Sport Bowling

By Neil Stremmel

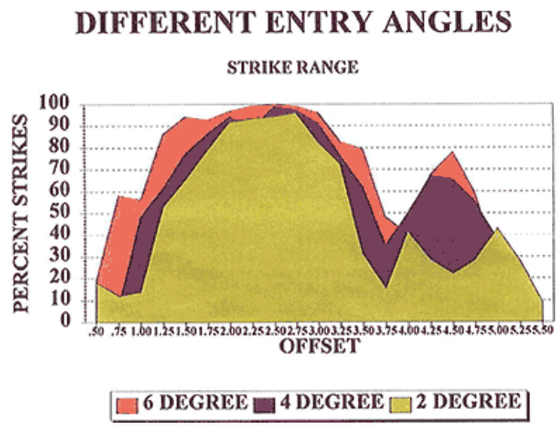
Entry Angle, Part 1

It's crucial to raising strike percentage and average

I keep a pad of paper and a pen near my bed. I do this for two reasons: to write things down in the middle of the night so I don't forget them in the morning, and more importantly, so I can purge these thoughts from my memory and get to sleep. I've learned that if I don't do this I can't stop thinking about it, but if I jot down the ideas, I feel confident that I've captured their essence and I can forget about them.

Of course, there have been times when I couldn't read my own writing in the morning, so this gives me something else to worry about when I should be sleeping. Anyway, the other night at about 3 a.m., a thought occurred to me and I had to write it down. It involved the equation of a line drawn 6 degrees back from the pins up the lane.

Before I discuss the details of this equation, however, I want to address why this is important. This is the first article in a series about the importance of entry angles in bowling. The angle at which a bowling ball enters the strike pocket plays an enormous role in strike percentage, pin carry and, therefore in a bowler's average.

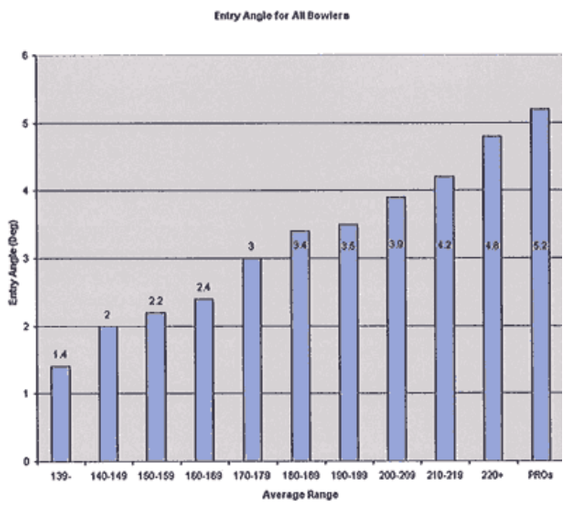


You may have read that the USBC is taking a close look at bowling's credibility relating to scoring. The USBC Sport Bowling program is one important aspect of that research. The significant technological improvements of bowling balls, lane oils, lane conditioners and lane machines over the last 20 years have played a key role in increasing the average amount of entry angle bowlers regularly can achieve.

The two charts - developed through testing and research by the USBC Equipment Specifications and Certification Department - illustrate why bowlers are continuously working to increase their entry angle through release (revolutions, axis rotation and ball speed) and bowling balls.

Figure 1 shows the influence entry angle plays in pin carry. The left side of the graph shows strike percentage. Across the bottom shows offset (distance from the center of the ball to the center of the headpin). The three colors reflect the degrees of entry angle.

For example, green represents 2 degrees, purple 4 degrees and red 6 degrees. Notice how much wider the red section (6 degrees) is at 90 percent strikes versus the green section (2 degrees) and even the purple section (4 degrees).



This shows what we all know; the pocket is "bigger" at a higher entry angle.

Figure 2 illustrates that as bowlers increase their degree of entry angle, they increase their average. There are other factors that determine your final average, but this chart makes it quite clear that if your entry angle goes up, so does your average.

