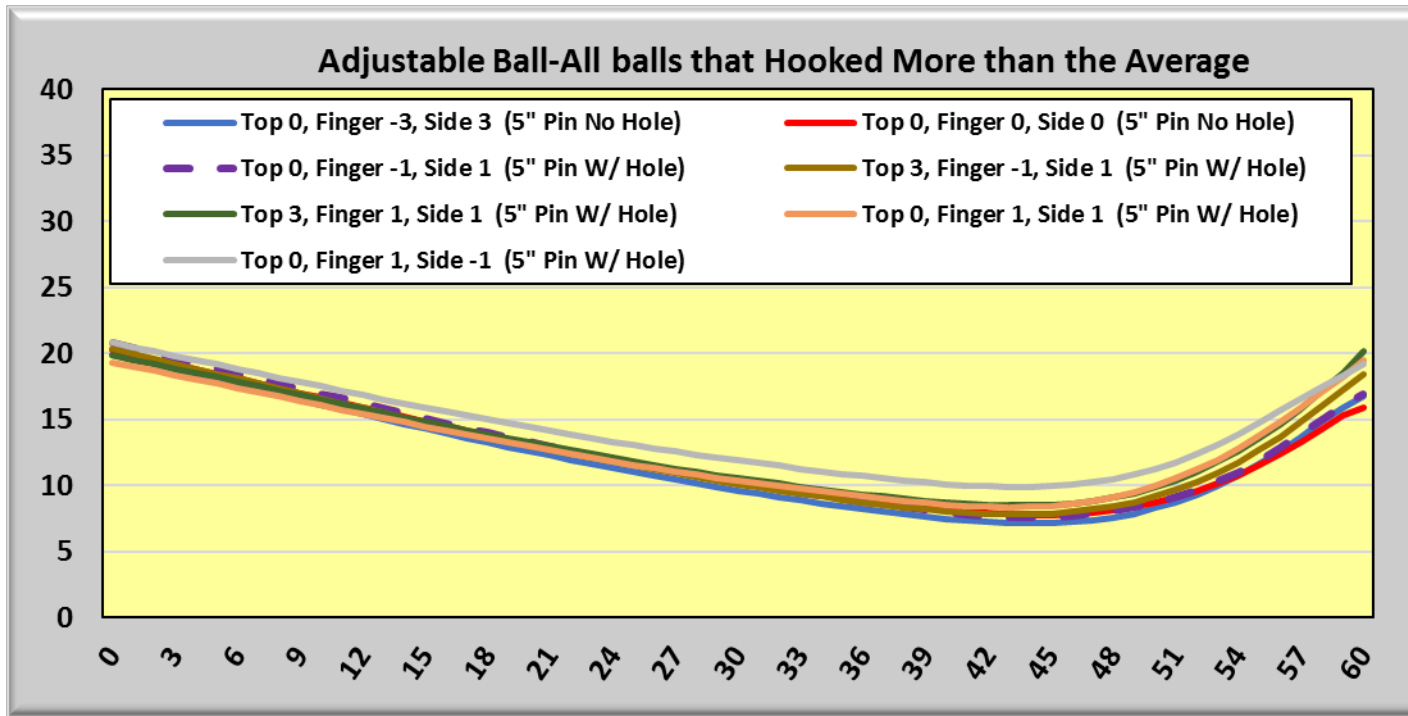
Goal was to determine if 3 oz. static weight or balance hole will increase the hook the most.

Below is a lane graph of all the test results. There were 8 combinations with 3 oz. static weight and eight with balance hole within existing static weight limits (16 total test combinations).



Everything will be compared to a 0-balance ball with no weight hole (solid red line in chart). Below are all the combinations that hooked more than the average ball plus the 0-balance ball which hooked slightly less than average:

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There were six balls that hooked more than the average with five of these balls being ones with a with a weight hole and within existing static weights specs.

