ENGINEERING REPORT

Subject: Comparing Different Weight Balls on House Pattern

Date: 2/26/16

Place: International Training & Research Center

Present: Danny Speranza

Purpose:

Repeat the RG and differential RG ball study varying rotation rate to maintain the same rotational energy for each ball on a house oil pattern. For this test, the balls are comparing the performance from 14- vs. 15- vs. 16-pound balls from the total weight study.

Summary:

This was a repeat of a previous test using different weight balls (14, 15 and 16 pounds):

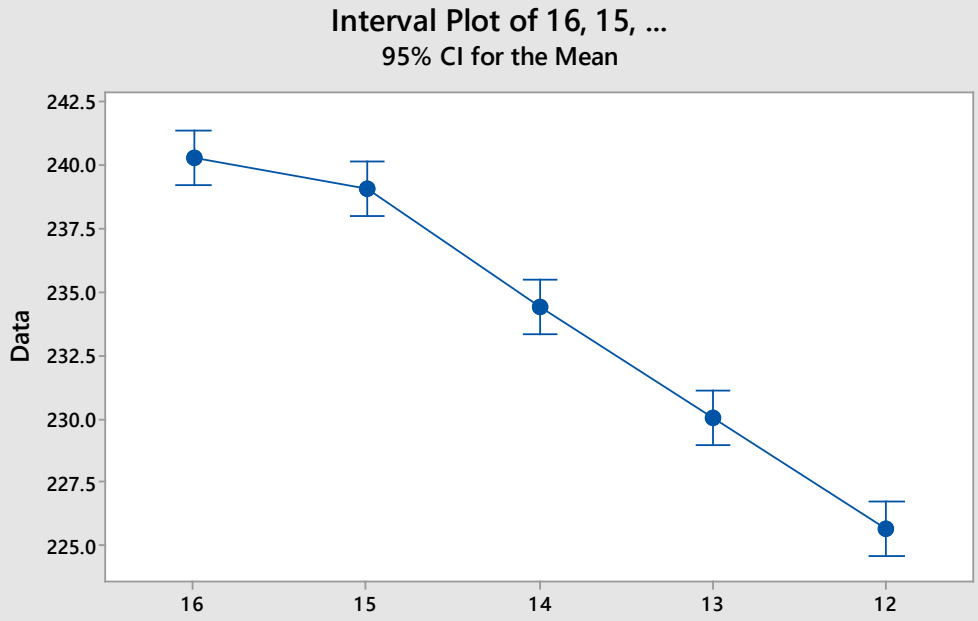
- Vary RPM to match ball moment of inertia
- Test on house condition
- Adjust launch settings to line up to hit pocket with all balls

The test was to use the RG, differential RG ball study parameters and compare different weight balls (14 pounds vs. 15 pounds vs. 16 pounds). All ball paths were adjusted to hit the pocket. The lighter balls have less moment of inertia and therefore were thrown with 7 RPM more for each pound change in weight. The results show the 14-pound ball hooked the most and 16lb. hooked the least, but this resulted in starting deeper inside with the 14-pound ball and resulted in a similar entry angle for the 14- and 15-pound balls, while the 16-pound ball had about a ½ degree less entry angle.

