MCCA

MANUFACTURERS COUNCIL ON COLOR AND APPEARANCE

COLLABORATIVE REFERENCE PROGRAM COLOR AND APPEARANCE

RETROREFLECTANCE

REPORT NO. 5

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

NBS COLLABORATIVE REFERENCE PROGRAMS

TAPPI Paper and Board (6 times per year)

- Bursting strength
- Tearing strength
- Tensile breaking strength
- Elongation to break
- Tensile energy absorption
- Folding endurance
- Stiffness
- Air resistence
- Grammage
- Smoothness
- Surface pick strength
- K & N ink absorption
- pH
- Opacity
- Blue reflectance (brightness)
- Specular gloss, 75°
- Thickness
- Concora (flat crush)
- Ring crush

FKI KRAFTBOARD (48 times per year)

- Mullen burst of linerboard
- Concora test of medium

MCCA Color and Appearance (4 times per year)

- Gloss at 60°
- Color and color difference
- Retroreflectivity

Rubber (4 times per year)

- Tensile strength, ultimate elongation and tensile stress
- Hardness
- Mooney viscosity
- Vulcanization properties

ASTM Textiles (3 times per year)

- Flammability (FF3-71 and FF5-74)

ASTM Cement (2 times per year)

- Chemical (11 chemical components)
- Physical (8 characteristics)

AASHTO Bituminous

- Asphalt cement (2 times per year)
- Cutbacks (once a year)

Collaborative Reference Programs
B360 Polymer Bldg.
National Bureau of Standards
Washington, D.C. 20234

MANUFACTURERS COUNCIL ON
COLOR AND APPEARANCE

COLLABORATIVE REFERENCE PROGRAM FOR COLOR AND APPEARANCE

RETROREFLECTANCE

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U. S. DEPARTMENT OF COMMERCE
National Bureau of Standards

NBSIR 78-1355

Introduction

Sample sets of retroreflective road-sign sheeting material were sent to 18 laboratories participating in this Collaborative Reference Program. The sample set consisted of two specimens each of silver sheeting and of orange sheeting. Ten laboratories returned data taken in accordance with Federal Specification L-S-300 (A or B) or a close modification thereof, and two laboratories followed "other" methods.

If there are any questions on the notes, the analyses, or this report in general, please contact Jeff Stevenson or Jeffrey Horlick on (301) 921-2946.

November 6, 1978

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KEY TO TABLES AND GRAPHS

MEAN - The average of individual TEST DETERMINATIONS. The number of TEST DETERMINATIONS in the mean is given in the upper right corner of the first table (TEST D.) and again at the bottom of this table.

GRAND MEAN - (GR. MEAN) The average of the individual laboratory MEANS, excluding laboratories flagged (see column F) with an X or #.

DEV - The DEViation of difference of the laboratory MEAN from the GRAND MEAN.

N. DEV - The Normal DEViate or ratio of the DEV to the SD OF MEANS; an indication of the degree of divergence of the laboratory MEAN from the GRAND MEAN.

INST CODE - Code for instrument type or variation in condition, see second table.

F - Flag, with following meaning:

- # - Excluded because data were not understood or because analysis indicated extreme performance values or non-compliance with required test procedures.
- X - Excluded because plotted point would fall outside of the 99% error ellipse, (see below for explanation of Graph).
- * - Included in grand means but plotted point would fall outside of the 95% error ellipse.
- 0 - Included in grand mean and inside 95% error ellipse.

Graph - For each laboratory the MEAN for the second sample is plotted against the MEAN for the first sample, with each point representing a laboratory. The horizontal and vertical lines are the GRAND MEANS. The dashed line is drawn at 45°. The solid sloping line, which may or may not lie close to the 45° line, is along the major axis of the error ellipse. The ellipse is drawn so that, on the average, it will include 95% of the points representing the laboratories.

Plotted symbols are as explained above (under F). A participant whose plotted point falls outside of the ellipse or the rectangular area should carefully re-examine the testing procedure he is following.

Note: Graphs are plotted with an ellipse when there are 20 or more instruments in the analysis.

