

ENGINEERING REPORT

Subject: Simulate league with E.A.R.L. on House Pattern

Date: 2/26/16

Place: International Training & Research Center

Present: Danny Speranza

Purpose:

Run RG and differential RG study using a combination of high and low RG with high and low differential RG balls to simulate three games of bowling with five bowlers each using one of the five ball combinations and varying rotation rates to maintain the same rotational energy for each ball on a house oil pattern.

Summary:

This test was a repeat of previous tests, except using five ball combinations at the same time to simulate a five-person team bowling three games of league format:

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

Five balls used in test:

- High RG, high differential RG with 278 RPM
- High RG, low differential RG with 278 RPM
- Low RG, low differential RG with 297 RPM
- Low RG, high differential RG with 297 RPM
- Med RG, med differential RG with 287 RPM

This test was to use the RG and Differential RG Ball Study parameters and compare the RG and differential RG ball combinations over a test simulating three games of a five-person team. With more shots on the house condition, the ball track dries up more, and the goal was to determine if some ball combination can take advantage of the oil depletion better than other combinations. All ball paths were adjusted to hit the pocket. The low RG balls have less moment of inertia and, therefore, were thrown with more RPM. The results showed the following order from most boards of hook to least and the same order for most total angle change to least:

- Med RG, med differential RG ball
- Low RG, high differential RG ball
- High RG, high differential RG ball
- Low RG, low differential RG ball
- High RG, low differential RG ball

Data:

Test parameters

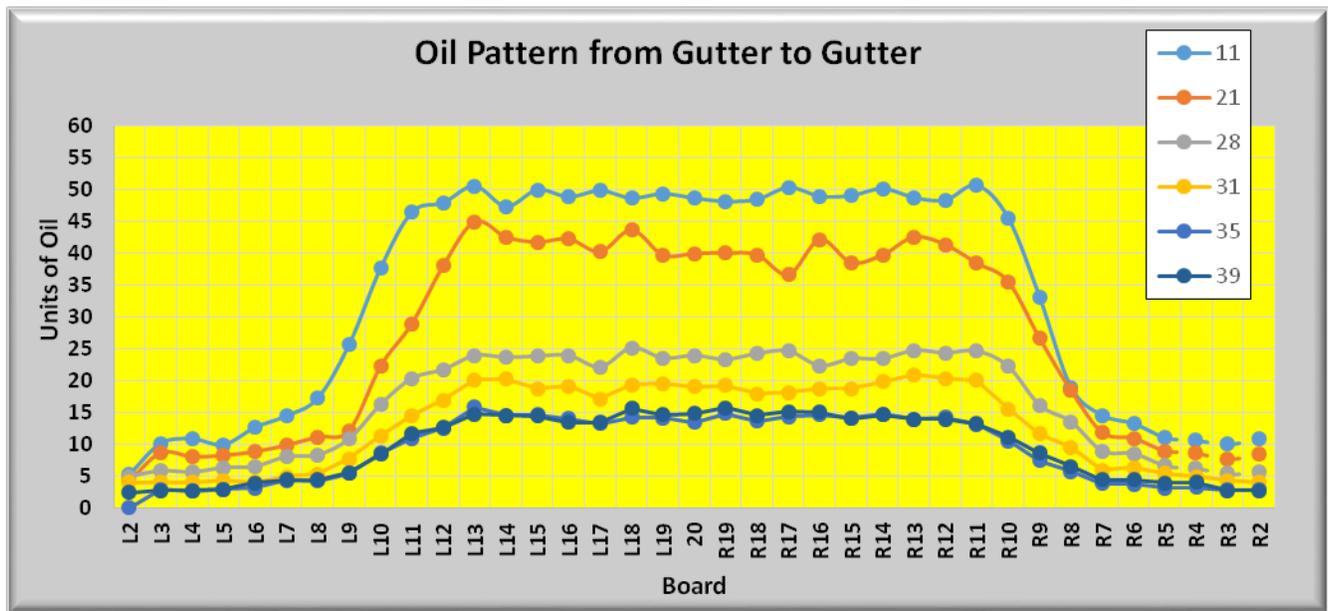
This test was to investigate the affects from drying up the ball track from more shots, which happens during a normal five-person league setting. Each ball was thrown as if it was a different bowler on a five-person team over the course of three games (30 shots per ball). The ball properties and initial launch conditions are listed in the table below:

