



BOWLING TECHNOLOGY STUDY

CONTINUED RESEARCH

A **Future** FOR
THE **Sport**

The Bowling Technology Study released by the United States Bowling Congress in February 2018 presented in-depth research specifically looking at bowling balls and their effect on the bowling environment.

Started in 2015 as a study to better understand bowling balls, the research looked at the oil absorption rates of coverstocks, how balance holes affect bowling balls, and the impact of Radius of Gyration (RG) and Differential RG. It also included a league simulation study to have a better understanding of oil depletion and ball reaction for bowlers during competition.

Major findings from the research concluded that RG affects the rotation rates (RPM), balance (weight) holes could change Differential RG, and bowling balls with coverstocks that absorb oil fast affected the lanes and would continually force bowlers to play deeper inside.

One of the most important takeaways from the study was that research must always be ongoing because so many factors can affect the bowling environment and those factors are continuously changing.

In its continuation of the study, the USBC Equipment Specifications and Certifications team turned its focus to balance holes and static weights in bowling balls, in addition to examining oil depletion and oil absorption.

SECTION I: A STUDY OF BALANCE HOLES AND STATIC WEIGHT

In its role as the sport's National Governing Body, USBC sets specifications for all bowling equipment and the field of play, everything from the bowling balls to the lanes and lane oil to the pins. It also includes continuous research of all factors that can affect the sport.

One of its major research studies was the Ball Motion Study released in 2008. Following the release of the study, USBC heard from many involved in the industry expressing concerns that static weights no longer were relevant in today's world of high-performance bowling balls affected more by ball dynamics and cover stock chemistry.

So, what exactly are static weights for bowling balls? First, know that the word static literally means still, so the term "static weight" refers to examining a bowling ball's weight and any imbalances when the ball is not moving.

USBC sets specifications for bowling balls and has determined static weight is a factor. USBC specifications allow a maximum three ounces of top or bottom weight, one-ounce maximum left- or right-side weight, and one-ounce maximum finger or thumb weight.

So, when an increase in the maximum static weight allowance or an outright elimination of the specification became a topic after the Ball Motion Study, USBC performed additional research to study the degree to which static weights affect ball motion.

The study showed if the current USBC static weight limits were eliminated or increased, the typical three-phase motion – skid, hook, roll – of bowling balls could be significantly altered. The research found in some cases, with slower ball speeds and extreme static weight variations, that the fourth phase in motion appeared that would lead to an undesirable effect of a bowling ball on the lanes.

The study, which can be viewed [here](#), determined static weight specifications remain valid.

The drilling of a bowling ball can alter its static weight and corrections are needed to ensure the ball has the correct balance to meet specifications. Drilling a hole into a bowling ball in the correct location removes weight, helping to balance the ball and bring it into specification. These types of drillings are called balance holes or weight holes.

But a balance hole – USBC specifications limit a ball to just one balance hole – also can change a ball's dynamics.

As part of the Bowling Technology Study, USBC looked at balance holes and found the overall flare and hook potential of bowling balls could be increased beyond the level of a ball's original design intent through balance-hole drilling techniques (location and size of the balance hole).



image 1

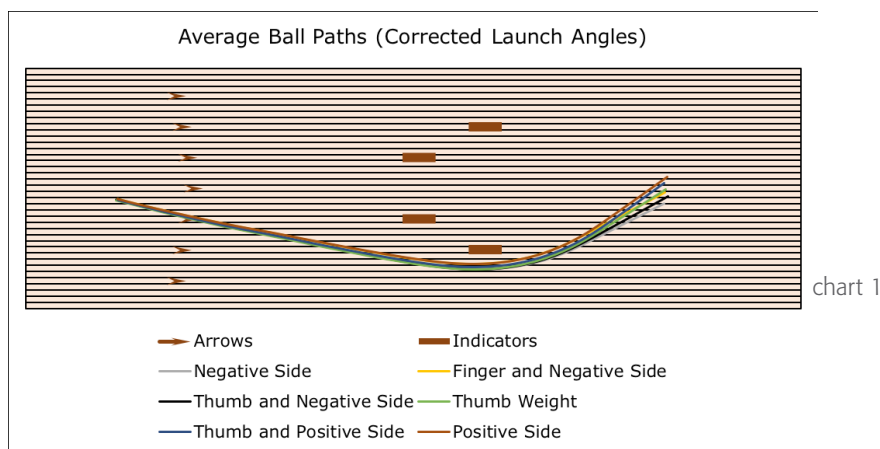
Ball manufacturers also have communicated ways for pro shops to enhance their products for customers by the use of balance holes.

