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A comparative study of the four-ball cylinder test, the Jackson cross-cylinder test, and the near cylinder

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Abstract
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TITLE A COMPARATIVE STUDY OF THE FOUR-BALL CYLINDER TEST, THE JACKSON CROSS-CYLINDER TEST, AND THE NEAR CYLINDER.

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Doctor of Optometry

Approved _____

_____

A COMPARATIVE STUDY OF THE FOUR-BALL CYLINDER TEST, THE JACKSON CROSS-CYLINDER TEST, AND THE NEAR CYLINDER TEST.

Submitted to the faculty of the College of Optometry, Pacific University, in partial fulfillment of the requirements for the degree Doctor of Optometry by Raymond L. Adams, Theodore S. Kadet and Dennis M. White.

May 27, 1965

ACKNOWLEDGEMENTS

We would like to acknowledge with gratitude the guidance of Dr. Carol B. Pratt and Dr. William R. Baldwin in the preparation of this paper.

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PURPOSE

The purpose of this paper was to discover if there is a significant difference between the Four-ball cylinder test, the Jackson cross-cylinder test and the Near cylinder test, thus validating the Near cylinder test. One hundred and thirty four eyes were tested, ranging in cylinder power from -.25 to -4.50. Sixty-five eyes had with-the-rule astigmatism, forty-nine had against-the-rule astigmatism and twenty fell in the oblique range.

HISTORICAL AND THEORETICAL BACKGROUND

The Four-ball cylinder test is described by Louis Jaques, O.D. in his book, Fundamental Refraction and Orthoptics.[1] He initially used a target consisting of four squares, however, the four ball or four diamond targets present on the American Optical and Bausch and Lomb projectors are easily adaptable. The test is done under a slight fog. The balls containing the horizontal and vertical lines are used to neutralize power and balls with the oblique lines are used to find the correct axis.

The Jackson cross-cylinder technique is reviewed in Clinical Refraction[2] by Irvin Borish, O.D. It utilizes the subjective determination of equal blackness and distinctness of the target as the cross cylinder is flipped. The cylinder axis is found first, then the power. The test is done through the spherical lens of maximum acuity, usually slightly "in the green" after the Red-green test.

The Near cylinder test, devised by Carol B. Pratt, PhD of Pacific University, is basically a Four-ball cylinder test done at the nearpoint. The testing distance is usually 16", and the fogging lens used is the recovery of the monocular #21 finding. The targets used by Dr. Pratt are illustrated in the appendix.

1. pp. 69-77.

2. pp. 285-288.

TESTING PROCEDURE

20/30 blur (monocularly)

Target: 20/30 horizontal line.
Illumination: 20 ft. candles
Lenses in place: none
Instructions: "When you can no longer read any of the letters in the line, say now."

Increase plus sphere to blur out and record

B & L sunburst test (monocularly)

Target: Sunburst and "T" chart
Illumination: 20 ft. candles
Lenses in place: 20/30 blur sphere
Instructions: "Do any of the lines on the chart stand out as being blacker? Do you see the small pointer at the edge of the circle? Tell me when I have moved the arrow to the blackest line."

With the pointer on the blackest line, roll the "T" chart into place and read off this chart the axis.

"When the two bars of the "T" are of equal darkness, say now."

Record the power and axis of the cylinder.

Red-Green test (monocularly)

Target: 20/40 split horizontal line of letters with red-green background.
Illumination: 3 ft. candles
Lenses in place: 20/30 blur sphere and sunburst test cylinder. If no cylinder found above, add -.50 x 180.
Instructions: "On which side of the chart are the letters more distinct, the red side or the green side?"

If red, reduce sphere toward minus in .25D steps and go to reversal.

Jackson cross-cylinder test (monocularly)

Target: 20/40 letters for .50 cross cylinder
Illumination: 20 ft. candles

Lenses in place: Red-green sphere and sunburst dial cylinder.
Instructions: Chasing the red dot - set axis indicator on axis of sunburst cylinder. Move indicator in direction of red dot with each flip; first 15 degrees, then 10 degrees, etc.

"I shall show you two choices. Tell me which is easier to read, #1 or #2?"

Cylinder power - set red dots on JCC axis. Flip and if red is preferred at cylinder axis, add -.25D cylinder. If white preferred, reduce -.25D cylinder. For every -.50D sphere, add plus .25D sphere. Leave the first red or the equalization power in refractor and record.

Four-ball cylinder test

Target: B & L Four-ball chart
Illumination: 20 ft. candles
Lenses in place: 20/30 blur sphere
Instructions: "Look at the top and bottom balls (lines are vertical and horizontal). Which ball is darkest, the top one or the bottom one?"

Use the rule of 30 to determine the tentative axis.

"Tell me when the other ball is blacker."

Go to reversal from the plus side, then the minus side. This will give a range. Put midpoint in refractor.

"Now look at the balls to the right and left. Which one is darker?"

Rock the axis back and forth to determine the points of reversal. Set axis at midpoint and record axis and power.

Near Cylinder test

Target: Horizontal-vertical cross grid and oblique cross grid
Illumination: 20 ft. candles
Lenses in place: #21 recovery taken monocularly (sphere only)
Instructions: (using horizontal-vertical grid) - "Which lines are darker, those going up and down or those

going across?"

Use the rule of 30 to determine the tentative axis.

"When the other lines are blacker, say now."

Add power to the point of reversal. Next, reduce power to reversal again to get range. Set power at the midpoint.

Put the oblique target in place.

"Which lines are blacker, those going up and to the left or up and to the right?"

Rock axis to the reversal points, giving a range. The axis was set at the midpoint of the range and the power and axis recorded.

ANALYSIS OF STATISTICS

In evaluating our data, we used a method suggested by Dr. Pratt. All cylinder powers were separated into components in the 90-180 meridians and 45-135 meridians using the $\sin^2$ function. The 90-180 and the 45-135 meridians were then each considered separately. Axis 45 degrees OD was made equal in sign to axis 135 degrees OS to make the right and left eyes comparable to each other. This eliminated cylinder axis as a variable.

The calculated powers were then coded with .12D being equal to 1. All powers were rounded off to the nearest .06D.

The table containing our statistical workup will be found in the Appendix.

Table I below gives an analysis of our findings.