The information provided in these two graphs clearly reflects the importance of increased entry angle when trying to increase your average. A 6-degree entry angle seems like a small amount, but it has a tremendous impact on scoring. Additionally, it doesn't take a large increase to move up the chart; a change from 4 to 5 degrees is a big jump.

The next segment of this series will address how to use this line that I've drawn in my head, how to use it to play long and short oil patterns for optimum entry angle, how USBC Sport Bowling lane conditions impact entry angle and most importantly, how all of this will make you a smarter and better bowler.

Sport Bowling

By Neil Stremmel

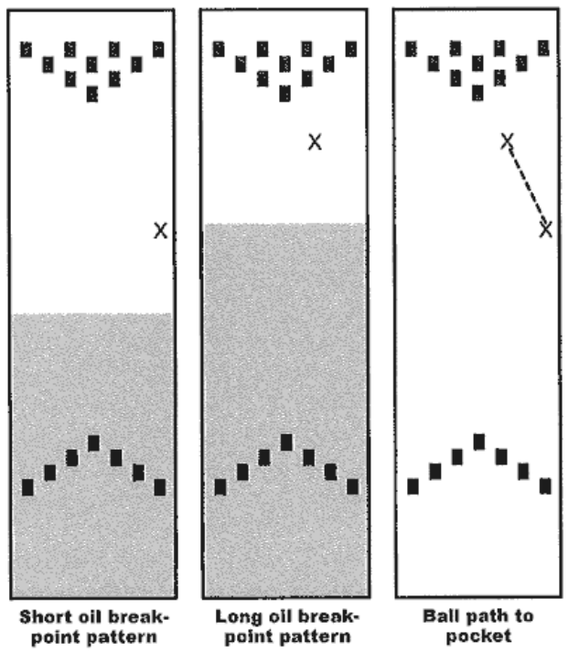
Entry Angle, Part 2

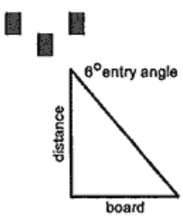
Figuring out your optimum entry angle; start with the right equation

In the last issue, I discussed the importance of entry angle and how USBC testing has shown that six degrees is the optimum angle of entry into the strike pocket.

We looked at two charts, one showing six degrees versus four and two degrees and the other showing that higher average bowlers typically have greater entry angles. The charts also showed that the increase in just one degree of entry angle, while seemingly immaterial, has a significant impact on scoring and your overall average.

All this talk stemmed from a math equation that I was thinking about as I lay in bed in the middle of the night. The equation was based on a conversation I had with USBC Coaching Certification manager Cary Pon. Illustrations from the USBC Coaching Silver level certification manual shown here relate to playing short and long oil patterns. Many people don't realize that typically it is best to play a short pattern further right (for a righthander) and a long pattern further left, toward the pocket. The reason this can be difficult to understand is that on a short pattern, bowlers see the ball hook and believe they must move deeper.





The X's represent where your breakpoint should be to best play the patterns. If you connect these two Xs - as in the third diagram in Figure 1 - you should have a line that goes to the pocket. As USBC Specification and Certification research has noted, the optimum entry angle for a strike ball is six degrees and the perfect strike occurs when the center of the ball is at the 17.5 board when it hits the pocket side of the headpin (at that same six-degree angle).

My 3 a.m. thought was that an equation exists based on this line drawn at six degrees from the 17.5 board back toward the bowler (see Figure 2).

The line that connects the two X's is the basis for the equation. A triangle can be formed (as shown) to help us derive the equation.

Theoretically, this is the line you want your ball to roll on from its breakpoint all the way into the pocket. We must realize, however, that the ball won't roll straight into th epocket from the breakpoint. We will look a the real world aspects of this line (arc) and the ball's actual entry angle into the pocket in an uplcoming article. For now, let's focus on this line and its associated "bowling equation." So, from the above line, we can now draw a triangle and then derive the following equation:

tan(angle) = (opposite / adjacent) => tan(entry / angle) = (board / distance)

This equation needs work. It must be changed into user-friendly, common sense bowling terms. Let's look at it one section / term at a time.