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

LAB CODE	SAMPLE R01 MEAN	RED AT -4..2 DEGREES DEV	N.DEV	SDR	R.SDR	SAMPLE 601 MEAN	ORANGE AT -4..2 DEG DEV	N.DEV	SDR	R.SDR	VAR	F	LAB	TEST D.F. = 4
C428	52.9	1.7	.31	.3	.41	207.7	3.0	.31	1.5	.67	72A	ó	C428	
C462	59.8	8.6	1.57	1.2	1.55	205.2	.5	.05	1.3	.55	72A	ó	C462	
C471	58.6	7.4	1.35	2.4	3.14	211.6	6.8	.70	3.3	1.48	72C	ó	C471	
C479	52.1	.9	.16	.4	.48	215.5	10.8	1.10	2.3	1.04	72A	ó	C479	
C480	53.8	2.6	.48	.5	.61	215.5	10.7	1.10	1.3	.57	72A	ó	C480	
C481	47.5	-3.7	-.68	.6	.75	192.5	-12.3	-1.25	3.0	1.33	72A	ó	C481	
C486	52.1	.9	.16	.9	1.21	208.1	3.4	.35	.5	.23	72A	ó	C486	
C488	53.5	2.3	.42	.6	.75	218.0	13.2	1.35	4.1	1.81	72C	ó	C488	
C490	39.3	-11.9	-2.17	1.3	1.62	188.9	-15.9	-1.62	4.5	2.01	72A	ó	C490	
C491	49.9	-1.3	-.24	.6	.80	199.7	-5.1	-.52	3.8	1.66	72A	ó	C491	
C522	45.8	-5.4	-.98	.5	.65	202.4	-2.4	-.24	1.0	.42	72A	ó	C522	
C611	46.4	-4.8	-.87	.2	.22	189.4	-15.4	-1.57	1.6	.73	72A	ó	C611	
C614	53.9	2.7	.50	.6	.83	207.3	2.5	.26	1.1	.49	72C	ó	C614	

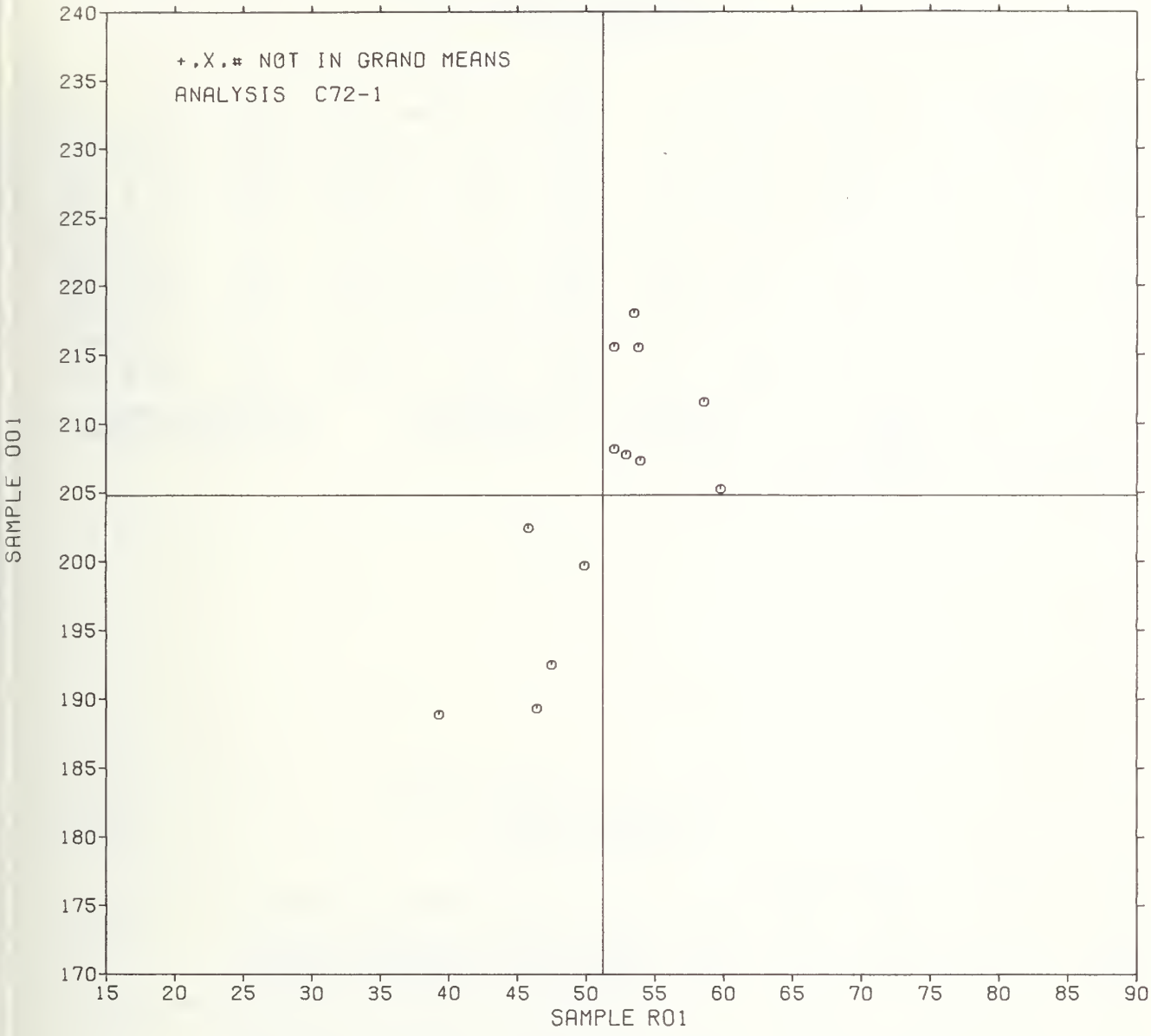
GR. MEAN = 51.2 CP/FT-C/SQFT GRAND MEAN = 204.8 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = 5.5 CP/FT-C/SQFT SD OF MEANS = 9.8 CP/FT-C/SQFT 13 LABS IN GRAND MEANS
AVERAGE SDR = .8 CP/FT-C/SQFT AVERAGE SDR = 2.3 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 13