Differences between tests	Mean	Standard Deviation	Standard Error of the Mean of Difference
Four ball - JCC (90-180)	.047D	.33D	.030D
Four-ball - JCC (45-135)	.029D	.34D	.031D
JCC - Near (90-180)	.031D	.26D	.024D
JCC - Near (45-135)	.021D	.22D	.020D
Four ball - Near (90-180)	.003D	.33D	.030D
Four ball - Near (45-135)	-.008D	.30D	.027D

From the above statistics, one can conclude the following:

1. Any one of the above tests can be substituted for any other with equal reliability and validity.
2. The variable of distance is not important; the cylinder power and axis do not change significantly with distance.

Our results agree very well with data collected by Dr. Pratt in his practice.

In concluding, the near cylinder test, the Jackson cross-cylinder test and the Four-ball test may be used with equal reliability and validity as a substitute for one another. Clinically, these three tests measure the same variable.

b) Time of day - The time of day varied. Most were done in the early afternoon, but the range was from late morning to late evening.

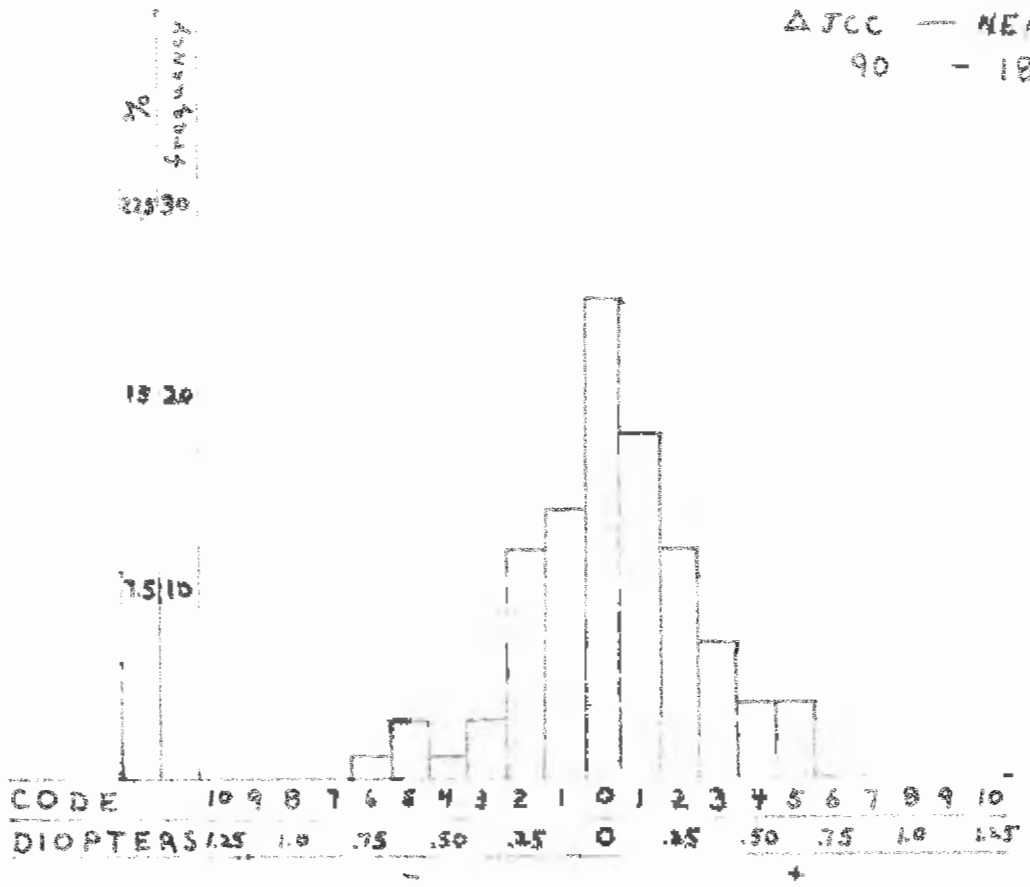
c) Patient pre-set - No recordings were made of the subject's activities immediately prior to testing.

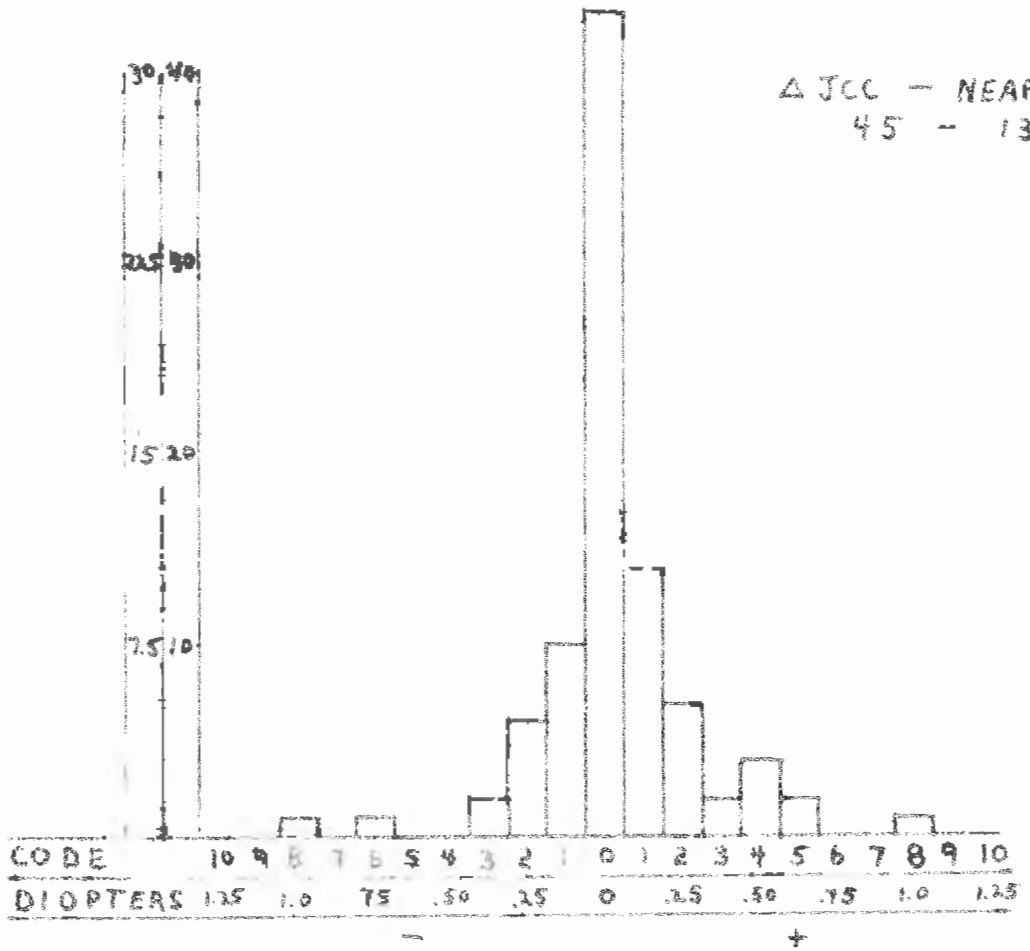
SUMMARY

From the statistical analysis of the findings, the correlation was favorable enough to conclude that any one of the tests could be considered comparable to the others. The clinician performing a Near cylinder test on a patient should find his results equal in magnitude and axis to those found on the Jackson cross-cylinder test or Four-ball test. The validity of the Near cylinder test has been shown.