Because USBC research showed balance holes can have a significant impact on various properties of the bowling ball, particularly Differential RG, the USBC Equipment Specifications team continued its research given the demonstrable effect of the overall dynamics and, therefore, performance of bowling balls.

First, USBC researchers wanted to test the effects of adding imbalance to the bowling ball with a fixed pin placement. Keeping the pin at the same distance to the positive axis point (PAP), the center of the grip was rotated in 45-degree increments such that the side weights and thumb weights of the ball would change.

Through the use of special balls with adjustable inserts, different combinations of static weight were tested.

During the static weight study from 2011, the bowling balls were thrown with a slow ball speed. For this test, the ball was thrown with a more normal speed of 17 miles per hour (MPH) and 350 revolutions per minute (RPM). The test was conducted on a 35-foot, flat pattern.



There were three key takeaways:

- Side weight is correlated to total angle change
- Side weight is related to total hook of the ball
- E.A.R.L.'s launch angle is effected by thumb weight (likely top weight, as well)

Side Weight Specification (oz.)	Entry Angle Range (Degrees)	Total Hook Range (Boards)
+/- 1	0.729	1.2112
+/- 2	1.458	2.4224
+/- 3	2.187	3.6336

table 1

Next, USBC researchers wanted to see if increasing static weight to three ounces in all directions could cause a ball to hook more than a ball with a balance hole located to increase the Differential RG and flare, which results in increased hook.

Again, through the use of special balls with adjustable inserts, different combinations of static weight were tested. The balls had different layouts for this test – a 5" pin to PAP (Positive Axis Point) and a 3-3/8" pin to PAP (leverage drilling).



image 2

Inserts with varying weights allowed researchers to adjust the static weight, though only three static weight adjusters were used to prevent the flaring ball track from rolling over the inserts. The use of inserts allowed for:

- Added positive side weight
- Added top weight
- Added thumb weight

Already understanding negative side weight and bottom weight reduces hook, three positions were selected because of their potential to increase the amount of hook and entry angle. While finger weight might increase hook slightly, using an insert to add finger weight likely would have been rolled over during track flare, which researchers wanted to avoid.

One of the weighted inserts matched the ball material removed. When a balance hole was added, this insert was used to return the ball to the original Differential RG.

Testing was performed on a flat pattern and the two test subjects were 220-plus average bowlers. Adjustable inserts of varying weights were used to allow different static weights in the same ball.

The first test subject was expected to hit the same three-board area at the target and at the down-lane marker, allowing the ball to hook wherever it would. For the second test subject, the three-board area was tightened to one board at the lay-down point and arrows, to ensure the ball was started on the same path to be able to see the difference down lane. The testers also had to roll five good shots in 15 or fewer shots to prevent the lane condition from changing during the test, though some tests did require 20 shots to get five good favorable shots.

The test involved 16 combinations – eight with three ounces of static weight and eight with a balance hole with-in existing static weight limits – for a total of 32 combinations between the two bowlers.

Test One

This test included several different variations. Below are all the combinations with a five-inch pin to PAP that hooked more than the average ball, plus the 0-balance ball which hooked slightly less than average.