"Tangent" (Tan) of the entry angle needs no adjustment. You might want to look up the background of this equation in a geometry book. Additionally, you will ned a scientific calculator to perform the calculation. One can be found online, for example, at http://www.creativearts.com/scientificcalculator/. "Board" is a board on the lane. But as the triangle is drawn, it would be the board (in inches) to the right of the 17.5 board (where the perfect strike occurs), not the actual board on the lane as we typically refer to it. This should be adjusted. "Distance" also is accurate, but it is the distance (in feet) from the headpin back to the breakpoint, not the breakpoint distance as we all know it. This also should be adjusted.

In an effort to adjust the above enginnering-type equation into bowling-type terminology to make sure we obtain information from the equation that makes sense, we need to change it to the following:

tan(entry angle) = ((17.5 - board) / ((80 - pattern length) * 12))

or

Entry Angle = Tan^{-1} * ((17.5 - board) / ((80 - pattern length) * 12))

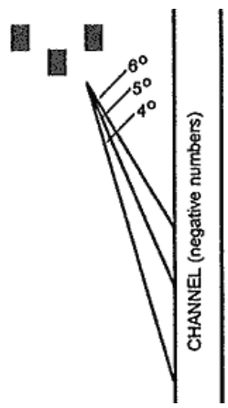
Okay, now let's look at this equation more closely. "Entry Angle" is the ball's angle into the pocket as we have discussed before. "Board" is now the board on the lane as we normally refer to it (where the ball comes off the end of the oil pattern as it enters its roll phase). "Pattern Length" is the distance the lane is oiled. Tangent and inverse tangent (Tan^{-1}) are geometric terms and require a scientific calculator to compute. "Pattern Length" values and "Board" values are a good place to start for creating this triangle, but ultimately we will need to look at actual break point values.

For now, assumptions will need to be made. In an upcoming article, we will look at typical skid length past the end of the pattern to the breakpoint. We also will discuss how skid length is dependent on speed, revolutions and coverstocks and how this equation is most accurate on USBC Sport Bowling-type patterns.

Now that we have an equation, let's use our scientific calculator to plug in some numbers and see what we get:

17.5

Pattern Distance / Entry Angle	6"	5"	4"
60 Feet	17.5	17.5	
59	16.2	16.5	16.7
58	15.0	15.4	15.8
57	13.7	14.4	15.0
56	12.5	13.3	14.1
55	11.2	12.3	13.3
54	9.9	11.2	12.5
53	8.7	10.2	11.6
52	7.4	9.1	10.8
51	6.1	8.1	9.9
50	4.9	7.0	9.1
49	3.6	6.0	8.3
48	2.4	4.9	7.4
47	1.1	3.9	6.6
46	-0.2	2.8	5.8
45	-1.4	1.8	4.9
44	-2.7	0.7	4.1
43	-3.9	-0.3	3.2
42	-5.2	-1.4	2.4
41	-6.5	-2.4	1.6
40	-7.7	-3.5	0.7
39	-9.0	-4.5	-0.1
38	-10.2	-5.6	-1.0
37	-11.5	-6.6	-1.8
36	-12.8	-7.7	-2.6
35	-14.0	-8.7	-3.5



This chart shows board positions of each "Line" (refer to Figure 3) at a given pattern distance and entry angle.

First, we must realize that the negative numbers mean the line is off the lane and into the channel (See Figure 4).

This is a graphical representation of the chart in Figure 3. Now that we can see where the lines are, the next objective is to figure out how to get our ball on that line and into the pocket. Another advantage of the chart is that it can help us determine what our entry angle is based on and where our breakpoint is (based on a known oil pattern length).

The third and final article of this series will tie this information together to help you become a better bowler. We will do that by using these lines as a starting point and determine the arcing path a ball takes as it rolls into the pocket. Using Computerized Aided Tracking System (CATS) data, we will look at the "offset" different types of bowlers have while trying to get to six (or four) degrees of entry angle.