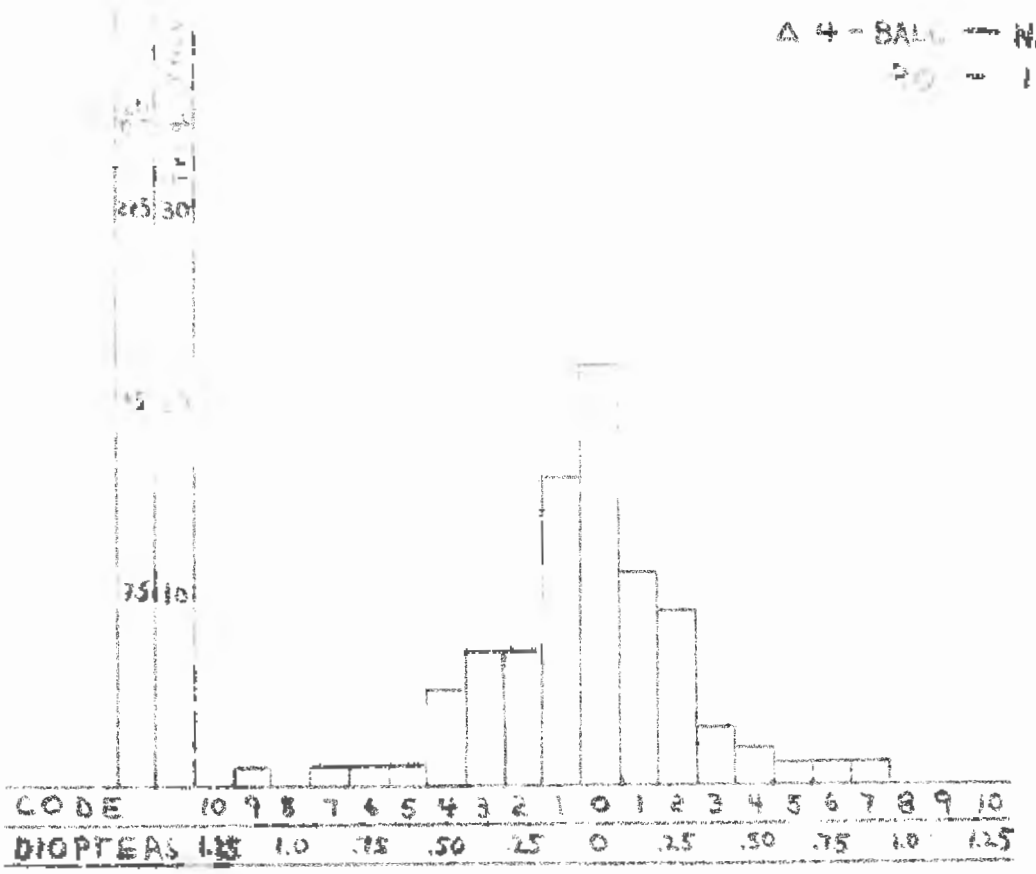
Further study in this area might consist of keeping the power constant for a given subject and measuring the change in axis from far to near. laboratory methods, such as photography, would have to be used as the grossness of clinical tests make changes of a small magnitude difficult to detect.

APPENDIX

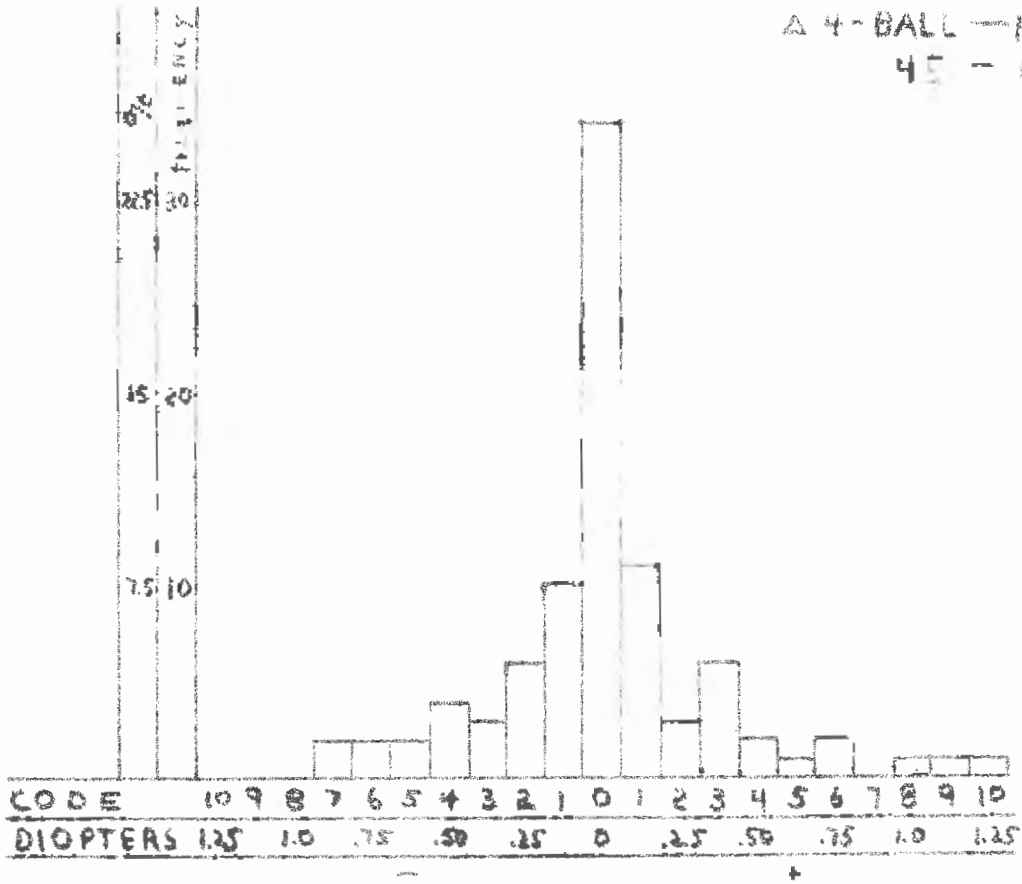

Δ JCC — NEAR CYL
90 - 180
% frequency
22.5 30
15 20
7.5 10
CODE 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10
DIOPTERS 1.25 1.0 .75 .50 .25 0 .25 .50 .75 1.0 1.25
− +