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

LAB CODE	F	MEANS R01	601	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	ó	39.3	188.9	-19.4	4.1	1.82	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	ó	45.8	202.4	-4.4	3.9	.54	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	ó	46.4	189.4	-16.0	-2.1	.48	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	ó	47.5	192.5	-12.7	-1.8	1.04	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	ó	49.9	199.7	-5.2	-.9	1.23	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C486	ó	52.1	208.1	3.4	.6	.72	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	ó	52.1	215.5	10.2	3.7	.76	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	ó	52.9	207.7	3.4	-.3	.54	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C488	ó	53.5	218.0	13.0	3.5	1.28	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C480	ó	53.8	215.5	10.8	2.1	.59	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C614	ó	53.9	207.3	3.5	-1.4	.66	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C471	ó	58.6	211.6	9.3	-3.8	2.31	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C462	ó	59.8	205.2	4.0	-7.6	1.05	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
GMEANS:		51.2	204.8			1.00		
		95% ELLIPSE:		31.4	10.3	WITH GAMMA = 65 DEGREES		

RETROREFLECTANCE

SAMPLE R01 = 51. CP/FT-C/SQFT SAMPLE 001 = 205. CP/FT-C/SQFT



REPORT NO. 5 — MCCA COLLABORATIVE REFERENCE PROGRAM — 1977-1978

ANALYSIS C72-1 TABLE 1

RETROREFLECTANCE

LAB CODE	SAMPLE R02 MEAN	RED AT 30,.2 DEGREES DEV	N.DEV	SDR	R.SDR	SAMPLE 602 MEAN	ORANGE AT 30,.2 DEG DEV	N.DEV	SDR	R.SDR	TEST D.= 4 VAR	F	LAB
C428	42.2	.5	.07	1.7	.98	156.7	-3.9	-.28	9.5	1.04	72A	6	C428
C462	50.5	8.8	1.42	2.5	1.47	163.9	3.3	.24	5.1	.56	72A	6	C462
C471	55.9	14.2	2.28	3.6	2.10	193.4	32.7	2.37	11.2	1.23	72C	6	C471
C479	41.1	-.6	-.09	1.9	1.11	169.3	8.7	.63	5.8	.63	72A	6	C479
C480	42.2	.5	.09	1.9	1.09	171.5	10.8	.78	18.9	2.07	72A	6	C480
C481	37.7	-4.0	-.63	1.5	.88	153.0	-7.7	-.56	7.7	.84	72A	6	C481
C486	41.3	-.4	-.07	.8	.49	159.6	-1.1	-.08	3.8	.42	72A	6	C486
C488	41.0	-.7	-.11	1.8	1.08	165.5	4.8	.35	8.5	.93	72C	6	C488
C490	30.9	-10.8	-1.74	1.3	.76	137.1	-23.6	-1.71	11.2	1.22	72A	6	C490
C491	38.1	-3.6	-.57	1.8	1.08	145.4	-15.3	-1.11	8.9	.98	72A	6	C491
C522	35.6	-6.1	-.98	1.7	1.00	150.4	-10.3	-.75	10.9	1.20	72A	6	C522
C611	42.8	1.1	.18	.2	.13	164.9	4.2	.30	11.2	1.22	72A	6	C611
C614	42.7	1.0	.16	1.4	.83	158.0	-2.7	-.19	6.0	.66	72C	6	C614

GR. MEAN = 41.7 CP/FT-C/SQFT — GRAND MEAN = 160.7 CP/FT-C/SQFT — TEST DETERMINATIONS = 4

SD MEANS = 6.2 CP/FT-C/SQFT — SD OF MEANS = 13.8 CP/FT-C/SQFT — 13 LABS IN GRAND MEANS

AVERAGE SDR = 1.7 CP/FT-C/SQFT — AVERAGE SDR = 9.1 CP/FT-C/SQFT

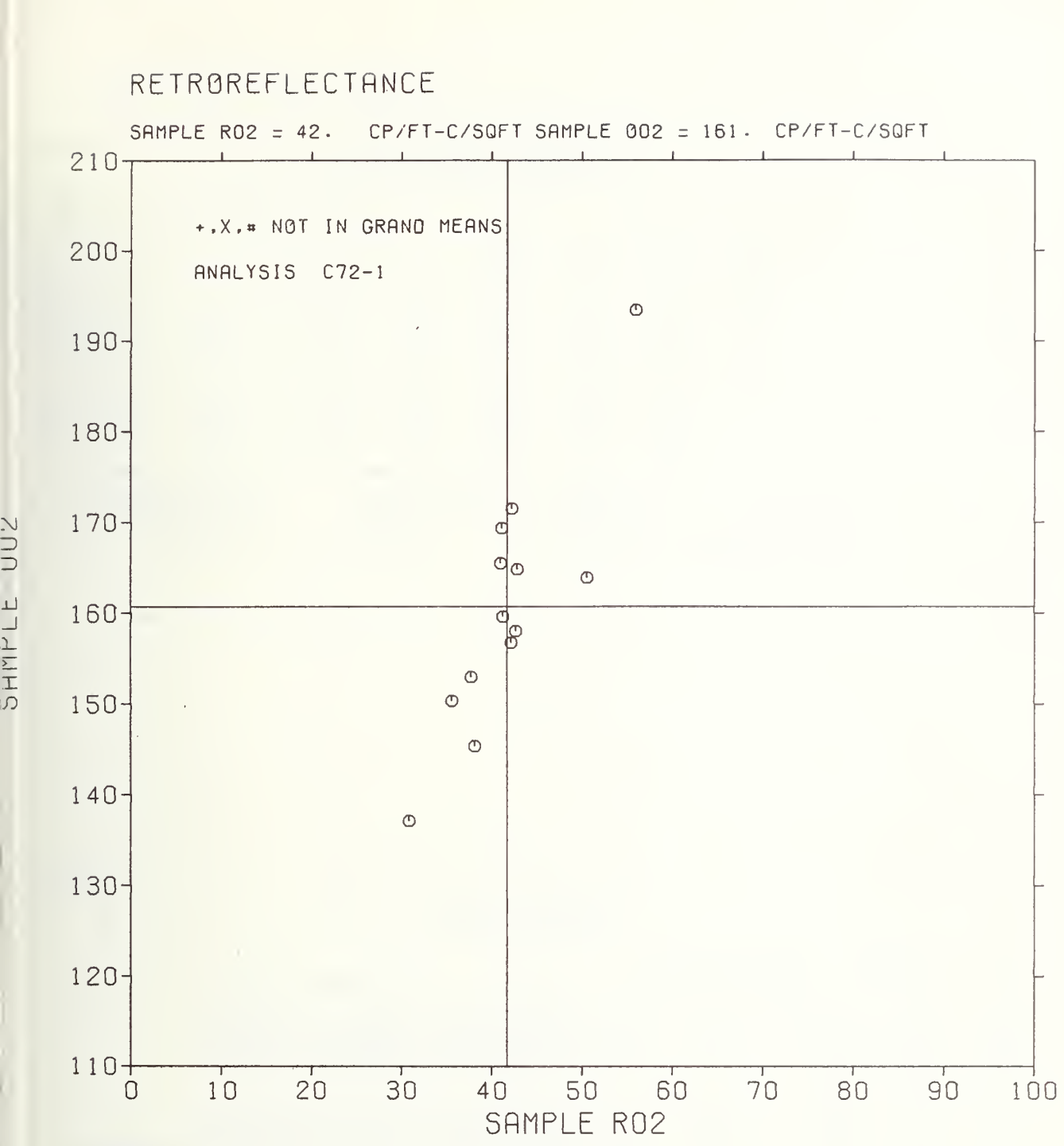
TOTAL NUMBER OF LABORATORIES REPORTING = 13