Finally, we should be able to develop a chart that will show you where you want the ball to be at its breakpoint based on the length of the pattern. How you get there and what angle you can achieve will be up to you.

Sport Bowling

By Neil Stremmel

Entry Angle, Part 3

USBC research shows where your ball should be to achieve the best angle

The first two articles of this three-part series included a discussion of how United States Bowling Congress testing has shown that six degrees is the optimum angle of entry into the strike pocket. In the previous article, we discussed the equation of a line drawn from the pocket back toward the bowler at two, four and six degrees. Finally, we concluded that we must know how far a ball will push past the end of an oil pattern to determine how to get our ball on one of these lines into the pocket and how noting where the ball comes out of the oil can be crucial to telling us what entry angle we have.

Research completed on USBC Sport Bowlling patterns

During the past month, the USBC Specifications and Certification team (mainly research engineers Bob Roloff and Rory Holland and senior technician Jim Jaryszak) have been conducting research in the eight-lane testing facility in Greendale, Wisconsin to determine the average skid length, or "push", pas the end of the oil pattern to the breakpoint. I was confident that if we used a USBC Sport Bowling pattern in our research, the push would be contingent on speed and rev rate, but wondered which would be more dominant.

Since we didn't want the balls to see friction early - as can happen on a typical house shot - the test was performed on Sport Bowling lane conditions. We used two Sport patterns with the same amount of oil side to side but buffed out to distances of 37 and 41 feet. A group of 14 test bowlers with a wide range of ball speeds and rev rates provided the data by bowling on these patterns in our research center. Using the Computer Aided Tracking System (CATS), we could distinctly observe that shots rolled by our test bowlers pushed past the end of the pattern and further down the lane (in the oil) on the longer pattern, so I am confident we met our objective.

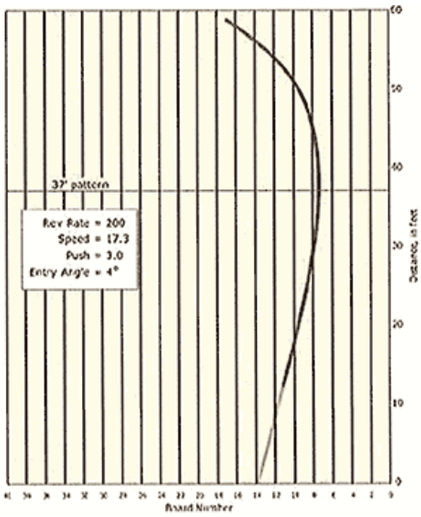
Data shows rev rate more important than ball speed

Let's start with a look at the data. In Figure 1, we see a summary of the results of this test.

Since I thought that speed would be the dominant factor in the amount of push past the oil line, the results were a little surprising to me. But once I thought about the fact that most higher average bowlers throw the ball from about 17 to a bit less than 19 miles per hour (a relatively tight range), it is clear that rev rate has a much larger variance among higher average bowlers (200-500 rpm).

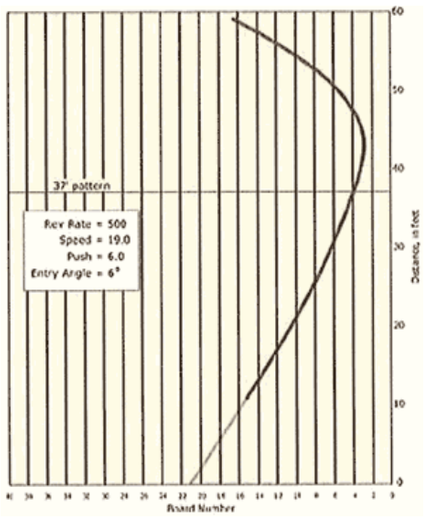
Rev Rate	MPH	Push (in feet)
170-200	16.9	2.3
200-250	17.7	2.7
250-300	18.1	5.4
300-350	18.0	7.7
350-400	18.4	6.3
400-500	18.7	5.9

Research data of test bowlers showing average speed and rev rate as associated with the "push" past the end of a USBC Sport Bowling oil pattern.