Δ JCC — NEAR CYL
45 - 135
30 37.5
22.5 30
15 20
7.5 10
CODE 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10
DIOPTERS 1.25 1.0 .75 .50 .25 0 .25 .50 .75 1.0 1.25
− +

Δ 4 - BALL — NEAR CYL
90 - 180

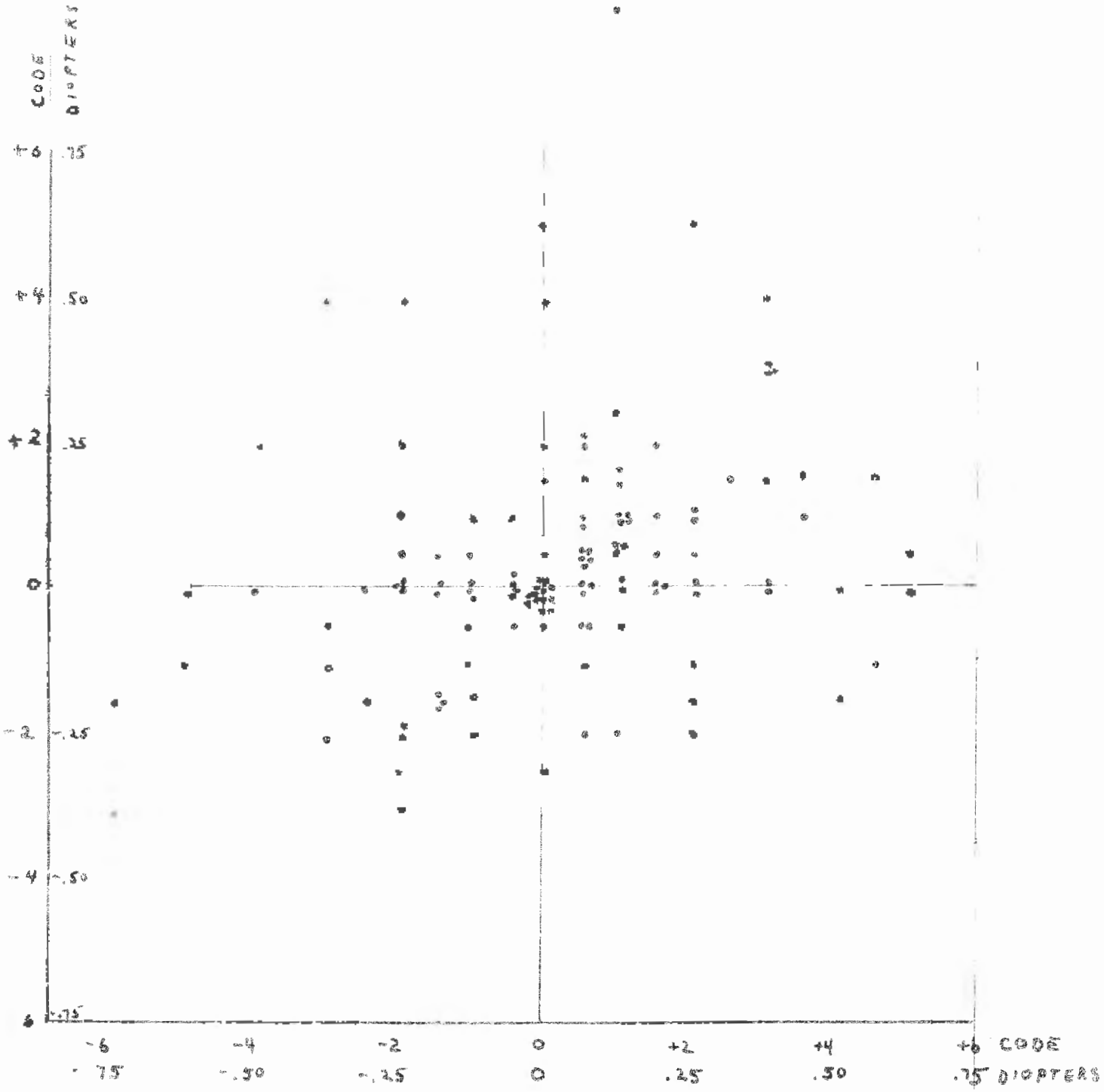