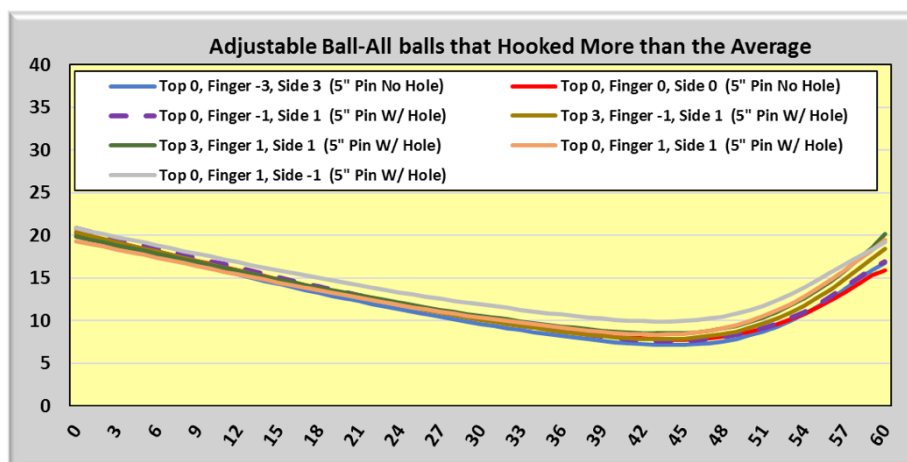


chart 2

There were six balls that hooked more than the average:

- Five had a balance hole and met current static weight specifications

Below are all the combinations with an entry angle greater than the average plus the 0-balance ball, which had less entry angle than the average:

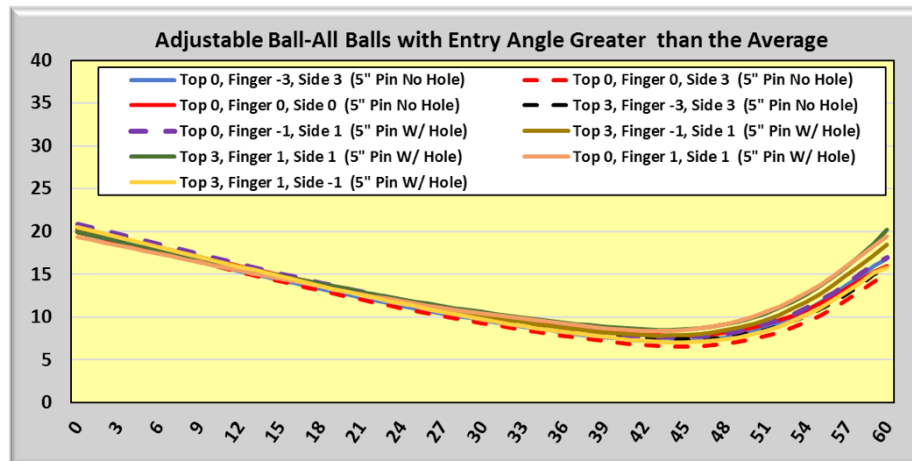


chart 3

There were eight balls with an entry angle greater than the average:

- Three balls had three ounces of side weight with no hole
- 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

Two balls had total angle greater than 8-degrees and both had a balance hole within existing static weight specifications.

Test Two

This test utilized adjustable-weight balls drilled with a leverage drilling (3 3/8" from pin to PAP) layout comparing three ounces of static weight versus the same ball with a balance hole and within existing static weight limits.

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

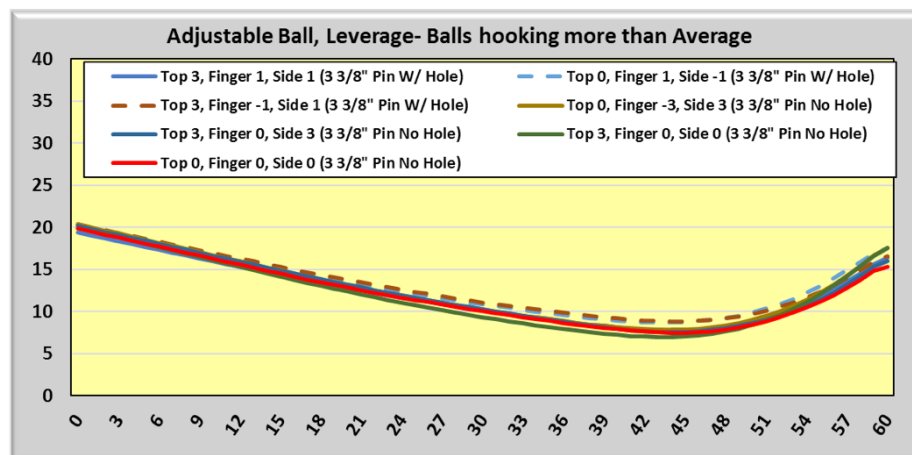


chart 4

There were six balls that hooked more than the average:

- Three balls had a weight hole with existing static weights

- Two balls did not have a weight hole with three ounces of static weight outside of existing specifications
 - o Three ounces of finger weight
 - o Three ounces of positive side weight
- One ball had no weight hole but passed existing specifications
 - o Three ounces of top weight