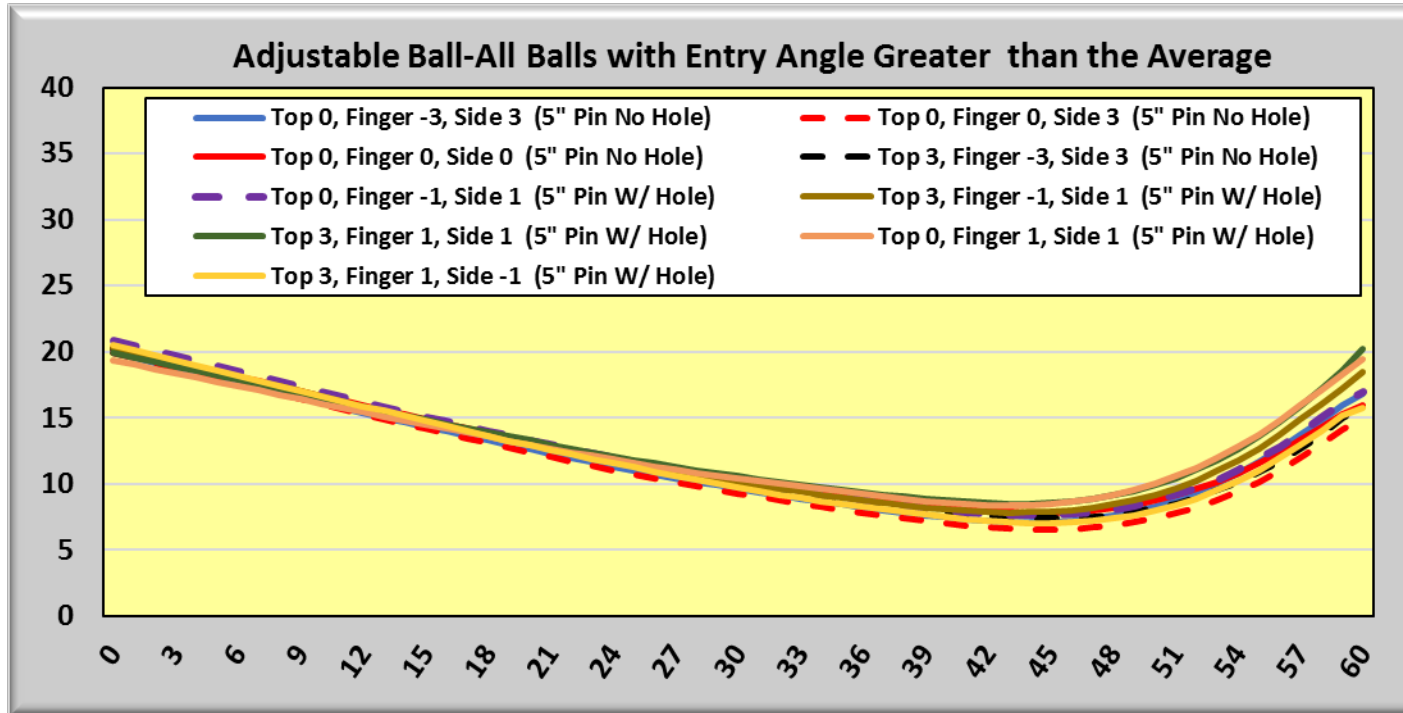
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Below is the data for these balls that hooked more than the average plus the 0-balance ball data:

Data	Top 0, Finger -3, Side 3 (5" Pin No Hole)	Top 0, Finger 0, Side 0 (5" Pin No Hole)	Top 0, Finger -1, Side 1 (5" Pin W/ Hole)	Top 3, Finger -1, Side 1 (5" Pin W/ Hole)	Top 3, Finger 1, Side 1 (5" Pin W/ Hole)	Top 0, Finger 1, Side 1 (5" Pin W/ Hole)	Top 0, Finger 1, Side -1 (5" Pin W/ Hole)	Avg
Positions 60	16.78	15.94	16.91	18.46	20.20	19.46	19.22	16.21
Launch Angle	-1.93	-1.84	-1.95	-1.90	-1.71	-1.66	-1.68	-1.87
Angle (53-57')	4.66	3.97	4.53	4.95	5.15	5.05	4.49	4.17
Entry Angle	5.72	5.08	5.55	6.11	6.83	5.92	4.33	5.30
Total angle	7.65	6.92	7.51	8.01	8.54	7.58	6.01	7.17
4th phase of motion	no	no	no	no	no	no	yes	
Backup Angle (57-60') vs (53-57')							0.160	
Positive Angle Change (57-60')	1.07	1.12	1.021	1.163	1.679	0.872		

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The lane graph below shows all the balls with an entry angle greater than the average plus the 0-balance ball which had less entry angle than the average:



There were eight balls with an entry angle greater than the average. Three balls had 3 oz. of side weight with no hole and five balls had a balance hole within existing static weight limits. The top three entry angle balls all had a weight hole within existing static weights limits. Below is the data for the balls with entry angles greater than the average:

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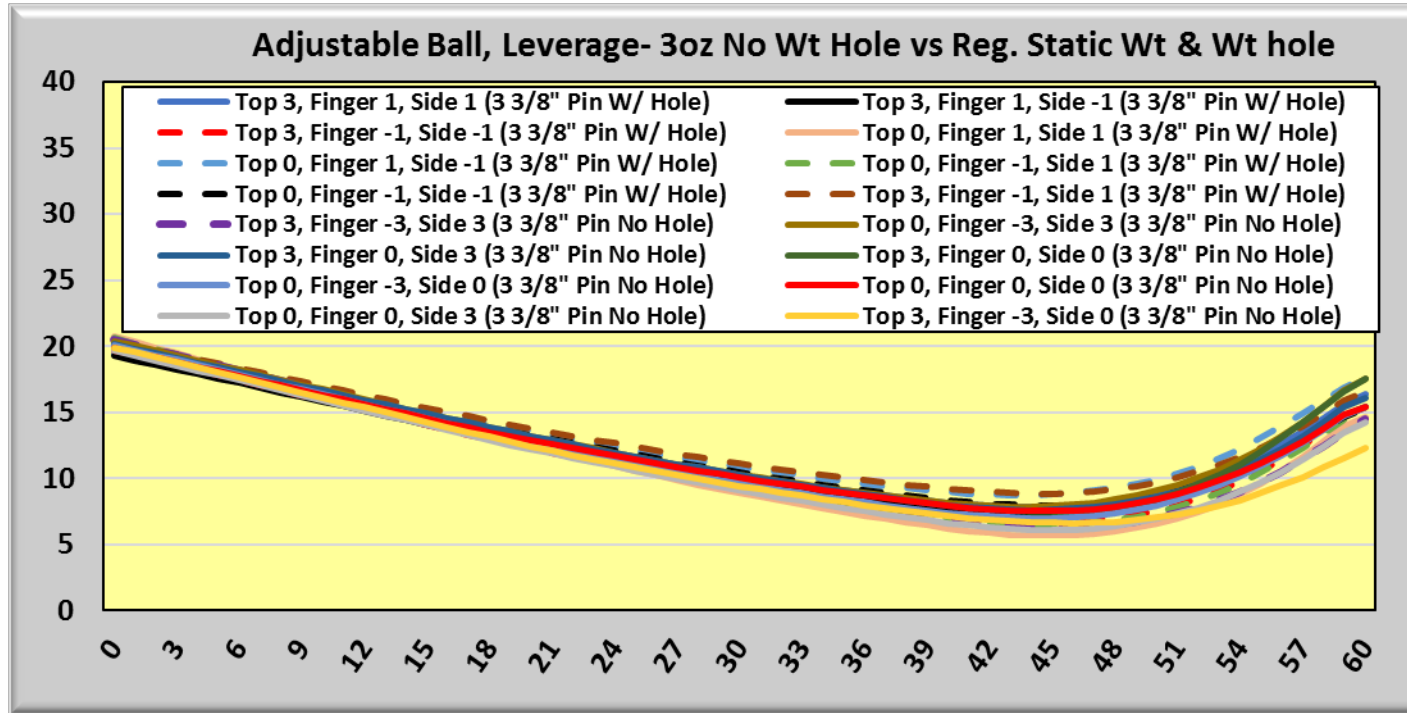
Data	Top 0, Finger -3, Side 3 (5" Pin No Hole)	Top 0, Finger 0, Side 3 (5" Pin No Hole)	Top 0, Finger 0, Side 0 (5" Pin No Hole)	Top 3, Finger -3, Side 3 (5" Pin No Hole)	Top 0, Finger -1, Side 1 (5" Pin W/ Hole)	Top 3, Finger -1, Side 1 (5" Pin W/ Hole)	Top 3, Finger 1, Side 1 (5" Pin W/ Ho)	Top 0, Finger 1, Side 1 (5" Pin W/ Ho)	Top 3, Finger 1, Side -1 (5" Pin W/ Ho)	Ave
Positions 60	16.78	14.96	15.94	15.80	16.91	18.46	20.20	19.46	15.74	16.21
LaunchAngle	-1.93	-1.97	-1.84	-1.88	-1.95	-1.90	-1.71	-1.66	-1.94	-1.87
Angle(53-57')	4.66	4.10	3.97	4.03	4.53	4.95	5.15	5.05	4.37	4.17
EntryAngle	5.72	5.51	5.08	5.77	5.55	6.11	6.83	5.92	5.54	5.30
Total angle	7.65	7.48	6.92	7.65	7.51	8.01	8.54	7.58	7.48	7.17
4th phase of motion	no	no	no	no	no	no	no	no	no	
Backup Angle (57-60') vs (53-57')										
Positive Angle Change (57-60')	1.07	1.41	1.12	1.73	1.021	1.163	1.679	0.872	1.164	

This same group of balls were the ones with a total angle greater than the average. Two balls had total angle greater than 8-degrees and both of these had a balance hole within existing static weight specs.