Δ 4 - BALL — NEAR CYL
45 - 135



SCATTERGRAM

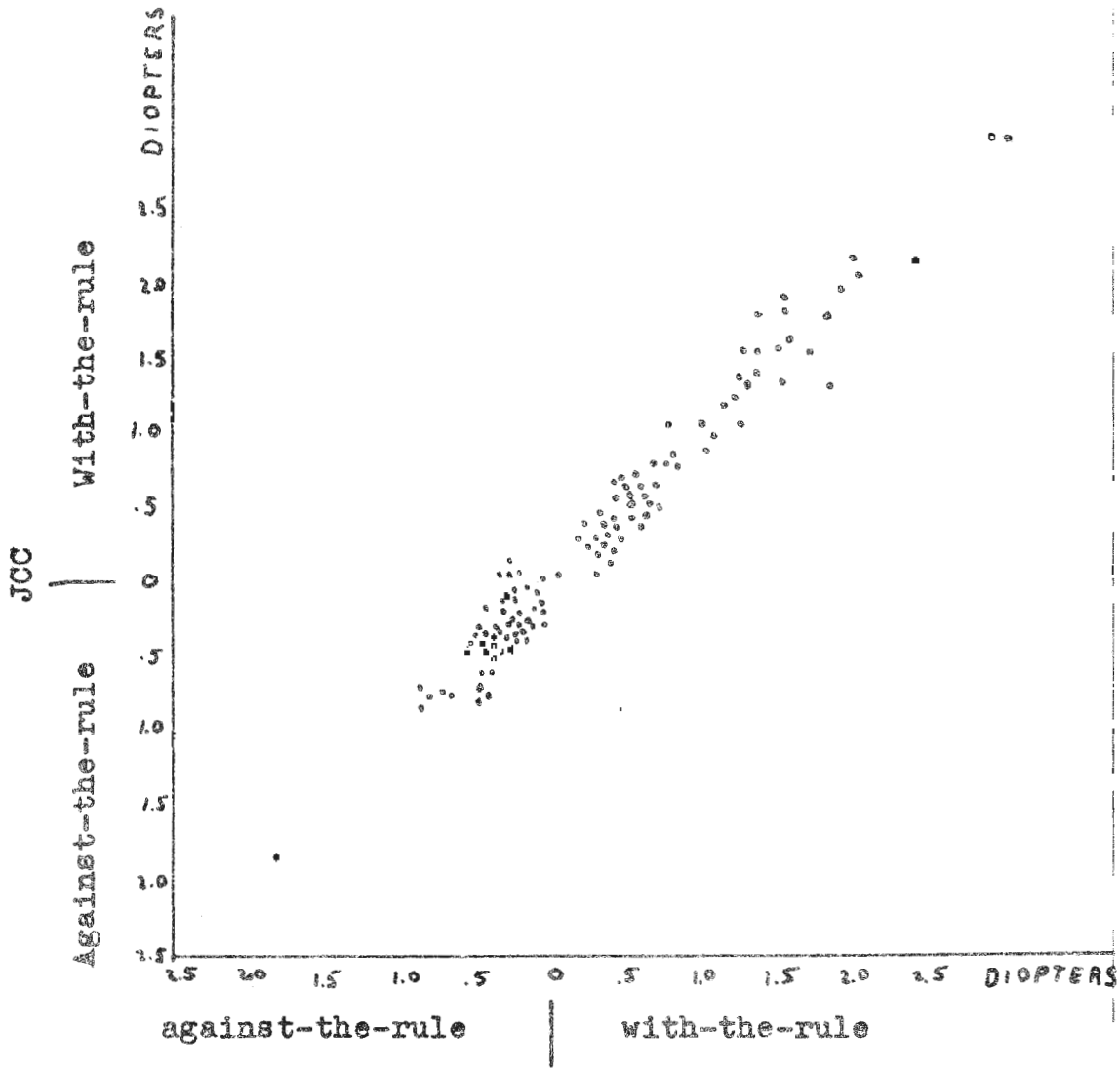
45 - 135



Abscissa.....4 ball-JCC

Ordinate.....JCC-Near Cyl

SCATTERGRAM



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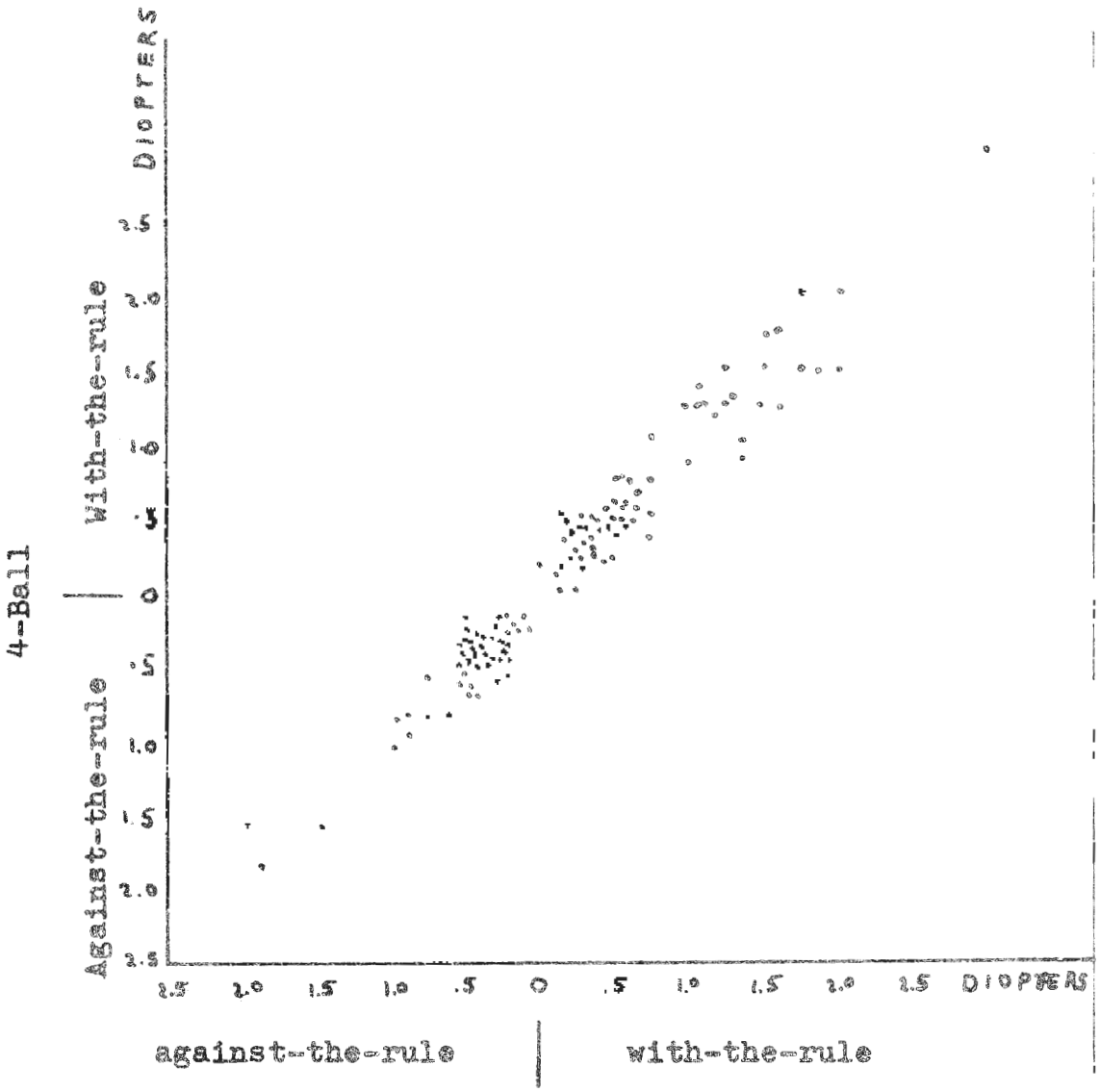