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Test	Rg	RG	RG @	MOI @	calc	initial			
Ball #	Ball	wt	min	max	PAP	PAP	RPM	initial bd	angle
1	2.509_-.006	15.94	2.503	2.509	2.51	100.1	282	9.5	-0.4
2	2.48_.060	15.9	2.478	2.540	2.51	100.1	282	13	-0.6
	2.57_.030	15.8			0.00	105.6	275		
3	2.592_.031	15.9	2.592	2.623	2.61	108.1	272	13	-0.6
4	2.68_.057	15.8	2.676	2.733	2.70	115.6	263	13	-0.5
5	2.71_.001	15.7	2.712	2.713	2.71	115.5	263	8	-0.2

During the test, if a ball hooked high, the launch conditions were adjusted by moving inward .5 boards and increase the launch angle by -0.1 degrees. This worked well to keep all balls hitting about the same location at the end of the of oil (8-10 board at about 40 feet) and hitting around the strike pocket.

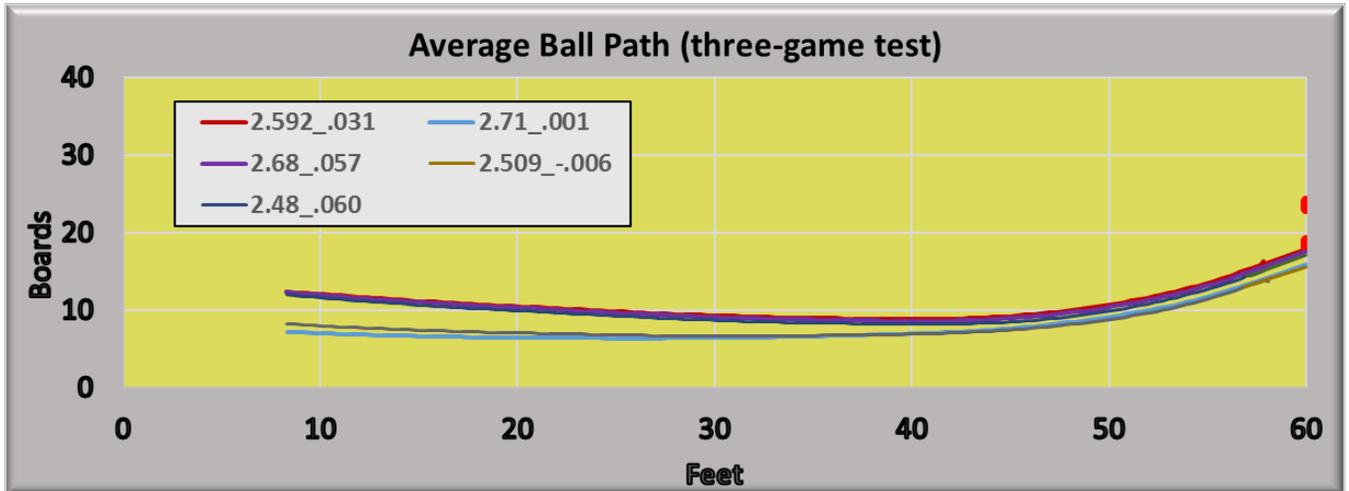
The oil pattern was a house condition from Kegel called Stonehenge and was oiled by a Kegel lane machine.