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Test#2- Adjustable weight ball drilled with a leverage drilling layout comparing 3 oz. static weight vs. same ball with a balance hole and within existing static weight limits

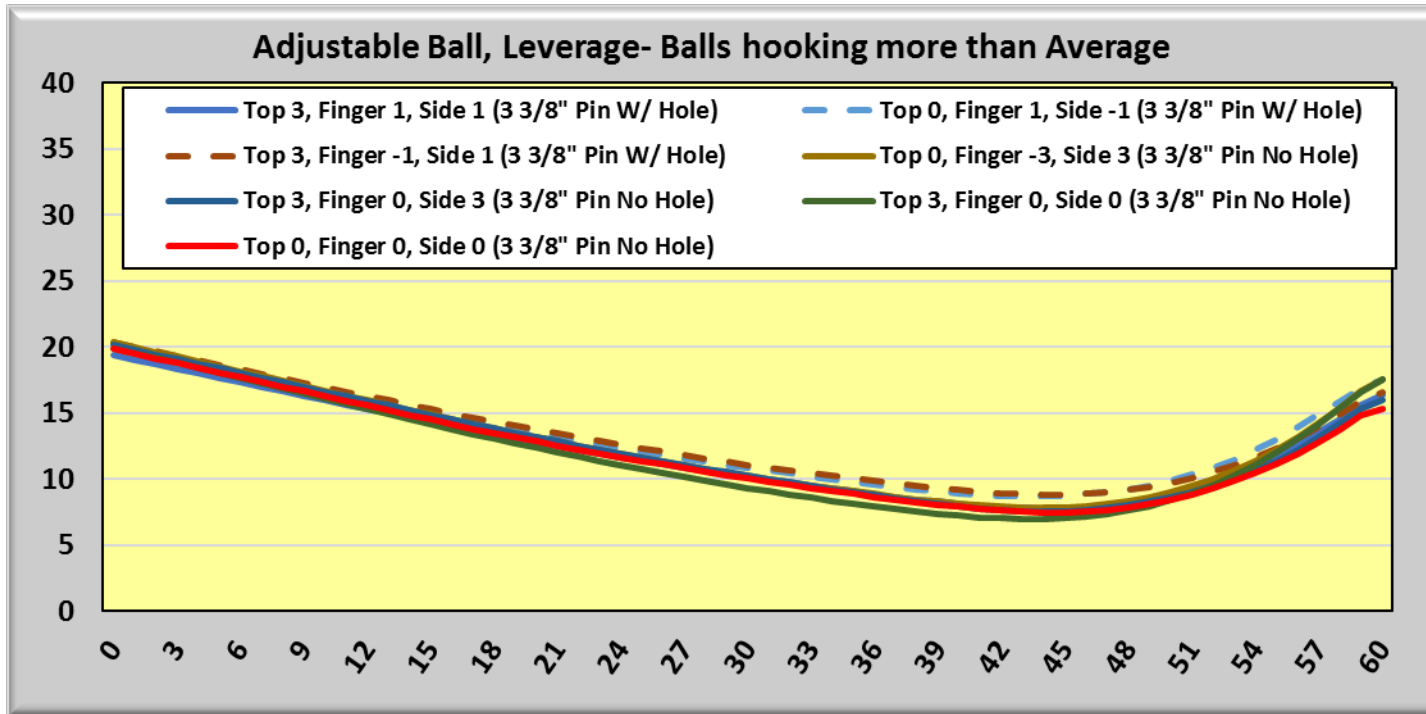
Below all the lane graphs for all the balls in this test:



There were eight combinations with 3 oz. static weight with no hole and eight combinations with a weight hole within existing static weight limits.

The lane graph below shows all the ball paths that hooked more than the average and the 0-balance ball and the 0-balance ball (red line).

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There were six balls that hooked more than the average. Of these, three balls had a weight hole with existing static weights, two balls did not have a weight hole with 3 oz. static weight outside of existing specs and one ball had no weight hole but passed existing specs (had 3 oz. of top weight):

- One had 3 oz. of finger weight
- One had 3 oz. of positive side weight
- One had 3 oz. of top weight which is within static weight limits today.

Below is the data for the balls that hooked more than the average along with the 0-balance ball:

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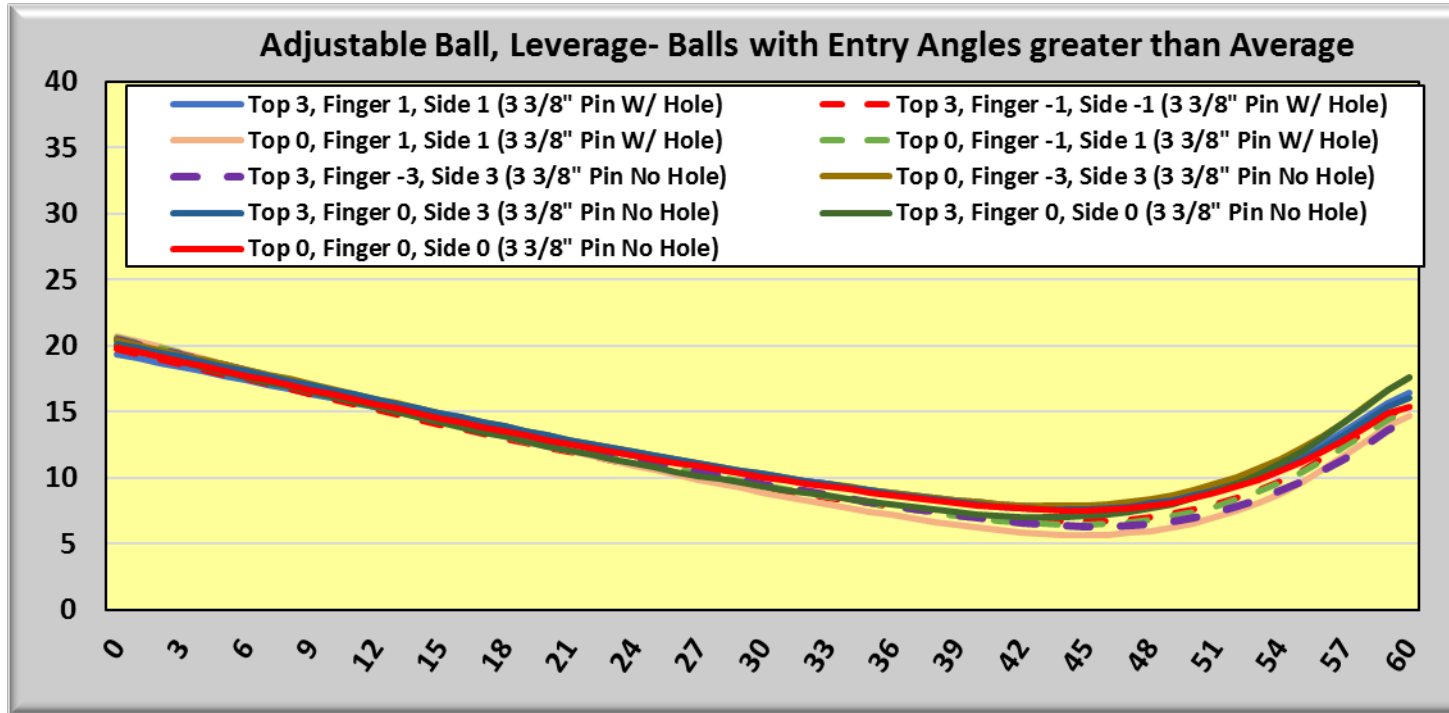
Data	Top 3, Finger 1, Side 1 (3 3/8" Pin W/ Hole	Top 0, Finger 1, Side -1 (3 3/8" Pin W/ Hole)	Top 3, Finger -1, Side 1 (3 3/8" Pin W/ Hole)	Top 0, Finger -3, Side 3 (3 3/8" Pin No Hole	Top 3, Finger 0, Side 3 (3 3/8" Pin No Hole	Top 3, Finger 0, Side 0 (3 3/8" Pin No Hole	Top 0, Finger 0, Side 0 (3 3/8" Pin No Hole	Ave
Positions 60	16.42	17.60	16.57	17.55	16.06	17.55	15.38	15.59
LaunchAngle	-1.72	-1.76	-1.72	-1.87	-1.79	-1.96	-1.81	-1.88
Angle(53-57')	4.14	4.35	3.68	4.55	4.00	5.04	3.75	4.06
EntryAngle	5.34	4.95	5.03	6.13	5.53	6.03	5.18	5.25
Total angle	7.06	6.71	6.75	8.00	7.32	7.99	7.00	7.13
4th phase of motion	no	no	no	no	no	no	no	
Backup Angle (57-60') vs (53-57')								
Positive Angle Change (57-60')	1.20	0.60	1.348	1.581	1.526	0.990	1.434	

The three most hooking balls all hooked about the same and were:

- Top 0, Finger 1, Side -1 with weight Hole- 17.6 board (legal today)
- Top 0, Finger -3, Side 3 with no weight- 17.55 boards (not legal today)
- Top 3, Finger 0, Side 0 with no Hole- 17.55 boards (legal today)

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Below is the lane graph for all balls with an entry angle greater than the average and the 0-balance ball (red line):



There were eight balls of the 16 balls that had an entry angle greater than the average. There were four balls with a weight hole within existing static weights limits. There were three balls with no weight hole and exceeded existing static weight limits. And there was one ball with no weight hole and within existing static weight limits.