EYE	Δ Wear − 90-180	Δ 4Ball − JCC 45-135	Δ Dent − P 90-180	Δ JCC − P 45-135	Δ 4Ball-Wear 90-180	Δ 4Ball-Wear 45-135	CODE 90-180 (1)	CODE 45-135 (2)	CODE 90-180 (3)	CODE 45-135 (4)	CODE 90-180 (5)	CODE 45-135 (6)	$(1)^2$	$(2)^2$	$(3)^2$	$(4)^2$	$(5)^2$	$(6)^2$
1	.06	.11	−.13	−.21	.19	.32	0	1	−1	−2	1	2	1/4	1	1	4	2 1/4	6 1/4
3	−.04	−.23	−.21	.45	.17	−.68	−1	−2	−2	4	1	−6	−1/4	4	4	16	2 1/4	36
5	.16	.38	.32	.18	−.16	.20	1	3	3	1	−1	1	2 1/4	9	9	2 1/4	2 1/4	2 1/4
7	−.04	.14	.17	.01	−.21	.13	−1	1	1	0	−2	1	1/4	2 1/4	2 1/4	0	4	1
9	.17	.16	−.17	.30	.34	−.20	1	1	−1	2	3	−1	2 1/4	1	2 1/4	6 1/4	9	2 1/4
11	.01	.04	.14	.02	−.13	.02	0	0	1	0	−1	0	0	1/4	1	0	1	0
13	−.10	−.17	−.10	−.17	0	0	−1	−1	−1	−1	0	0	1	2 1/4	1	2 1/4	0	0
15	1.0	−.40	.43	.29	.57	−.69	8	−4	3	2	4	−6	64	16	12 1/4	4	20 1/4	42 1/4
17	−.20	−.38	.20	−.23	−.40	−.15	−2	−3	2	−2	−4	−1	4	9	4	4	16	2 1/4
19	−.14	.06	.00	.18	−.14	−.12	−1	0	0	1	−1	−1	1	1/4	0	2 1/4	1	1
21	.00	.00	−.11	.09	.11	−.09	0	0	−1	0	1	−0	0	0	1	1/4	1	1/4
23	.35	.12	.15	.02	.20	.16	3	1	1	0	2	1	9	1	1	0	4	1
25	.17	−.14	.15	.04	.02	−.18	1	1	1	0	0	−1	2 1/4	2 1/4	1	1/4	1/4	2 1/4
27	−.14	−.23	−.65	−.25	.51	.02	−1	−2	−5	2	4	0	2 1/4	4	25	4	20 1/4	0
29	.39	.08	.62	.00	−.23	.08	3	1	5	0	−2	0	16	1	25	0	4	1/4
31	.52	−.08	.28	−.17	.24	.09	4	−1	2	−1	2	0	20 1/4	1	4	2 1/4	4	1/4
33	.00	.00	−.12	.00	.12	0	0	0	−1	0	1	0	0	0	1	0	1	0
35	.06	−.11	.02	.13	.04	−.24	0	−1	0	1	0	−2	1/4	1	0	1	1/4	4
37	.42	−.01	.17	−.30	.25	.29	4	0	1	−2	2	2	16	0	2 1/4	6 1/4	4	6 1/4
39	.00	−.17	−.26	−.16	.26	−.01	0	−1	−2	−1	2	0	0	2 1/4	4	2 1/4	4	0
41	−.18	.09	.19	.11	.37	−.02	−1	1	1	1	3	0	2 1/4	1	2 1/4	1	9	0
43	.00	.00	.00	.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	.00	.06	.00	.06	0	0	0	0	0	0	0	0	0	1/4	0	1/4	0	0
47	.93	.48	−.13	.02	.86	.46	6	4	−1	0	7	4	36	16	1	0	49	16
49	−.11	.23	.00	.12	−.11	.11	−1	2	0	1	1	1	1	4	0	1	1	1
51	.06	.15	−.13	.02	.19	.13	0	1	−1	0	1	1	1/4	2 1/4	1	0	2 1/4	1
53	.09	.12	−.19	.04	.28	.08	1	1	−1	0	2	0	1	1	2 1/4	1/4	6 1/4	1/4
55	.13	.22	−.11	+.11	.24	.11	1	2	−1	1	2	1	1	4	1	1	4	1
57	−.27	.08	.00	.00	−.27	.08	−2	0	0	0	−2	0	4	1/4	0	0	6 1/4	1/4

EYE	Δ 4Ball-JCC 90-180	Δ 4Ball-JCC 45-135	Δ JCC.-P 90-180	Δ JCC.-P 45-135	Δ 4Ball-near 90-180	Δ 4Ball-near 45-135	CODE 90-180 (1)	CODE 45-135 (2)	CODE 90-180 (3)	CODE 45-135 (4)	CODE 90-180 (5)	CODE 45-135 (6)	(1)²	(2)²	(3)²	(4)²	(5)²	(6)²
59	.50	.08		.00		0	4	0		0	0	0	16	0			0	0
61	.11	.04	.26	-.24	-.15	.28	1	.	-24	.	.-1	2.	1	1/4	4	1/4	1	6 1/4
63	.20	-.25	-.03	-.20	.23	-.05	1.	-2	0	-2	2	-.	2 1/4	4	0	4	4	1/4
65	.10	-.08	-.09	.08	.19	.16	1	.	-1	1	1.	1.	1	1/4	1	1	2 1/4	2 1/4
67	.14	-.30	-.08	-.16	.22	-.14	1	-2.	-.	-1.	2	-1	1	6 1/4	1/4	2 1/4	4	1
69	-.03	.30	-.10	.16	.09	.14	0	2.	-1	1.	.	1	0	6 1/4	1/4	2 1/4	1/4	1
71	.00	.00	.00	.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
73	.02	.04	.03	-.08	-.01	.12	0	.	0	-.	0	1	0	1/4	0	1/4	0	1
75	.03	-.40	-.60	-.91	.63	.31	0	-3	-5	-6	5	2.	0	9	25	36	25	6 1/4
77	-.30	-.50	.00	.00	-.30	-.50	-2.	-4	0	0	-2.	-4	6 1/4	16	0	0	6 1/4	16
79	-.26	-.29	.14	-.06	-.40	-.23	-2	-2	1	0	-3.	-2	4	4	1	0	12 1/4	4
81	-.35	.13	.31	1.00	-.66	-.87	-3	1	2.	8	-5.	-7	9	1	6 1/4	64	30 1/4	49
83	.13	.02	.13	.02	0	0	1	0	1	0	0	0	1	0	1	0	0	0
85	-.41	.68	.07	-.16	-.48	.84	-3.	6	.	-1.	-4	7	12 1/4	36	1/4	2 1/4	16	49
87	.25	.40	-.67	.40	.92	0	2	3	-5.	3	7.	0	4	9	30 1/4	9	56 1/4	0
89	-.36	.06	.38	-.07	-.74	.13	3	.	3	-.	-6	1	9	1/4	9	1/4	36	1
91	-.16	.29	-.08	-.09	-.08	.38	-1.	2	-.	-1	-.	3	2 1/4	4	1/4	1	1/4	9
93	-.50	-1.60	-.33		-.17		-4	-13	-3		-1.		16	169	9		2 1/4	
95	.17	.18	.23	.24	-.06	-.06	1.	1.	2	2	-.	-.	2 1/4	2 1/4	4	4	1/4	1/4
97	.25	.00	.32	.18	-.07	-.18	2	0	2.	1.	-.	-1.	4	0	6 1/4	2 1/4	1/4	2 1/4
99	.15	-.04	.15	-.14	0	.10	1	.	1	-1	0	1	1	1/4	1	1	0	1
101	-.10	.10	-.60	.10	.50	0	-1	1	-5	1	4		1	1	25	1	16	
103	-.06	-.14	-.21	-.12	.15	-.02	-.	-1	-2	-1	1.	0	1/4	1	4	1	2 1/4	0
105	.58	-.21	.86	.06	.22	-.27	5	-2	3	.	2	-2	25	4	9	1/4	4	4
107	.16	.12	-.35	.12	.51	0	1.	1	-3	1	4	0	2 1/4	1	9	1	16	0
109	-.24	.08	-.12	.06	-.12	.02	-2	.	-1	.	-1	0	4	1/4	1	1/4	1	0
111	.35	.12	.49	.08	-.14	.04	3	1	4	.	-1	0	9	1	16	1/4	1	0
113	.09	.60	.00	00	.09	.60	1	5	0	0	1	5	1	25	0	0	1	25
115	.25	.00	-.17	.60	.42	-.60	2	0	-1.	5	3.	-5.	4	0	2 1/4	25	12 1/4	25