Most hooking balls:

- Zero ounces top weight, one-ounce finger weight and negative one ounce of side weight with a weight hole – 17.6 boards (legal today)
- Zero ounces top weight, negative three ounces finger weight, and three ounces of side weight with no balance hole – 17.55 boards (not legal today)
- Three ounces top weight, zero-ounces of finger weight, and zero-ounces of side weight with no weight hole – 17.55 boards (legal today)

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

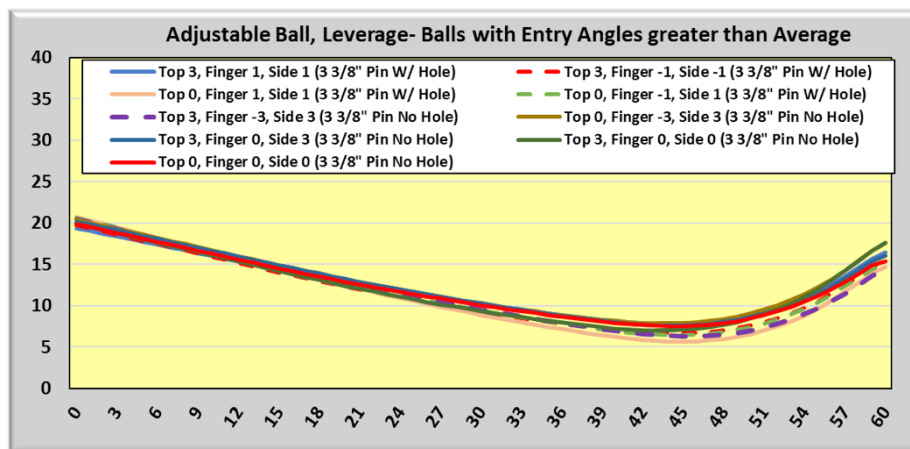


chart 5

Of the 16 balls, there were eight balls with an entry angle greater than the average:

- Four balls with a weight hole, within existing static weights limits
- Three balls with no weight hole and exceeded existing static weight limits
- One ball with no weight hole and within existing static weight limits

The most entry angle balls were:

- Zero ounces top weight, negative three ounces finger weight, and three ounces of side weight without a weight hole – 6.13 degrees (exceeds existing static weight limits)
- Three ounces top weight, zero ounces of finger weight, and zero ounces of side weight without a weight hole – 6.03 degrees (passes existing specifications)
- Zero ounces top weight, one ounce of finger weight, and one ounce of side weight with a weight hole – 5.86 degrees (passes existing specifications)

Test Three

Next, we wanted to compare a 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
- Three ounces of imbalance

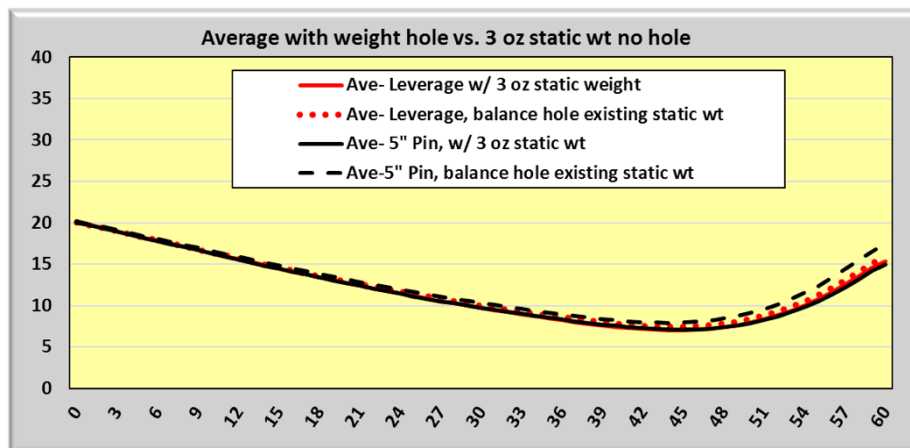


chart 6

Leverage layout with a balance hole with existing static weights hooked about the same as the leverage drilling with no balance hole and three-ounces imbalance. The leverage drilling with a balance hole hooked about one-half inch more than the three-ounce static weight combinations.