The heavy oil is from 10 to 10 and has a taper from 7 to 10 board to approximately 3-4 units on the outside boards at the end of the pattern.

The ball path for each test ball was adjusted to hit around the 8 board at 41 feet down lane and hit the pocket. Below are the average ball paths for each test ball.

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As the test went along, the two low differential RG balls started to hit light in the pocket, probably due to carrydown. That is why, in the above chart, the average ball paths were further outside for the two low differential RG balls. The ball path was not adjusted outward when this happened. But, when a ball hooked high, the launch conditions were adjusted with the same movement for all balls inward to continue to hit the pocket (moved $\frac{1}{2}$ board in at the foul line and increased launch angle - 0.1 degrees to throw further out). This adjustment kept the ball in the pocket throughout the test.

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 Moment of Inertia (MOI) of ball
- Pin was positioned 3.375" from PAP
- PAP located 5" over from center of grip - E.A.R.L. PAP setting was manipulated to achieve approximately 5" over PAP

Test results

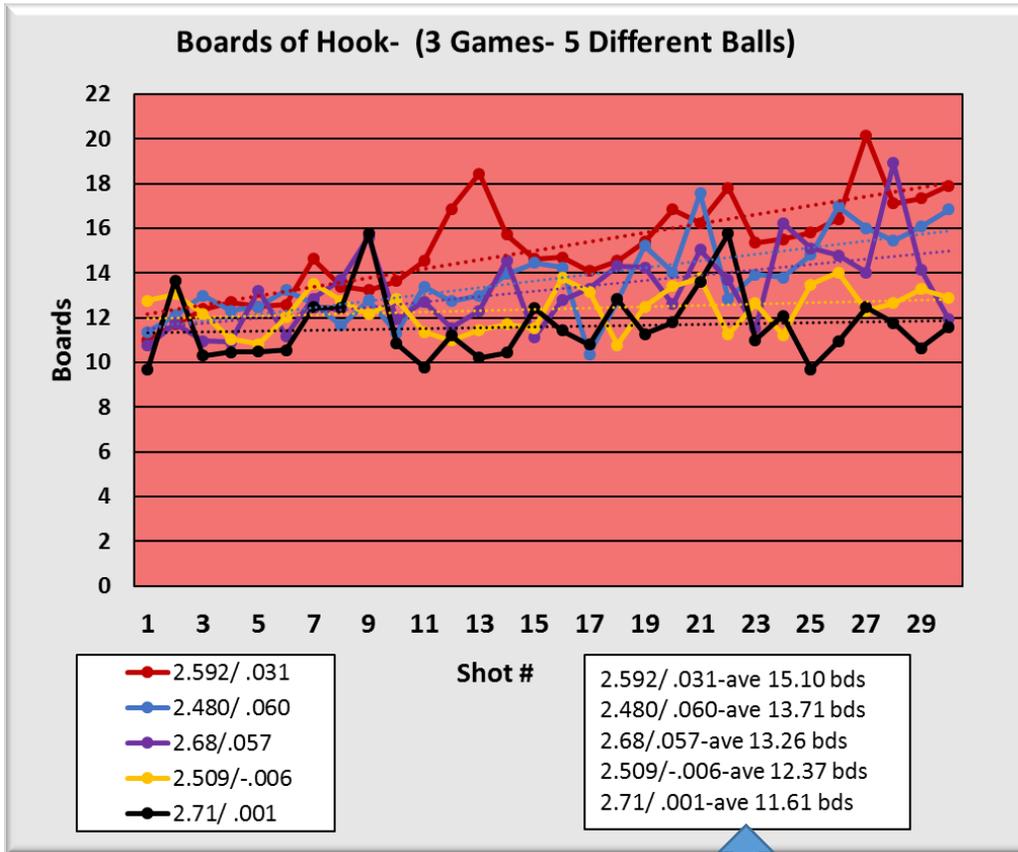
The following test parameters were monitored:

- Boards of hook
- Entry angle
- Break point

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Boards of hook:

Below is the chart for the boards of hook during three games using five different balls.