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Below is the data for the balls with entry angles greater than the average:

Data	Ave										
	Top 3, Finger 1, Side 1 (3 3/8" Pin	Top 3, Finger -1, Side -1 (3 3/8" Pin	Top 0, Finger 1, Side 1 (3 3/8" Pin	Top 0, Finger -1, Side 1 (3 3/8" Pin	Top 3, Finger -3, Side 3 (3 3/8" Pin	Top 0, Finger -3, Side 3 (3 3/8" Pin	Top 3, Finger 0, Side 3 (3 3/8" Pin No	Top 3, Finger 0, Side 0 (3 3/8" Pin	Top 0, Finger 0, Side 0 (3 3/8" Pin		
	W/ Hole	W/ Hole	W/ Hole	W/ Hole	No Hole	No Hole	Hole)	No Hole	No Hole		
Positions 60	16.42	15.38	14.65	15.16	14.43	17.55	16.06	17.55	15.38	15.59	
LaunchAngle	-1.72	-1.92	-2.18	-2.05	-1.98	-1.87	-1.79	-1.96	-1.81	-1.88	
Angle(53-57')	4.14	4.32	4.53	4.33	3.94	4.55	4.00	5.04	3.75	4.06	
EntryAngle	5.34	5.60	5.86	5.28	5.35	6.13	5.53	6.03	5.18	5.25	
Total angle	7.06	7.52	8.04	7.32	7.32	8.00	7.32	7.99	7.00	7.13	
4th phase of motion	no	no	no	no	no	no	no	no	no		
Backup Angle (57-60') vs (53-57')											
Positive Angle Change (57-60')	1.20	1.28	1.32	0.95	1.410	1.581	1.526	0.990	1.434		

The most entry angle balls were:

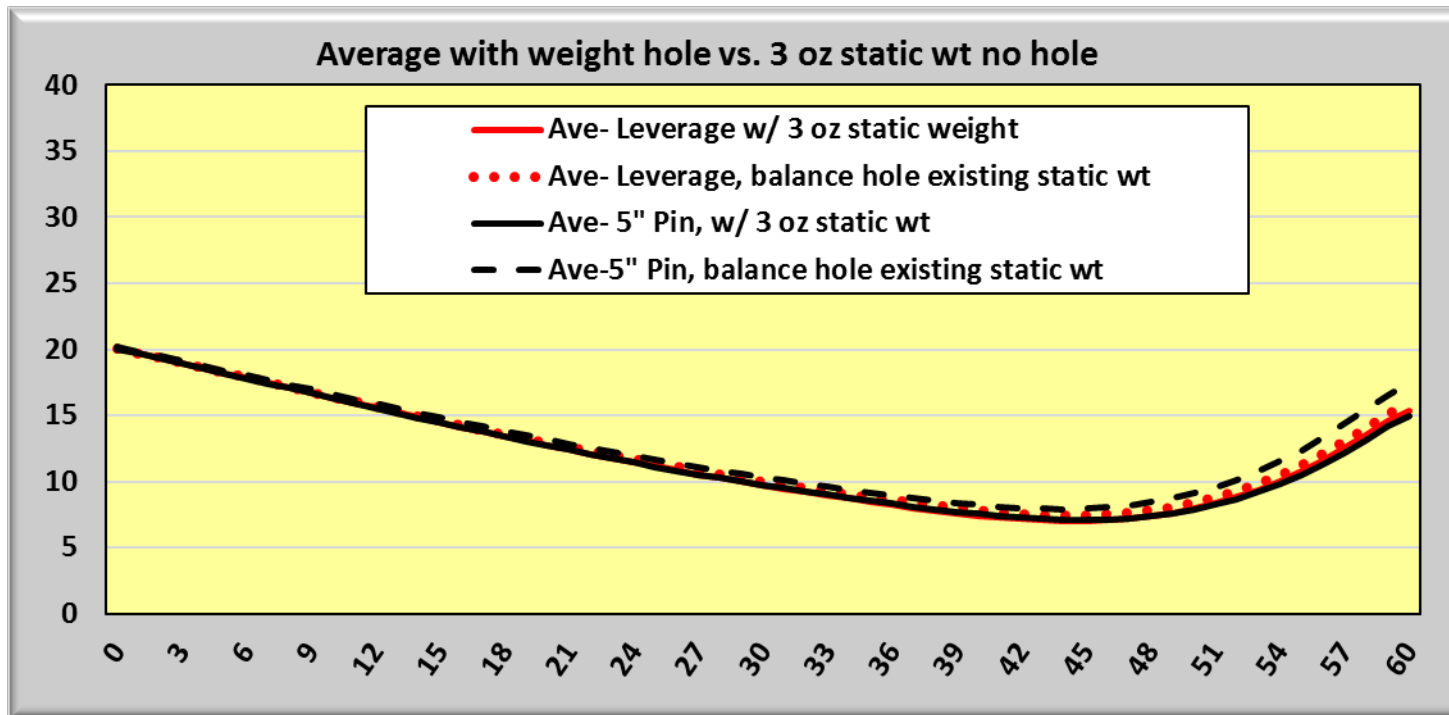
- Top 0, Finger -3, Side 3 No weight hole- 6.13 degrees (exceeds existing static weight limits)
- Top 3, Finger 0, Side 0 No weight hole- 6.03 degrees (passes existing specs)
- Top 0, Finger 1, Side 1 with weight hole- 5.86 degrees (passes existing specs)