REPORT NO. 5 — MCCA COLLABORATIVE REFERENCE PROGRAM — 1977-1978

ANALYSIS C72-1 TABLE 2

RETROREFLECTANCE

LAB CODE	F	MEANS R02	602	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	6	30.9	137.1	-25.9	1.1	.99	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	6	35.6	150.4	-11.8	1.8	1.10	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	6	37.7	153.0	-8.6	.8	.86	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	6	38.1	145.4	-15.5	-2.5	1.03	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C488	6	41.0	165.5	4.2	2.5	1.01	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C479	6	41.1	169.3	7.8	3.8	.87	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C486	6	41.3	159.6	-1.2	.0	.45	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	6	42.2	156.7	-3.5	-1.9	1.01	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	6	42.2	171.5	10.2	3.6	1.58	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C614	6	42.7	158.0	-2.1	-1.9	.74	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C611	6	42.8	164.9	4.3	.5	.68	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C462	6	50.5	163.9	6.4	-6.9	1.02	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	6	55.9	193.4	35.7	-.8	1.67	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		41.7	160.7			1.00		
		95% ELLIPSE:		43.9	8.6	WITH GAMMA = 67 DEGREES		


RETROREFLECTANCE
SAMPLE R02 = 42. CP/FT-C/SQFT SAMPLE 002 = 161. CP/FT-C/SQFT
+,X,* NOT IN GRAND MEANS
ANALYSIS C72-1
SAMPLE 002
210
200
190
180
170
160
150
140
130
120
110
0
10
20
30
40
50
60
70
80
90
100
SAMPLE R02

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

LAB CODE	SAMPLE R03 MEAN	RED AT -4,2.0 DEGREES DEV	N.DEV	SDR	R.SDR	SAMPLE 603 MEAN	ORANGE AT -4,2.0 DEG DEV	N.DEV	SDR	R.SDR	TEST D." VAR	F	LAB
C428	1.30	-.05	-.26	.00	.00	5.07	-.29	-.71	.05	.69	72A	O	C428
C462	1.70	.35	1.87	.00	.00	5.70	.34	.83	.00	.00	72A	O	C462
C471	1.57	.23	1.20	.05	.60	6.19	.83	2.03	.06	.80	72C	O	C471
C479	1.40	.05	.27	.00	.00	5.42	.06	.15	.21	2.85	72A	O	C479
C480	1.38	.04	.19	.14	1.65	5.58	.21	.53	.08	1.15	72A	O	C480
C481	1.25	-.10	-.53	.50	5.80	5.00	-.36	-.89	.00	.00	72A	O	C481
C490	1.04	-.31	-1.63	.12	1.35	4.82	-.54	-1.34	.11	1.54	72A	O	C490
C491	1.39	.04	.23	.02	.24	5.54	.18	.44	.10	1.31	72A	O	C491
C522	1.24	-.11	-.58	.01	.16	5.21	-.15	-.36	.08	1.05	72A	O	C522
C611	1.21	-.14	-.74	.02	.19	5.08	-.28	-.68	.04	.61	72A	O	C611
C614	24.02	22.68	120.74	.21	2.39	77.10	71.74	176.41	.36	4.92	72C	#	C614