Also, in the text box on the above charts, are the average boards of hook for all 30 shots for each test ball (see blue arrow). The medium RG, medium differential RG ball (2.59 / .031) had the most boards of hook with 15.10, followed by the low RG, high differential RG ball (2.48 / .060) with 13.71 boards of hook, and then the high RG, high differential RG ball with 13.26 boards of hook. The least hooking balls were the two, low differential (non-flaring) balls with 12.37 and 11.61 boards of hook.

In the above chart, it can be seen that the separation in the boards of hook between the five different balls was much tighter together at the beginning and spread apart towards the end of the test. The balls that did not flare hooked about the same for all 30 shots. The flaring balls (either .030 or .060 differential RG) hooked more and more as the ball path dried up. The chart below shows the difference in boards of hook for different sections of the test.

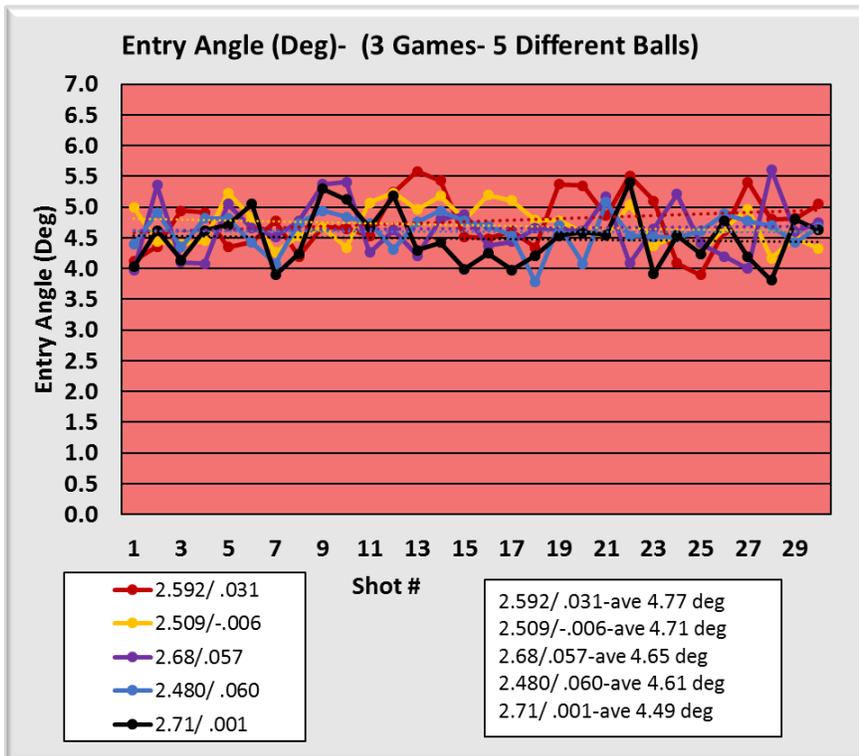
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Ball	Property	Ave for		Ave for		Ave for		Ave for		# of moves to keep hitting pocket
		shots 1-10	shots 11-20	shots 21-30	shots last 5	Shots all	Shots			
2.592/ .031	boards hooked	12.8	15.6	17.0	17.8	15.1			6	
2.480/ .060	boards hooked	12.3	13.4	15.4	16.3	13.7			4	
2.68/.057	boards hooked	12.3	13.0	14.5	14.8	13.3			5	
2.509/-.006	boards hooked	12.3	12.1	12.8	13.0	12.4			1	
2.71/ .001	boards hooked	11.7	11.2	12.0	11.5	11.6			2	
	Max difference	1.1	4.4	5.0	6.3	3.5				

For the first 10 shots, all five balls hooked within 1.1 board of each other. But, at the end of the 150-shot test (30 shots per ball), the difference was 6.3 boards for the last five shots between the most hooking ball and the least hooking ball. The non-flaring balls hooked approximately the same number of boards throughout the entire test. The flaring balls hooked more as the test went along and the ball track dried up. This required the larger differential RG balls to move more to keep hitting the pocket.