Comparing Leverage drilling to 5" pin to PAP drilling

Below is the lane chart for the average ball paths for leverage drilling vs. 5" pin layout with:

- A balance hole and existing static weight
- 3 oz. of imbalance

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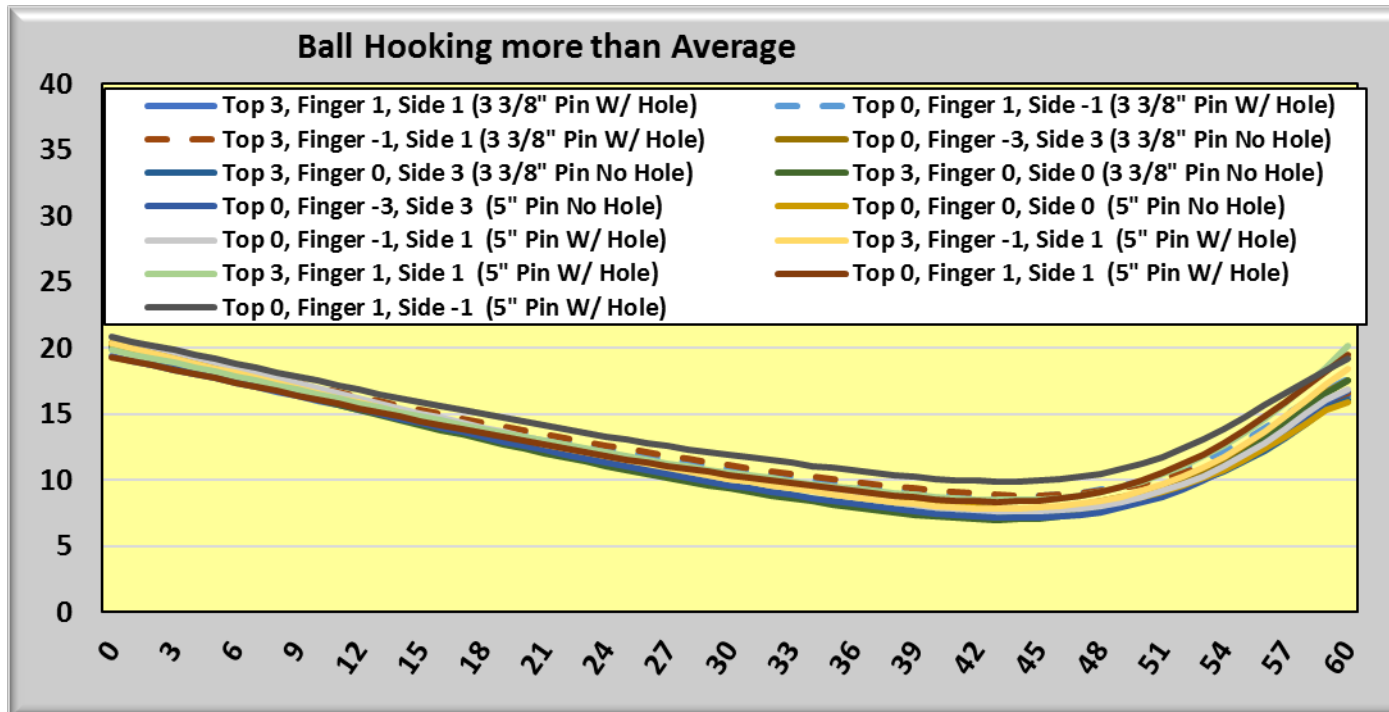
Leverage layout with a balance hole with existing static weights hooked about the same as the leverage drilling with no hole and 3 oz. imbalance. The leverage drilling with a balance hole hooking about .5 inches more than the 3 oz. static weight combinations.

The 5" pin layout had a larger different between the combinations with a balance hole and existing static weights vs the 3 oz. imbalance combinations. The balance hole combinations hooked on average 2.5 boards more than the 3 oz. static weight combinations.

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Balls that hook more than average.

Below are all the balls that hooked more than the average.



