A Future FOR THE Sport

# SOP-BALL-31
# Ball-On-Lane CoF

**STANDARD OPERATING PROCEDURES**

24053

# Contents

# PURPOSE

To determine the on-lane friction of a bowling ball.

# MATERIALS

1. Bowling ball to be tested
2. Ball cup
3. Grease pencil
4. Pro-Sect
5. Metal ruler
6. Scribe
7. Ball thrower (EARL Bowling Robot, Air Compressor)
8. Bowling lane (Brunswick ProLane)
9. Lane machine capable of applying Red Square oil pattern (Kegel Flex)
10. Lane conditioner (Kegel Fire)
11. Lane cleaner (Kegel Defense C 4:1)
12. Computer with ball tracking system (Kegel SPECTO)
13. Thesis by Martin David Smalc titled "The Dynamics of the Trajectory of the Bowling Ball" (1980)
14. Dry towel

# EQUIPMENT / SET UP PROCEDURE

**LANE**

1. Run lane machine with Kegel Fire lane conditioner and Kegel Defense-C lane cleaner, set to clean and condition with Kegel Red Square oil pattern, for a minimum of three lanes prior to application of test pattern.

2. Apply test pattern to lane using lane machine with Kegel Fire lane conditioner and Kegel Defense-C lane cleaner, set to clean and condition with Kegel Red Square oil pattern (available in the Kegel Pattern Library). NOTE: Allow 20 minutes between conditioning lane and throwing test samples.

**BALL**

1. Place each test sample ball (previously prepared to 500-Grit Abralon for the approval testing process) in ball cup.

2. Using Pro-Sect and grease pencil, apply 60 X 4 ½ X 30 Dual-Angle Layout to each sample ball.

3. Using metal ruler and scribe, scribe a grip center based on a PAP location of 5" over X 0" up/down.

**EARL**

1. Power up EARL and turn on air compressor. Make sure air flow valve is set to open on the compressor.

2. Set the following release parameters in EARL's control screen:

| Parameter | Setting |
|---|---|
| **P.A.P. Over** | 5.0 |
| **P.A.P. Up** | 0.0 |
| **Speed** | 17 MPH |
| **Trajectory** | -2.2 degrees |
| **RPM** | 400 |
| **Release Height** | 1.0 |
| **Loft** | -2.0 |
| **Axis Rotation** | 50 degrees |
| **Axis Tilt** | 10 degrees |
| **Laydown** | Start at 33, move 0.5 right every 3 shots |
| **Mode** | Right-Handed |

**SPECTO**

1. Open Blue/S and SPECTO.
2. Open a new SPECTO file using these settings (Research Bowling).
3. Name the SPECTO File as "Brand, Ball Name, Serial Number." NOTE: Get the Serial Number off the bowling ball and not the box.

# TESTING PROCEDURE

## TEST SAMPLE FOR COEFFICIANT OF FRICTION

1. Make sure lane is turned on, EARL is powered up and set with release parameters, and SPECTO is set to record.
2. For each shot, place test sample in the EARL ball pedestal, centering crosshairs scribed on the grip center of the test sample with the laser crosshair, with the pin positioned up and toward the foul-line side of the lane.
3. Using the proper EARL settings, throw three shots cleaning the ball between each shot with a microfiber towel.
4. Move the laydown board 0.5 boards to the right and repeat Step 3.
5. After the six test shots are thrown, the testing for that sample ball is complete.
6. Continue Steps 2 through 5 until each test sample has been thrown. Re-oil as needed to allow for each test sample to be tested in a fresh area of the lane condition.

7. Export the Raw Data File to Excel and save in the On-lane friction folder within P:\\Approvals and Certification\Bowling Balls\On-Lane COF.

8. Using the results from SPECTO and the CoF formula based on the 1980 thesis by Martin David Smalc titled "The Dynamics of the Trajectory of the Bowling Ball" (below), calculate the friction values in both the oiled portion of the lane (10' to 40'), and the dry portion of the lane, 41' to 51':

$$\mu = \frac{1}{2g}\frac{(V_{x1}^2 - V_{x2}^2)}{(x_2 - x_1)}\frac{1}{\cos(\alpha)}$$

Where:

g is acceleration due to gravity (32.2 ft/s^2)
$x_1$ is the starting distance of the friction measurement
$x_2$ is the ending distance of the friction measurement
$V_{x1}$ is the speed of the ball at the starting distance of the friction measurement
$V_{x2}$ is the speed of the ball at the ending distance of the friction measurement
Alpha is the angle the velocity of the contact point of the ball makes with the down-lane direction

$\mu$ is the average COF from $X_1$ to $X_2$ on the lane

**Note: The units must be used correctly for the formula to be correct. The recommendation is reporting g in ft per second squared, the distances in feet and the speeds in feet per second.**

***Note: Alpha is assumed in the 1980s thesis to typically be less than 10 degrees for the small angle approximation. Modern releases do not fit that approximation.***

The alpha angle can be calculated with the following formula:

$$\alpha = \arctan\left(\frac{Vsin(L.A.) + wrsin(90 - A.T.)\cos(A.R. + L.A. + 90)}{Vcos(L.A.) - wrsin(90 - A.T.)\sin(A.R. + L.A. + 90)}\right)$$

Where:
L.A. is the launch angle of the ball
A.T. is the axis tilt of the release
A.R. is the axis rotation of the release
V is the launch speed of the ball
W is the release rev rate of the ball
R is the radius of the ball.

**Note: Rev rate must be reported in radians per second, the radius of the ball in feet, the speed of the ball in feet per second, and all angles in degrees for the formula to be correct.**

For E.A.R.L.'s parameters in this document the alpha angle is approximately -38.2 degrees.

9. The COF result for the ball is the average COF of Shots 2 through 6. Shot 1 is omitted due to heightened performance before oil accumulation.

# CALIBRATION

Calibration for this procedure is to follow standard practices for calibrating SPECTO and maintaining the lane machine.

# MONITORING PROCEDURE

Prior to testing, test the lane machine pattern volumes for the test pattern Red Square to ensure proper oil application.