EYE	Δ 4Ball-Acc. 90-180	Δ 4Ball-Acc. 45-135	Δ Acc.-P 90-180	Δ Acc.-P 45-135	Δ 4Ball-Near 90-180	Δ 4Ball-Near 45-135	CODE 90-180 (1)	CODE 45-135 (2)	CODE 90-180 (3)	CODE 45-135 (4)	CODE 90-180 (5)	CODE 45-135 (6)	(1)²	(2)²	(3)²	(4)²	(5)²	(6)²
117	.13	.02	.13	.02	0	0	1	0	1	0	0	0	1	0	1	0	0	0
119	.26	.36	.64	.02	-.38	.38	2	3	5	0	-3	3	4	9	25	0	9	9
121	-.12	.04	.15	.11	-.27	.07	-1	0	1	1	-2	-0	1	1/4	1	1	4	1/4
123	.24	-.04	.26	.08	-.02	-.12	2	-0	2	1	0	-1	4	1/4	4	1	0	1
125	.44	-.68	.06	-.36	.38	-.32	4	-6	0	-3	3	-2	16	36	1/4	9	9	6 1/4
127	-.21	-.12	.00	.00	-.21	-.12	-2	-1	0	0	-2	-1	4	1	0	0	4	1
129	-.12	.21	.12	.00	-.24	.21	-1	2	1	0	-2	1	1	4	1	0	4	2 1/4
131	.37	.00	.49	-.08	-.12	.08	3	0	4	-0	-1	0	9	0	16	1/4	1	1/4
133	-.58	.21	-.25	.00	-.33	.21	-6	2	-2	0	-3	1	36	4	4	0	9	2 1/4
135	-.35	.37	.00	0	-.35	.37	-3	3	.00	0	-3	3	9	9	0	0	9	9
2		.81		-1.0				7		-8				49		64		
4	.35	.55	.05	.18	.30	.37	3	4	0	1	2	3	9	20 1/4	1/4	2 1/4	6 1/4	9
6	-.12	.04	-.25	.04	.13	0	-1	0	-2	0	1	0	1	1/4	4	1/4	1	0
8	-.37	.00	-.24	-.08	-.13	.08	-3	0	-2	-0	-1	0	9	0	4	1/4	1	1/4
10	-.16	.36	-.26	.36	.10	0	-1	3	-2	3	1	0	1	9	4	9	1	0
12	.12	.00	.00	.00	.12	0	1	0	0	0	1	0	1	0	0	0	1	0
14	-.24	.09	.23	-.08	-.47	.17	-2	1	2	-0	-4	1	4	1	4	1/4	16	2 1/4
16	.17	-.29	.04	-.31	.13	+.02	1	-2	0	-2	1	0	2 1/4	4	1/4	6 1/4	1	0
18	-.04	.12	.32	.18	-.36	-.06	-0	1	2	1	-3	-0	1/4	1	6 1/4	2 1/4	9	1/4
20	-.16	.19	.32	-.18	-.48	.37	-1	2	2	-1	-4	3	2 1/4	4	6 1/4	2 1/4	16	9
22	.20	.00	.00	.00	.20	0	2	0	0	0	1	0	4	0	0	0	2 1/4	0
24	.10	-.16	.24	.05	-.14	-.21	1	-1	2	0	-1	-1	1	2 1/4	4	1/4	1	2 1/4
26	-.13	-.02	.29	.47	-.42	-.49	-1	0	2	4	-3	-4	1	0	4	16	12 1/4	16
28	.33	-.62	.40	-.15	-.07	-.47	3	-5	3	-1	-0	-4	9	25	9	1	1/4	16
30	.26	.08	.26	.08	0	0	2	0	2	0	0	0	4	1/4	4	1/4	0	0
32	.05	.57	-.04	.08	.09	.49	0	5	-0	0	0	4	1/4	25	1/4	1/4	1/4	16
34	-.30	-.37	-.15	.04	-.15	-.33	-2	-3	-1	-0	-1	-3	6 1/4	9	1	1/4	1	9
36	-1.24	.07		.20		-.13	-10	0		2		-1	100	1/4		4		1
38	-.43	-.24	-.11	-.23	-.32	-.01	-3	-2	-1	-2	-3	0	12 1/4	4	1	4	9	0