The 5" pin layout had a larger different between the combinations with a balance hole and existing static weights versus the three-ounce imbalance combinations.

The balance hole combinations hooked, on average, 2.5 boards more than three-ounce static weight combinations.

Combination Tests

Next, we combined the results of all the balls that hooked more than the average.

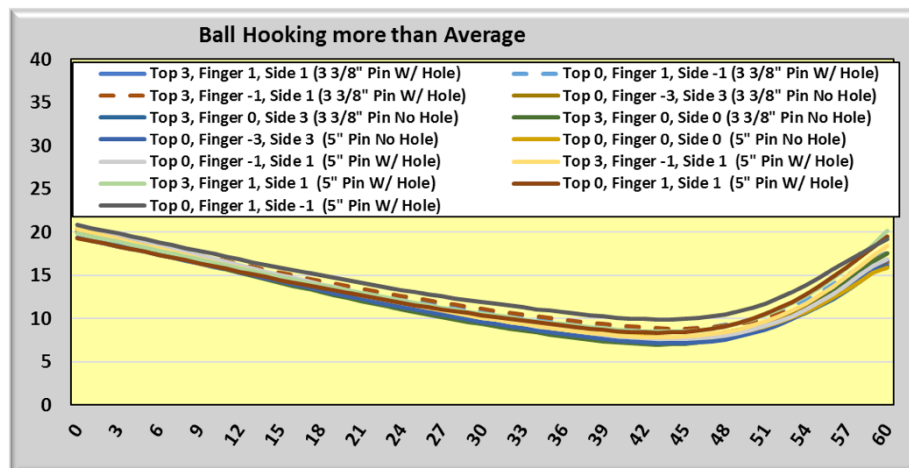


chart 7

Of the 32-ball combination, there were 13 balls that hooked more than the average:

- Eight balls met current imbalance specifications (i.e. had a balance hole to increase flare)
- Two balls met specifications with three ounces of top weight
- Three balls had three ounces imbalance outside of specifications
 - o Two with three ounces of thumb weight
 - o One ball with three ounces of thumb and positive side weight

Most hooking balls:

- Four balls hooked at least to the 18 board or greater
 - o All had 5" pin to PAP

- o All had a weight hole and met current specifications

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

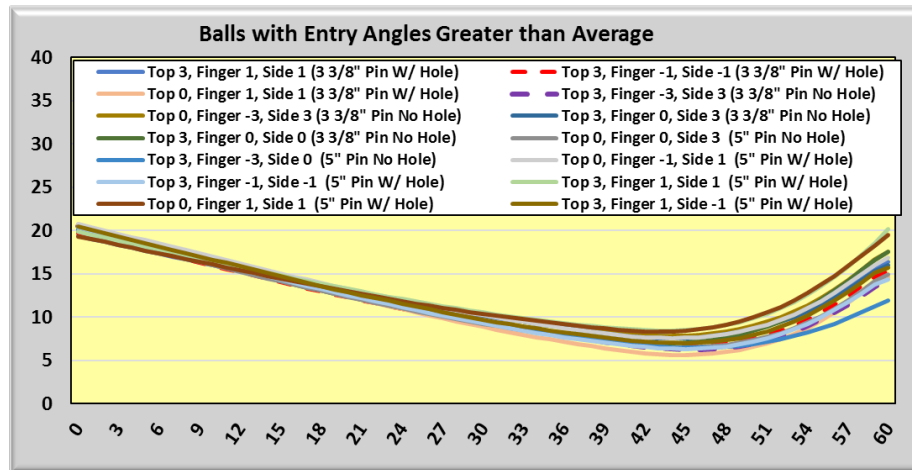


chart 8

Of the 32 balls, there were 14 balls that had an entry angle greater than the average angle:

- Nine balls met current specifications
 - o Eight had a weight hole
 - o One had three ounces of top weight
- Five balls did not meet current specifications (three ounces of imbalance with no weight hole)
 - o Thumb and side
 - o Thumb and top
 - o Thumb, top, and side
 - o Top and side
 - o Side

Four balls had more than six degrees of entry angle with three of these meeting current specifications:

- Meets current specifications with weight hole – 6.83 degrees
- Three-ounce thumb and side weight with no hole – 6.13 degrees (does not meet current specifications)
- Three ounces of top weight, one-ounce finger and side weight with weight hole – 6.11 degrees
- Three ounces of top weight with no hole – 6.03 degrees

Key Takeaways

When looking at static weight versus balance holes, the bowling balls that showed the most hook were those with balance holes. Specifications for static weights remain relevant, though the research showed an increase in static weights does not impact a ball's performance as significantly as the use of a balance hole.