There were 13 balls out of the 32 combinations that hooked more than the average:

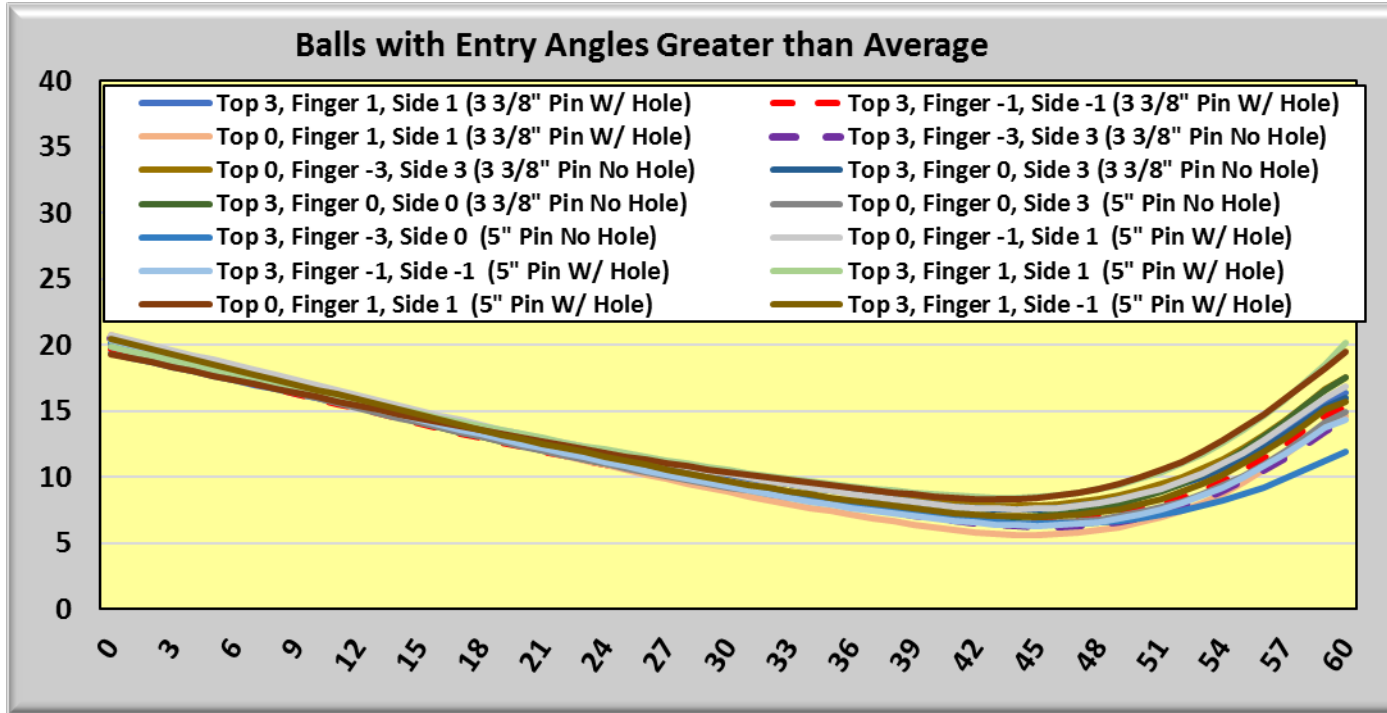
- 8 balls met current imbalance specs (i.e. had a balance hole to increase flare)
- 2 balls met specs with 3 oz. of top weight
- 3 balls had 3 oz. imbalance outside of specs
 - 2 with 3 oz. of thumb weight
 - 1 ball with 3 oz. of thumb and positive side weight

Most hooking balls:

- 4 balls hooked at least to the 18 board or greater
 - All had 5" pin to PAP
 - All had a weight hole and met current specs

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Below are all the balls with an entry angle greater than the average.



There were 14 balls out of 32 balls that had an entry angle greater than the average angle:

- 9 balls met current specs
 - 8 had a weight hole
 - 1 had 3 oz. of top weight
- 5 balls did not meet current specs (3 oz. of imbalance with no weight hole)
 - Thumb and side
 - Thumb and top
 - Thumb, top, and side
 - Top and side
 - Side

4 Balls had more than 6 degrees of entry angle with 3 of these meeting current specs

- Meets current specs with weight hole – 6.83 degrees

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- 3 oz. thumb and side weight with no hole- 6.13 degrees (does not meet current secs)
- 3 oz. top, 1 oz. finger and side weight with weight hole- 6.11 degrees
- 3 oz. top weight with no hole– 6.03 degrees

General Conclusion:

Changing to 3 oz. of static weight in all directions will not allow balls to hook more than balls in the market today that have a weight hole and meet existing static weight specs. The largest hooking balls had weight holes.