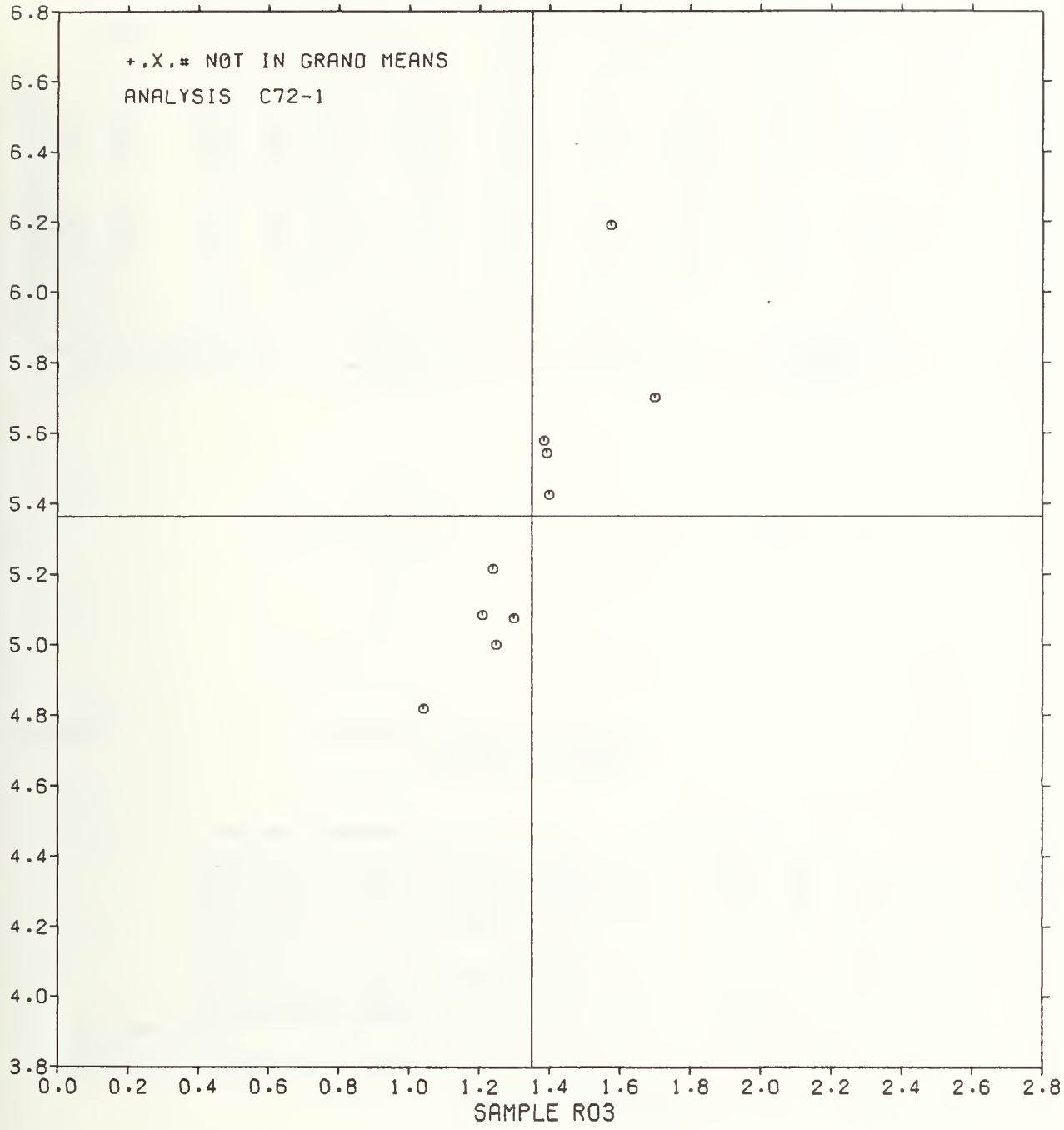
GR. MEAN = 1.35 CP/FT-C/SQFT GRAND MEAN = 5.36 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = .19 CP/FT-C/SQFT SD OF MEANS = .41 CP/FT-C/SQFT 10 LABS IN GRAND MEANS
AVERAGE SDR = .09 CP/FT-C/SQFT AVERAGE SDR = .07 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 11