Adding three ounces of static weight in all directions did not allow balls to hook more than bowling balls in the market today that use a balance hole and meet existing static weight specifications.

SECTION II: FIVE-PERSON LEAGUE SIMULATION

Technology's impact in the sport of bowling tends to focus on the bowling ball, as advancements in coverstocks and cores did have a significant impact in the late 1980s and into the 1990s.

Lane technology also has had a major impact as synthetic lanes eliminated the need to resurface lanes each season and lane machines allow centers to more easily strip and apply lane oil daily.

But it's the combination of these technology advancements that changed the way competitors attack the lanes. Today's bowlers use an arsenal of balls with specific surfaces and layouts, so as the lane pattern breaks down they adjust equipment (switch to another ball).

There is no arguing that an understanding of lane transition is an important part of learning how to bowl. But has switching bowling balls to adjust for changing lane conditions taken away from a player's skills, such as adjusting ball speed or hand placement?

When you hear about how lanes transition or how lanes break down, it means the lane oil is being depleted through use or being absorbed by bowling balls designed to do just that. Whether depleted or absorbed, moving/removing oil creates a drier lane surface that creates more hook for a bowling ball since more of the ball's surface contacts the lane.

The Bowling Technology Study showed how oil volume has dramatically increased since the 1980s as centers and tournament operators add more and more oil to slow transitions. Since the 1980s, the oil volume on lanes has tripled.

The USBC Equipment Specifications team put together the elements of recent studies – oil absorption of coverstocks and static weights – to see how different combinations of those elements would affect the lane patterns, specifically looking at oil depletion versus oil absorption.

Like the test that was part of the Ball Technology Study, this exercise followed the same five-person league format to compare slow oil absorption and fast oil absorption bowling balls with a maximum three ounces of imbalance. On one of the test days, the oil for the house lane condition was reduced to 80 percent to determine if less oil could be used with slow oil absorbing balls.

A look at the breakdown of the equipment used:

Slow Oil Absorption Balls

ball	O/A	Ball Static Weights			Ball RG		
	Time	Side	Finger	Top	X	Diff	Int
	0:19:29	2.000	0.500	-0.750	2.475	0.044	0.015
	0:40:29	0.625	-0.750	0.250	2.511	0.039	0.014
	0:19:05	2.000	-0.500	1.000	2.547	0.042	0.025
	0:15:07	1.125	0.250	0.375	2.494	0.040	0.012
	0:16:41	2.125	-0.375	0.125	2.486	0.048	0.014
	0:15:57	2.375	-0.625	-1.375	2.483	0.052	0.017
	0:50:37	2.375	-0.675	0.375	2.502	0.045	0.009
	0:49:19	1.750	-0.750	0.250	2.492	0.038	0.006
	0:17:19	2.875	-0.375	0.250	2.511	0.033	0.008
	0:31:06	1.750	-0.500	0.000	2.534	0.038	0.006
Ave	0:27:31	1.9	-0.38	0.05	2.504	0.042	0.013

table 2

Fast Oil Absorption Balls

ball	O/A	Static Weights with No Wt Hole			RG's Before Wt Hole		
	Time	Side	Finger	Top	X	Diff	Int
	10:58	2.625	0.125	0.625	2.485	0.041	0.015
	6:11	2.625	-0.125	0.000	2.496	0.049	0.018
	4:44	2.000	-0.750	0.625	2.533	0.042	0.021
	6:37	2.500	-0.250	0.500	2.516	0.034	0.008
	4:13	2.500	-0.875	0.250	2.517	0.043	0.020
	4:13	2.875	-1.500	-0.250	2.518	0.043	0.017
	5:43	2.500	0.375	0.500	2.511	0.047	0.016
	5:18	2.625	-1.000	1.000	2.481	0.037	0.003
	7:59	3.000	-0.500	0.750	2.504	0.032	0.007
	9:16	2.375	-0.375	0.375	2.506	0.033	0.005
Ave	6:31:12	2.56	-0.49	0.44	2.507	0.040	0.013

table 3

Once again, 10 bowlers who have averages of 190 and higher were used for the test. Each was told to bowl and make moves as they would normally. For each individual bowler, the ball layout was the same for both the slow oil absorbing balls and fast oil absorbing balls. Some wiped their ball with a dry towel during bowling, others did not.