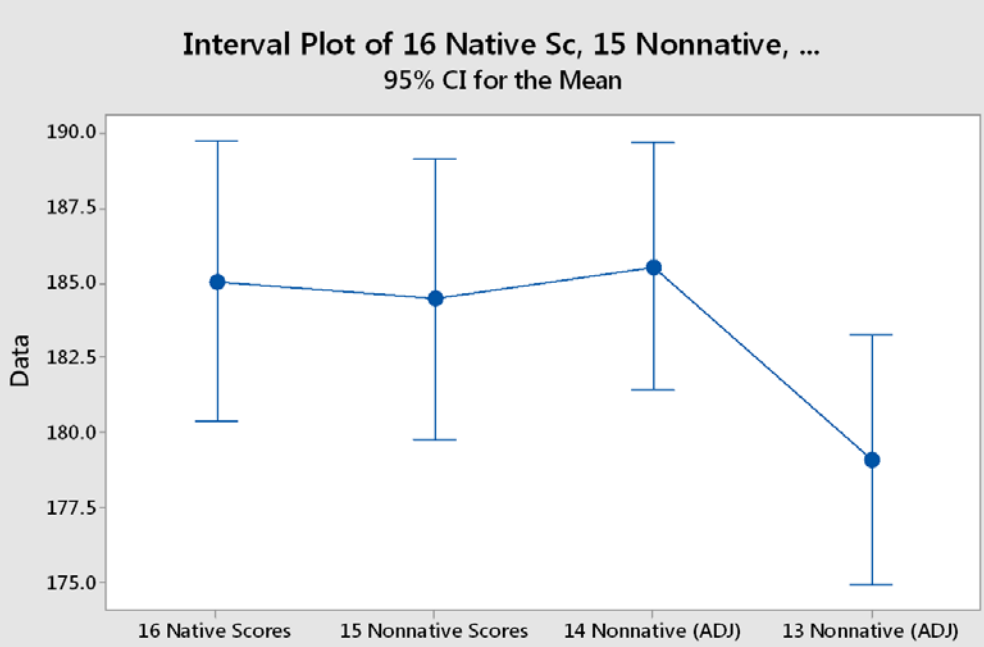
Data:

Test parameters

This test was to try to combine the RG and differential RG Study and the “Total Weight” study. Studies in the past using Bowlscore indicated that varying the total ball weight should reduce the size of the strike pocket, resulting in scoring differences. Below is an Interval Plot Chart showing a calculated score vs. ball weight based on results from Bowlscore testing, where a ball is rolled down a ramp at different entry angles and offsets to develop a strike profile.



But, during a "Total Weight" study where bowlers threw their normal ball weight plus a test ball which was one-pound lighter, they scored the same for 14- through 16-pound balls (see below).



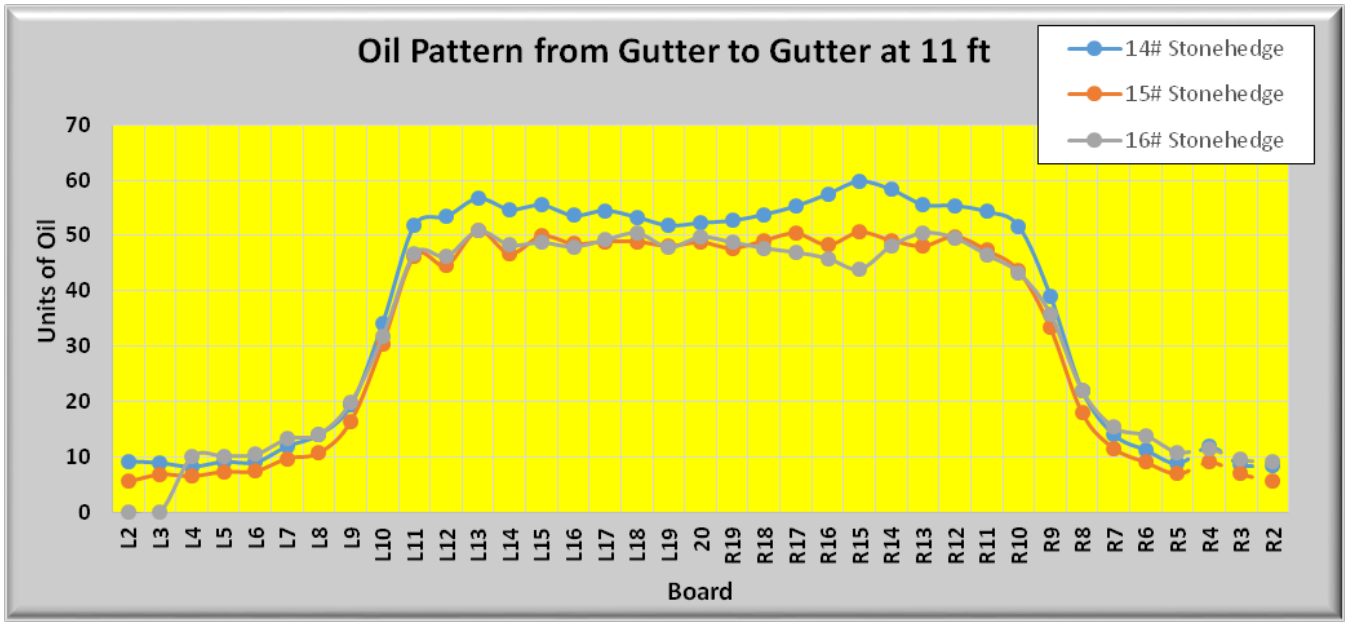
During this test, we threw the same 14-, 15- and 16-pound balls that were used in the total weight test and used the RG, differential RG ball study test parameters. The balls were measured for RG, moment of inertia, and then the ball rotation (RPM rate) was adjusted to maintain the same rotational energy for all three weights.