EYE	Δ 4Ball-Jcc. 90-180	Δ 4Ball-Jcc 45-135	Δ Jcc.-P 90-180	Δ Jcc.-P 45-135	Δ 4Ball-Wear 90-180	Δ 4Ball-Wear 45-135	CODE 90-180 (1)	CODE 45-135 (2)	CODE 90-180 (3)	CODE 45-135 (4)	CODE 90-180 (5)	CODE 45-135 (6)	(1)²	(2)²	(3)²	(4)²	(5)²	(6)²
40	-.20	-.17	.00	.00	-.20	-.17	-2	-1.	0	0	-1.	-1.	4	2¼	0	0	2¼	2¼
42	.25	-.25	.02	.08	.23	-.33	2	-2	0	.	2	-3	4	4	0	¼	4	9
44	.25	.04	.02	.25	.24	-.21	2	.	0	2	2	-2	4	¼	0	4	4	4
46	.19	-.04	.12	-.02	.07	-.02	1.	-.	1	0	.	0	2¼	¼	1	0	¼	0
48	.16	.08	-.13	.05	.29	.03	1.	1	-1	.	2.	0	2¼	1	1	¼	6¼	0
50	-.20	-.19	.13	-.02	-.35	-.15	-2	-1.	1	0	-3	-1	4	2¼	1	0	9	1
52	.04	-.11	.10	-.23	-.06	.12	.	-1	1	-2	-.	1	¼	1	1	4	¼	1
54	-.13	-.02	.00	.02	-.13	-.04	-1	0	0	0	-1	-.	1	0	0	0	1	¼
56	-.16	-.12	.11	-.08	-.27	-.04	-1.	-1	1	-.	-2	-.	2¼	1	1	¼	4	¼
58	.26	.43	.15	.17	.11	.26	2	3.	1	1.	1	2	4	12¼	1	2¼	1	4
60	.66	1.14	.60	-.18	.06		5	9	5	-1.	.		25	81	25	2¼	¼	
62	.05	.18	.15	.01	-.10	.17	.	1.	1	0	-1	1.	¼	1¼	1	0	1	2¼
64	.23	-.40	.24	-.09	-.01	-.33	2	-3	2	-1	0	-3	4	9	4	1	0	9
66		.55	.09	-.10		65		4	+1	-1		5.		2¼	1	1		30¼
68	.08	.56	-.20	-.17	.28	.73	1	4	-2	-1.	2	6	1	16	4	2¼	4	36
70	.50	.00	.43	.25	.09	-.25	4	0	3.	2	.	-2	16	0	12¼	4	¼	4
72	.00	.00	.00	.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0
74	-.09	.03	-.09	.03	0	0	-.	0	-.	0	0	0	¼	0	¼	0	0	0
46	-.06	-.34	-.39	.53	.33	-.87	-.	-3	3	4	3	-7	¼	9	9	16	9	49
48	.45	-.30	.50	.00	-.05	-.30	4	-2.	4	0	-.	-2.	16	6¼	16	0	¼	6¼
80	.36	-.13	-.11	.04	.47	-.17	3	-1	-1	.	4	-1.	9	1	1	¼	16	2¼
82	-.80	-.13	.00	.00	-.80	-.13	-6.	-1	0	0	-6.	-1	40¼	1	0	0	40¼	1
84	.09	.03	.13	.02	-.06	.01	.	0	1	0	-.	0	¼	0	1	0	¼	0
86	.16	-.25	.03	.12	.13	-.39	1.	-2	0	1	1	-3	2¼	4	0	1	1	9
88	-.11	.27	-.28	.09	.17	.20	-1	2	-2	.	1.	1.	1	4	4	¼	2¼	2¼
90	-.23	.25	-.06	-.25	-.17	.50	-2	2	-.	-2	-1.	4	4	4	¼	4	2¼	16
92	-.04	.39	-.06	.48	.02	-.09	-.	3	-.	4	0	-.	¼	9	¼	16	0	¼
94	-.75	.00	-.25	.00	-.50	0	-6	0	-2	0	-4	0	36	0	4	0	16	0
96	.17	.10	.42	.18	-.25	-.08	1.	1	3	1.	-2	-.	2¼	1	9	2¼	4	¼

EYE	Δ 4Ball-JCC 90-180	Δ 4Ball-JCC 45-135	Δ JCC-P 90-180	Δ JCC-P 45-135	Δ 4Ball wear 90-180	Δ 4Ball wear 45-135	CODE 90-180 (1)	CODE 45-135 (2)	CODE 90-180 (3)	CODE 45-135 (4)	CODE 90-180 (5)	CODE 45-135 (6)	(1)²	(2)²	(3)²	(4)²	(5)²	(6)²
98	-.41	.16	-.06	.13	-.35	.03	-3	1	--	1	-3	0	12¼	2¼	¼	1	9	0
100	.29	-.61	.00	.00	.29	-.61	2	-5	0	0	-2	-5	6¼	25	0	0	6¼	25
102	-.22	.43	.02	.10	-.24	.32	-2	3	0	1	-2	3	4	12¼	0	1	4	9
104	-.34	-.12	.00	.00	-.34	-.12	-3	-1	0	0	-3	-1	9	1	0	0	9	1
106	.23	-.27	.46	-.33	.69	.06	2	-2	-4	-3	6	.	4	4	16	9	36	¼
108	.19	.06	.08	.29	.11	-.23	1	.	.	2	1	-2	2¼	¼	¼	4	1	6¼
110	.06	-.16	-.07	-.16	.13	0	.	-1	-.	-1	1	0	¼	2¼	¼	2¼	1	0
112	.38	.00	.38	.00	0	0	3	0	3	0		0	9	0	9	0		0
114	.09	.20	-.08	.62	-.19	-.42	1	2	-.	5	1	-3	1	4	¼	25	1	12¼
116	1.20	1.20	.02	.12	+1.18	1.08	10	10	0	1	10	9	100	100	0	1	100	81
118	-.25	.00	-.24	-.08	-.01	.08	-2	0	-2	-.	0	.	4	0	4	¼	0	¼
120	-.56	-.29	.50	.00	-1.06	-.29	-5	-2	4	0	-9	-2	25	4	16	0	81	6¼
122	.25	.00	.97	.00	-.12	0	2	0	3	0	-1	0	4	0	9	0	1	0
124	.30	.13	.63	.10	-.33	.03	2	1	5	1	-3	0	6¼	1	25	1	9	0
126	.25	-.04	.00	.00	.25	-.04	2	-.	0	0	2	0	4	¼	0	0	4	0
128	.22	.12	.25	.00	-.03	.12	2	1	2	0	0	1	4	1	4	0	0	1
130	.25	-.04	.24	-.08	.01	.04	2	-.	2	-.	0	0	4	¼	4	¼	0	0
132	.00	.00	.12	.02	-.12	-.02	0	0	1	0	-1	0	0	0	1	0	1	0
134	.13	.01	.25	.00	-.12	.01	1	.	2	0	-1	0	1	¼	4	0	1	0

TARGETS USED IN THE NEAR CYLINDER TEST