The results showed the fast oil absorption balls tend to hook the most, required the most moves and depleted oil deeper inside. Those balls also depleted oil a little faster.

Using the SPECTO Data, researchers compared the average of each bowler's first three shots to their final shots to get a measurement of how the bowlers actually moved.

Test	Difference at 0 feet	Difference at 15 feet	Difference at 42 feet	Difference at 59.5 feet
Slow oil absorption, no balance hole	4.95	3.16	0.72	-0.08
Fast oil absorption, no balance hole	7.28	4.36	-0.21	-0.41
Slow oil absorption, no balance hole 80% oil	5.99	4.03	0.93	0.11

table 4

On average, the bowlers moved six boards in with their feet and about four boards left at the arrows. However, they moved an extra board in with their feet during the test with a fast oil absorbing ball with increased static weight. The slow oil absorption balls with increased static weights required the least moves.

Below you can see the oil pattern measured at eight feet:

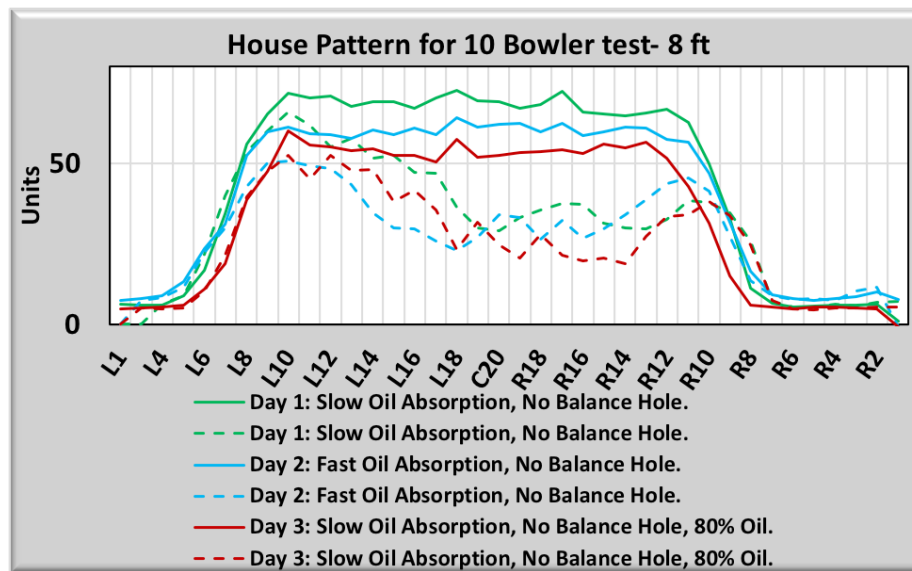


chart 9

- Day 1 - Slow oil absorption with increased static weight depleted the least amount of oil
- Day 2 - Fast oil absorption with increased static weight moved in deepest
- Day 3 – Slow oil absorption with increased static weight on 80% oil was similar to Day 1

The solid lines are before bowling and the dotted lines are after bowling. Notice the blue dotted line and how much oil was depleted further left, thus confirming more oil was depleted. As bowlers must move further left from faster oil absorbing balls, they cover more lane and, therefore, deplete more oil from the lane too.

Key Takeaways

The five-person team simulation test, using balls that absorbed oil at various rates, was designed to see how the varying dynamics of bowling balls affected the oil pattern in a real-world environment.

Was it shocking that bowling balls with coverstocks that absorb oil fast tend to hook the most and require bowlers to play deeper inside? Not really, as all the research has pointed to that result.

Over the course of the study, the tests showed that not only did faster oil absorbing balls require bowlers to move further inside, it also depleted more oil overall since they had to cover more of the lane.

The test did confirm that with slight increases in static weights, bowlers could use those balls in competition and expect minimal impact on ball reaction.