Ball	wt.	Rg min	RG max	RG @PAP	MOI	RPM
14#	14.19	2.542	2.590	2.566	93.4320	292
15#	15.25	2.514	2.566	2.540	98.3869	285
16#	16.10	2.524	2.568	2.546	104.3620	277

Notice that the RG value @ the PAP for all ball weights is about the same. However, due to the weight difference, the moment of inertia varies due to the relationship between the RG and moment of inertia $I = m(RG)^2$.

This results in approximately 7 RPM difference as the weight changes in one-pound increments. Therefore, during this test, the RPM values in the above chart are used for each ball weight.

The oil pattern is a house condition (the Kegel Stonehenge pattern was used in the Kegel lane machine).



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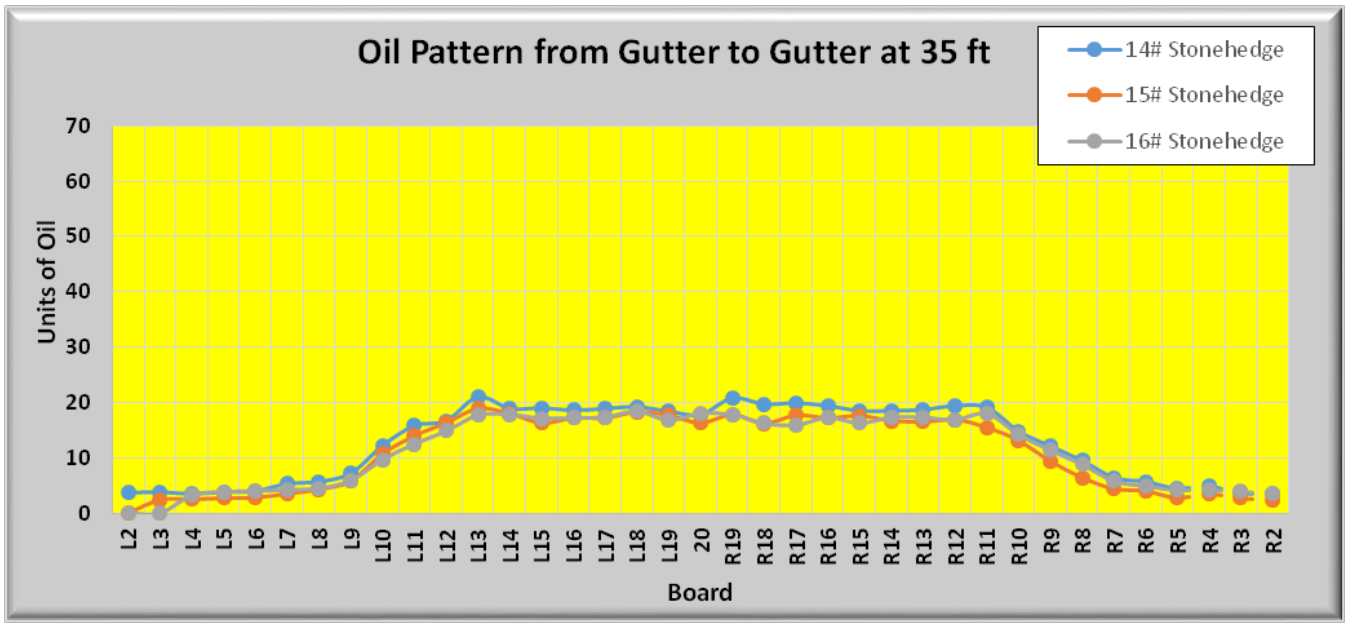
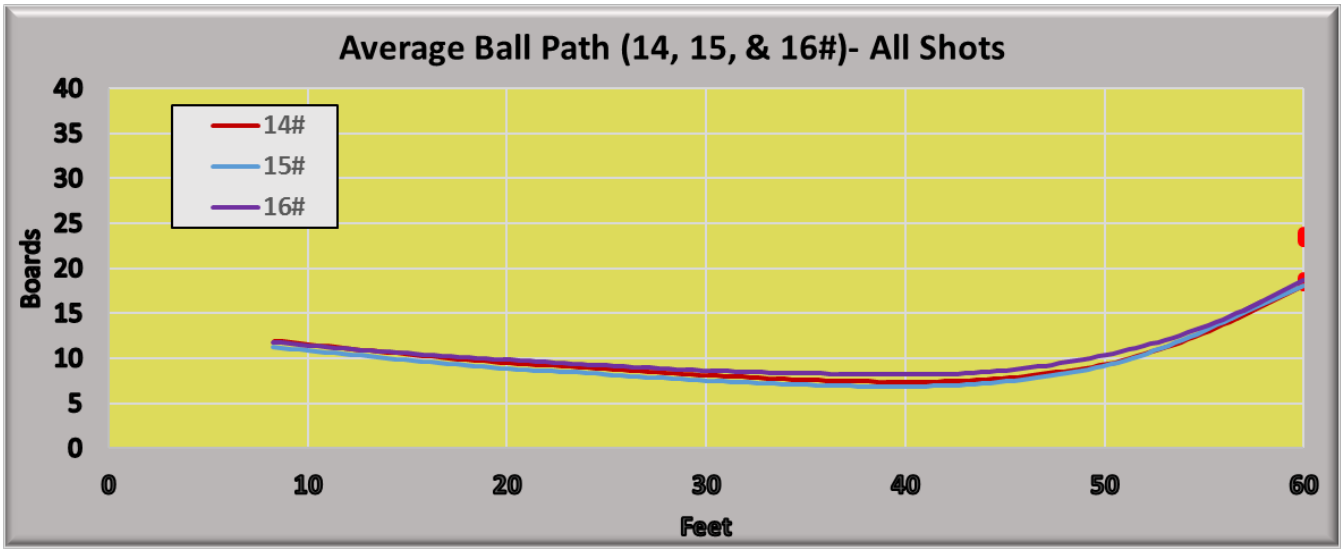