This graphic shows the ball path of a test bowler with a lower rev rate (about 180) and slower ball speed (17 mph). This bowler was playing a typical "down-and-in" line where the ball crosses the second arrow and has a breakpoint at about 40 feet.

Another potential discovery (that I'll think about during another sleepless night) is that a ball thrown with 350 rpm at about 18 miles per hour appears to be the optimum rev rate. Why? This preliminary research shows that at this rate a bowling ball seems to skid the proper amount to achieve optimum entry angle. As typical with research, more study is needed. Maybe this is why professional bowlers like Robert Smith and Michael Fagan felt like they needed to go to the Sarge Easter grip to cut down on their rev rate. Obviously, this will depend on conditions (lane surface, oil pattern, etc), but more often than not they seem to run out of room while trying to get the ball to push further down the lane.



The next task with this information is to add it to the equation I discussed in the February issue. Let's start by looking at the ball motion plots of two bowlers.

In Figure 2 we see a lower rev, slightly lower speed player trying to get the ball to the pocket. You can see the bowler is playing the typical down-and-in line, hitting the 10 or 11 board at the arrows with a breakpoint at about 40 feet on a 37-foot pattern.

Figure 3 shows that a bowler with a very high rev rate and fairly high speed playing about 13 (further right on a shorter pattern - smart!) with a breakpoint of 43 feet on the same 37-foot pattern.

Pattern Length / Entry Angle	6°	5°	4°
45	14.1	14.4	14.7
44	12.8	13.4	13.9
43	11.6	12.3	13.0
42	10.3	11.3	12.2
41	9.0	10.2	11.4
40	7.8	9.2	10.5
39	6.5	8.1	9.7
38	5.2	7.1	8.8
37	4.0	6.0	8.0
36	2.7	5.0	7.2
35	1.5	3.9	6.3

This chart shows the board at which your ball should come out of the oil to obtain the referenced entry angle. It is based on ball speed of 18.0 mph and a rev rate of 350 rpm, but also is valid for 19.0 mph, 500 rpm and 17.0 mph, 200 rpm.

Note that in the above figures the high rev, higher speed player sent the ball to about the fifth board at 50 feet on the six-degree entry angle line per my chart published in February. This bowler did achieve six degrees. Also note that the lower rev, slower speed player had the ball at about the ninth board at 50 feet on the four-degree entry angle line per my chart. I love it when the real world data backs up the equations derived in the lab!

Charting your course to the pocket

Using the above information and the table from February, I have created the chart shown in Figure 4. This diagram is based on speed and rev rate and shows you where you want the ball to come out of the oil (you'll need to know the pattern length) to achieve a four-, five- or six-degree entry angle.

Be advised that the accuracy of the chart's numbers is highly dependent on the friction on the outer portion of the lane. If you are bowling on a typical house shot, your breakpoint will depend on how quickly you get the ball outside, but on most types of challenging conditions such as Sport, USBC Open, Masters, Queens and most PBA patterns, this will help you learn to achieve the best entry angle.

It will be especially helpful on fresh oil when you are trying to get lined up for maximum area and best carry. Also realize that, based on the pattern, this point/board may not give you the most area or margin for error, just the best entry angle into the pocket. Since most patterns are between 35 and 45 feet long, I have only included this information in the chart. One observation is that the chart shows how challenging it is to achieve a six-degree entry on a short pattern because the ball must be so far outside.

This concludes the three-part series on entry angle. I hope this helps you determine what entry angle you are obtaining, as well as how to get there. Now maybe I can finally get some sleep.

Neil Stremmel is the Technical Director for the USBC in Greedale, Wisconsin. He is a Mechanical Engineer (BSME from Bradley University in Peoria, illinois), an IBPSIA certified technician and a Master Computer Aided Tracking System instructor. Neil previously worked in the nuclear power and aerospace industries. He has served as a local ABC director and is a lifetime bowler who began working in a center at age 13.