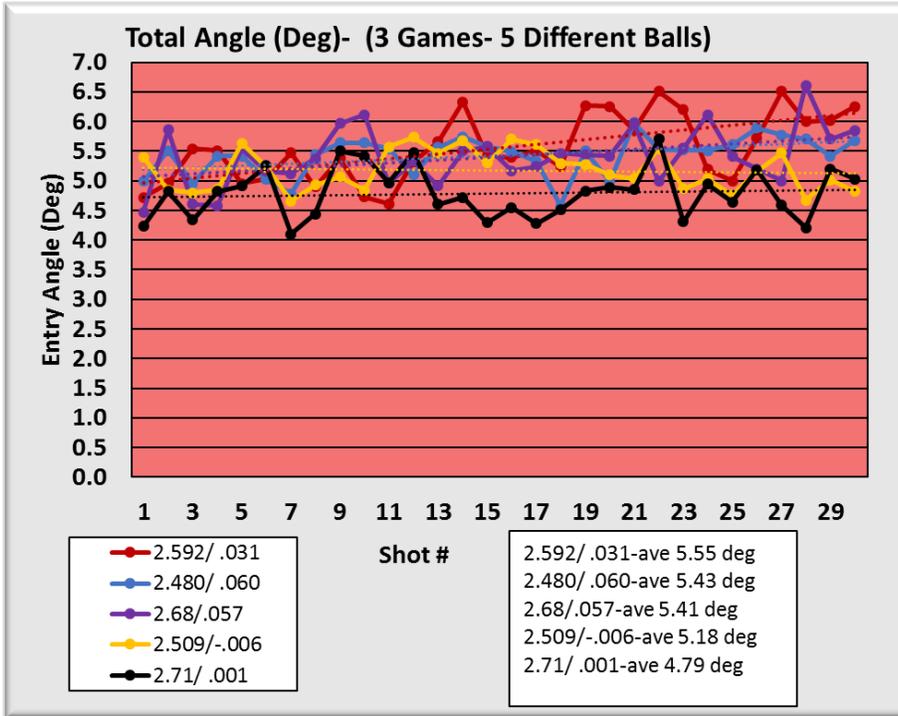
Conclusion: Flaring balls take more advantage of the dried-up ball track, resulting in added hook which requires more adjustments to hit the pocket.

Entry Angle and Total Angle during three games using five different balls:



The entry angle for all test balls were similar. While the non-flaring, low differential balls hooked less, its launch conditions were straighter, resulting in approximately the same entry angle.