The heavy oil is from 10 to 10 and has a taper from 7 to 10 to approximately 3-4 units on the outside boards at the end of the pattern. All three test balls were started from the 13 or 14 board at the foul line and hit the 8 board at the end of the oil pattern. So they all started their ball path in the heavy oil (inside 10 board) and targeted the lighter oil at the end of the pattern.

The ball path for all weights were adjusted to hit around the 8 board at 41 feet down lane and hit the pocket.



The 14-pound ball hooked the most and the 16-pound ball hooked the least, even though it is harder to see from the ball paths in the above chart. When the ball hooked high in the pocket, the launch conditions were adjusted by ½ board move inside at the foul line and increased the launch angle by -0.1 degrees. This adjustment kept the ball in the pocket throughout the test.

The three test balls had the following initial launch conditions:

- 14 pounds - lay down board 14 and -1.10-degree launch angle
- 15 pounds - lay down board 13 and -0.65-degree launch angle
- 16 pounds - lay down board 13 and -0.75-degree launch angle

BOLTS was used to collect the ball path data for every shot. The results are summarized below.

The following parameters were used for all tests:

- Velocity - 18 MPH
- Axis rotation angle - 60 degrees
- Axis tilt - 13 degrees
- Rotation rate - varied based on MOI of ball
- Pin was positioned 3.375" from PAP
- PAP located 5" over from center of grip- Earl PAP setting was manipulated to achieve approximately 5" over PAP

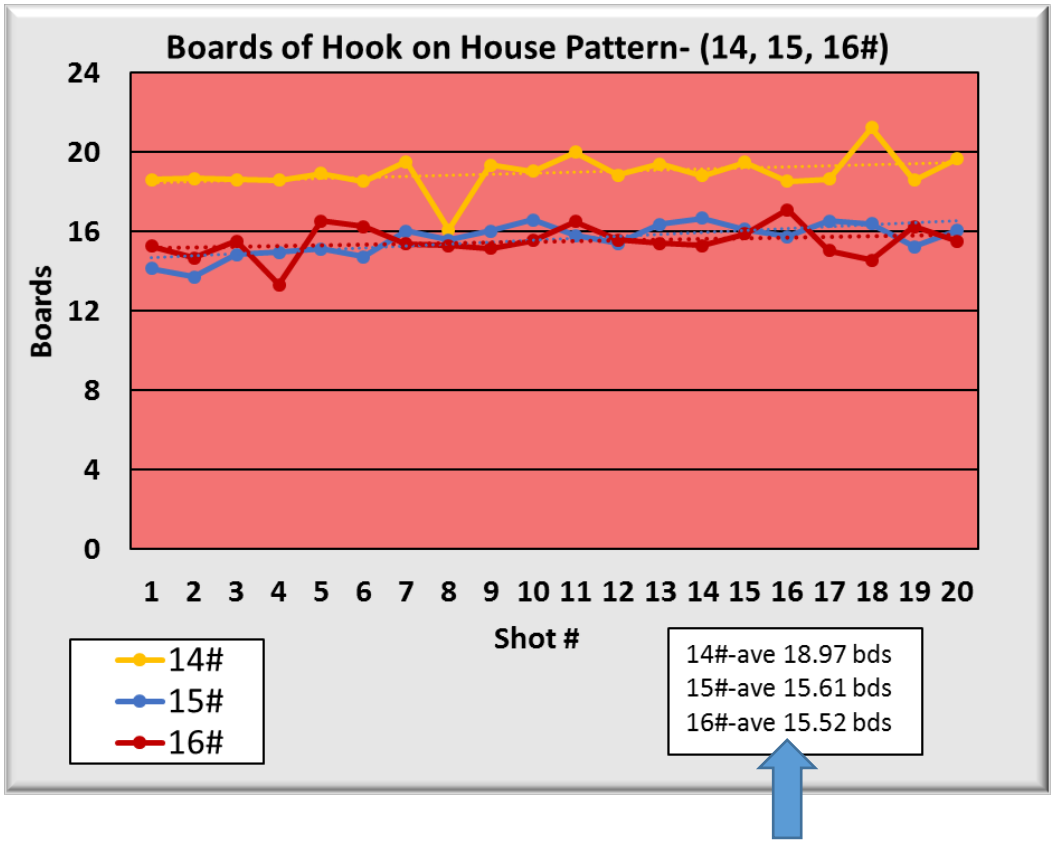
Test results

The following test parameters were monitored:

- Boards of hook
- Entry angle
- Break point

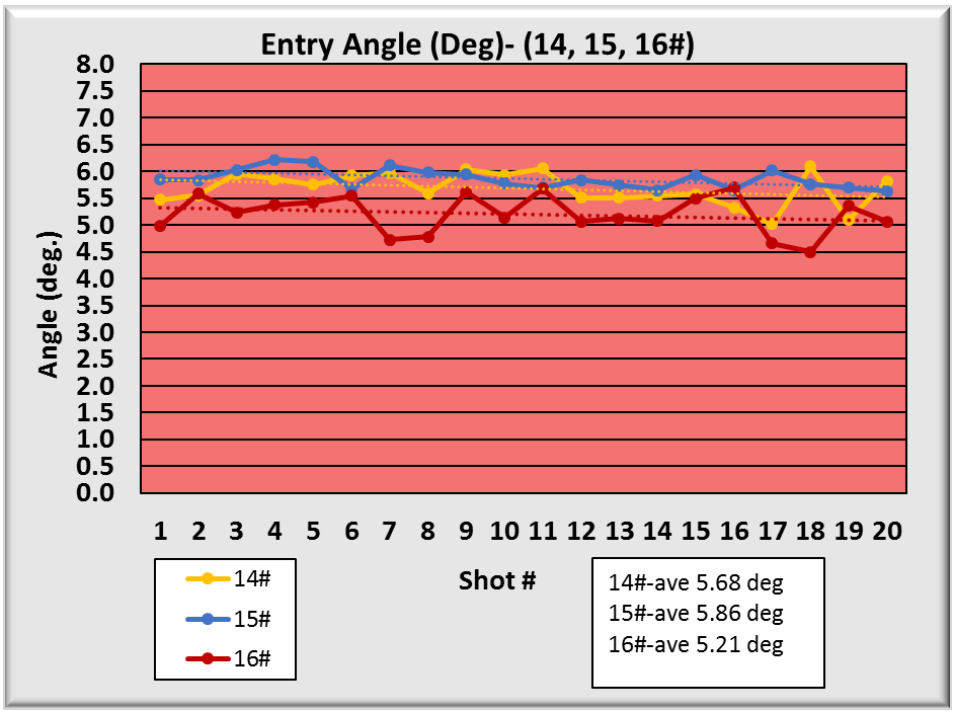
Boards of hook:

Below are charts for the boards of hook.

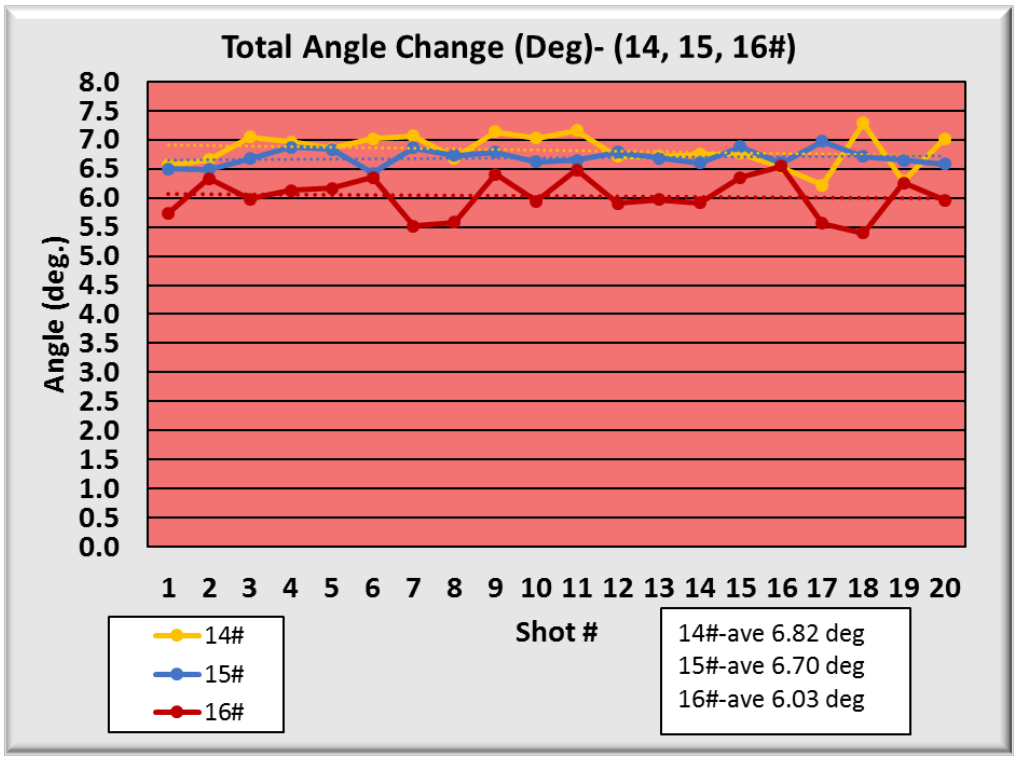


Also, in the text box on the above charts, are the average boards of hook for all 20 shots with each test ball (see blue arrow). The 14-pound ball hooked about three more boards while the 15- and 16-pound balls hooked about the same amount.

Entry Angle and Total Angle:

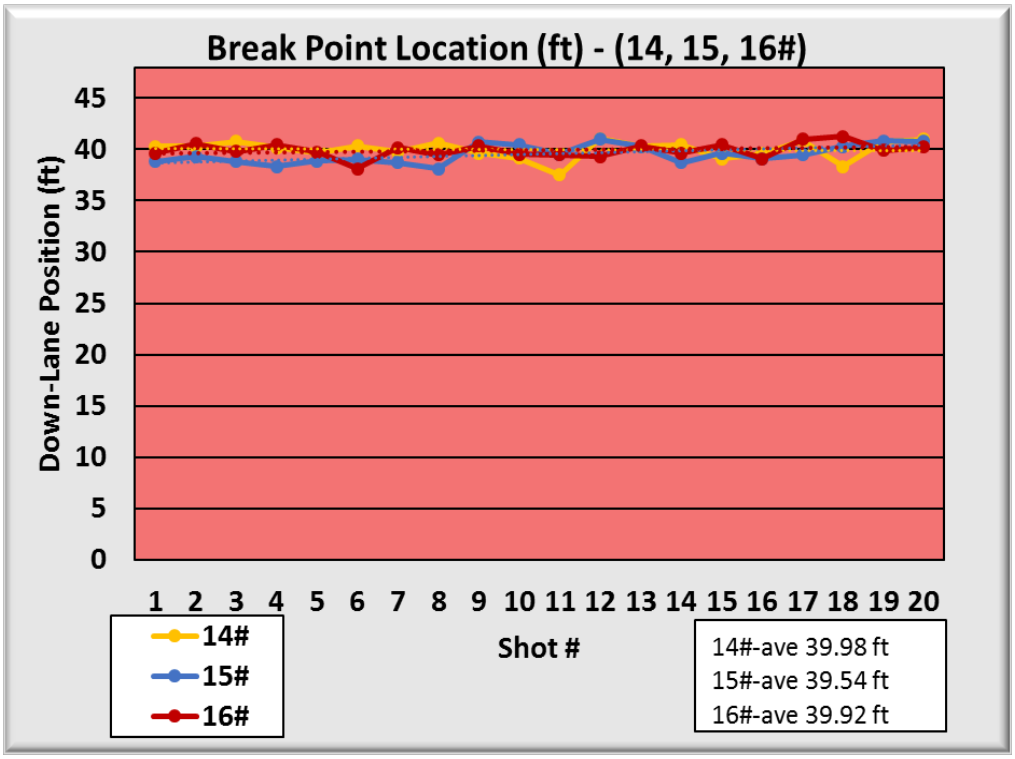


The 14- and 15-pound balls had about ½ degree more entry angle than the 16-pound ball.



The 14-pound ball had more launch angle, which resulted in having slightly more total angle than the 15-pound ball. The 16-pound ball still had about ¾ degree less total angle than the 14- and 15-pound balls.

Break point Location:



The break point is the location where the ball path is closest to the gutter. All ball paths were adjusted to hit the pocket and targeted approximately the 8 board at the end of the oil. With those launch conditions, the break points were all within 0.4 feet of each other (5 inches).

Bowlscore Test

Based on the results from this test, a Bowlscore test was conducted with these same 14-, 15- and 16-pound balls and used the entry angles from this test:

Ball Weight	Entry angle
16	5.21
15	5.86
14	5.68

Results:

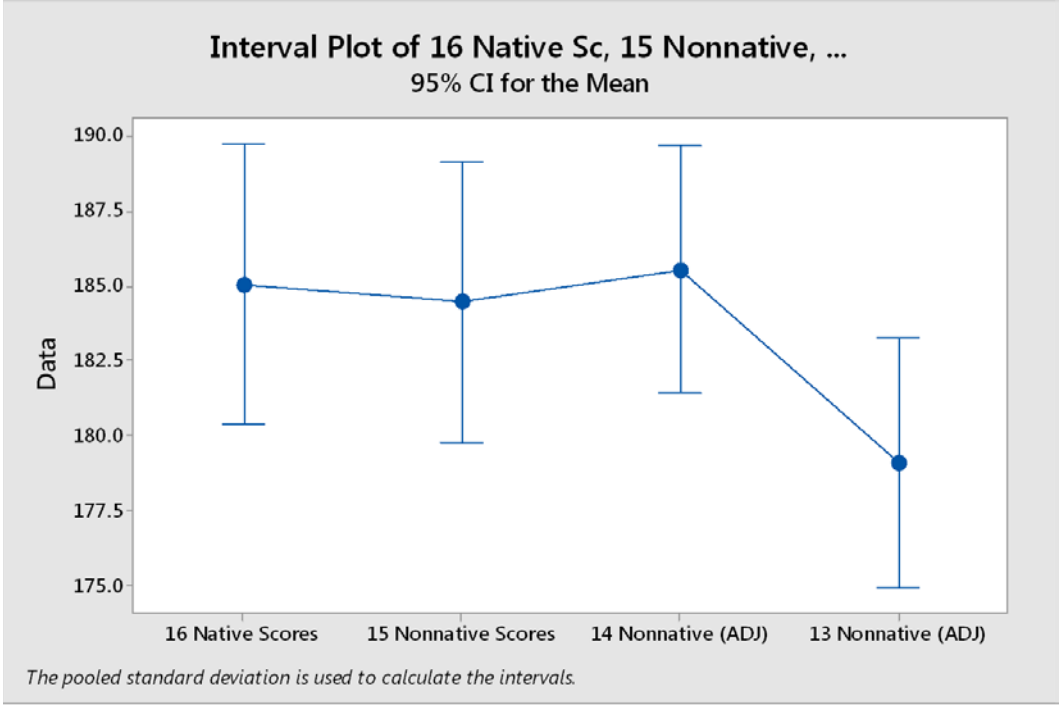
Test Parameters	Sum of Calc. Score	% Strikes	% 10	% Splits
16 lbs. @ 5.21 deg. Entry Angle	213.4	60.0%	5.4%	7.8%
15 lbs. @ 5.86 deg. Entry Angle	210.7	58.0%	6.1%	8.9%
14 lbs. @ 5.68 deg. Entry Angle	212.9	56.1%	6.5%	5.4%
Total Average	**212.4**	**58.0%**	**6.0%**	**7.4%**