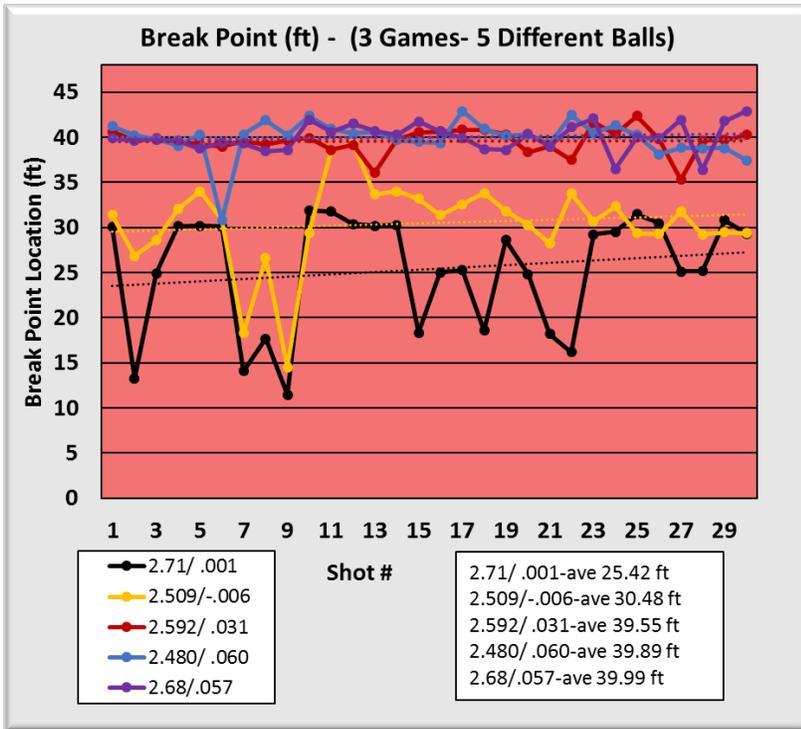
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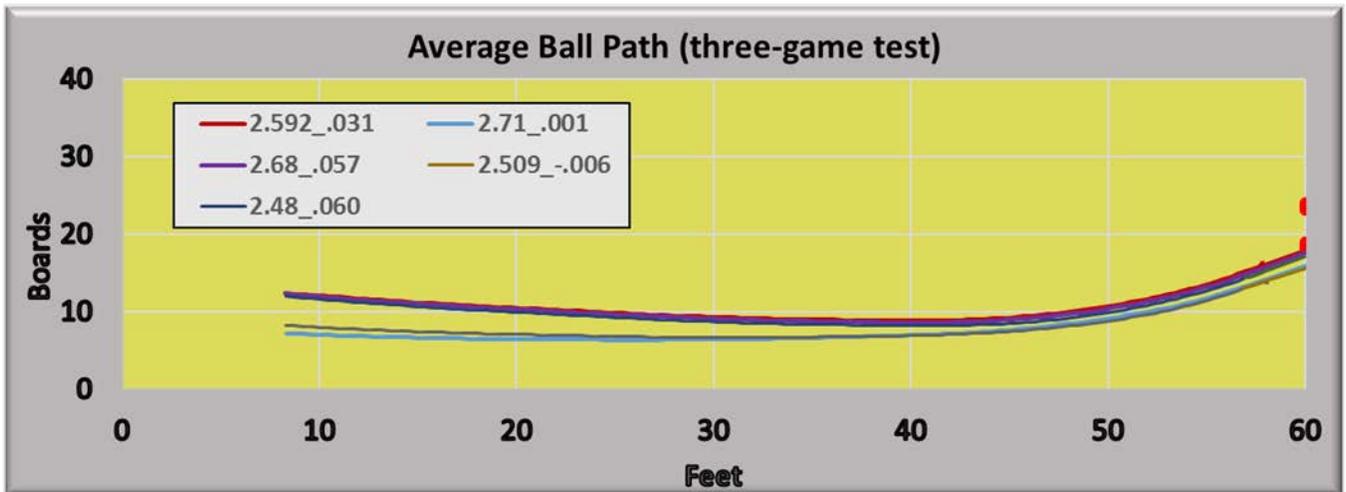
The total angle change shows more difference between test balls because it adds the launch angle to the entry angle. All the medium differential RG and high differential RG balls had more launch angle, which added to the total angle. Once again, the medium differential RG and high differential RG balls had about the same total angle (5.41 to 5.55 degrees). The low differential RG ball had reduced total angles due to less launch angles.

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Break point location is below (ball path location closest to the channel):



The break point is the location where the ball path is closest to the channel. All ball paths were adjusted to hit the pocket and targeted approximately the eight board at the end of the oil pattern.



From the average ball bath chart above, it is easy to see how the low differential RG balls had a straighter ball path at the start, resulting in a break point that was much closer to the foul line. The three flaring balls has approximately the same break point (0.4 feet, or 5-inch difference).