While the 14-pound ball had the lowest strike percentage, that was offset in the scoring calculation by also having the lowest split percent.

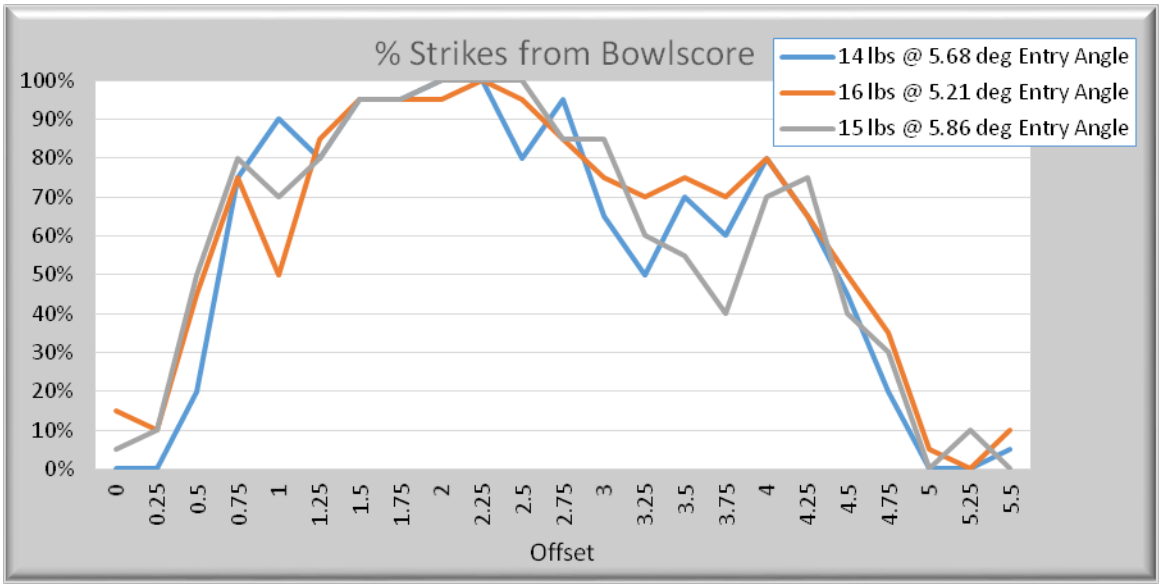
The calculated scoring equation was developed from tracking a league:

Score = (*9.8* strikes) +(1.8*spares) -(9*opens) +155.9

For the calculated score equation, it was assumed that splits are opens; and if it is not a strike or a split, then it is a spare. The calculated scores match well with the bowler field test results where 14- and 16-pound balls both scored slightly higher than the 15-pound ball (see below):



Graphs from Bowlscore are below:



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