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

LAB CODE	F	MEANS R03	603	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	O	1.04	4.82	-.62	.07	1.45	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	O	1.21	5.08	-.31	.02	.40	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	O	1.24	5.21	-.18	.04	.61	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	O	1.25	5.00	-.37	-.05	2.90	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	O	1.30	5.07	-.28	-.07	.35	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	O	1.38	5.58	.21	.05	1.40	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	O	1.39	5.54	.18	.03	.78	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	O	1.40	5.42	.08	-.02	1.42	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	O	1.57	6.19	.85	.11	.70	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C462	O	1.70	5.70	.45	-.19	.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C614	#	24.02	77.10	74.93	6.81	3.65	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		1.35	5.36			1.00		
		95% ELLIPSE:		1.39	.28	WITH GAMMA = 67 DEGREES		

RETROREFLECTANCE

SAMPLE R03 = 1.35 CP/FT-C/SQFT SAMPLE 003 = 5.36 CP/FT-C/SQFT



REPORT NO. 5 — MCCA COLLABORATIVE REFERENCE PROGRAM — 1977-1978

ANALYSIS C72-1 TABLE 1

RETROREFLECTANCE

LAB CODE	SAMPLE R04 RED AT 30.2.0 DEGREES MEAN	DEV	N.DEV	SDR	R.SDR	SAMPLE 604 ORANGE AT 30.2.0 DEG MEAN	DEV	N.DEV	SDR	R.SDR	VAR	F	LAB
C428	1.000	-.128	-.55	.000	.00	4.000	-.338	-.58	.216	1.89	72A	6	C428
C462	1.500	.372	1.60	.000	.00	4.475	.137	.23	.150	1.31	72A	6	C462
C471	1.505	.377	1.62	.064	2.75	5.795	1.456	2.49	.134	1.17	72C	6	C471
C479	1.150	.022	.09	.058	2.50	4.250	-.088	-.15	.058	.51	72A	6	C479
C480	1.075	-.053	-.23	.017	.75	4.520	.182	.31	.177	1.55	72A	6	C480
C481	1.000	-.128	-.55	.000	.00	4.000	-.338	-.58	.000	.00	72A	6	C481
C490	.747	-.381	-1.63	.017	.74	3.610	-.728	-1.24	.052	.46	72A	6	C490
C491	1.187	.059	.25	.030	1.29	4.212	-.126	-.22	.061	.54	72A	6	C491
C522	.975	-.153	-.66	.019	.83	4.017	-.321	-.55	.195	1.71	72A	6	C522
C611	1.142	.014	.06	.026	1.14	4.505	.167	.28	.098	.86	72A	6	C611
C614	20.500	19.372	83.15	.271	11.73	68.100	63.762	108.87	.627	5.49	72C	#	C614

GR. MEAN = 1.128 CP/FT-C/SQFT — GRAND MEAN = 4.338 CP/FT-C/SQFT — TEST DETERMINATIONS = 4

SD MEANS = .233 CP/FT-C/SQFT — SD OF MEANS = .586 CP/FT-C/SQFT — 10 LABS IN GRAND MEANS

AVERAGE SDR = .023 CP/FT-C/SQFT — AVERAGE SDR = .114 CP/FT-C/SQFT

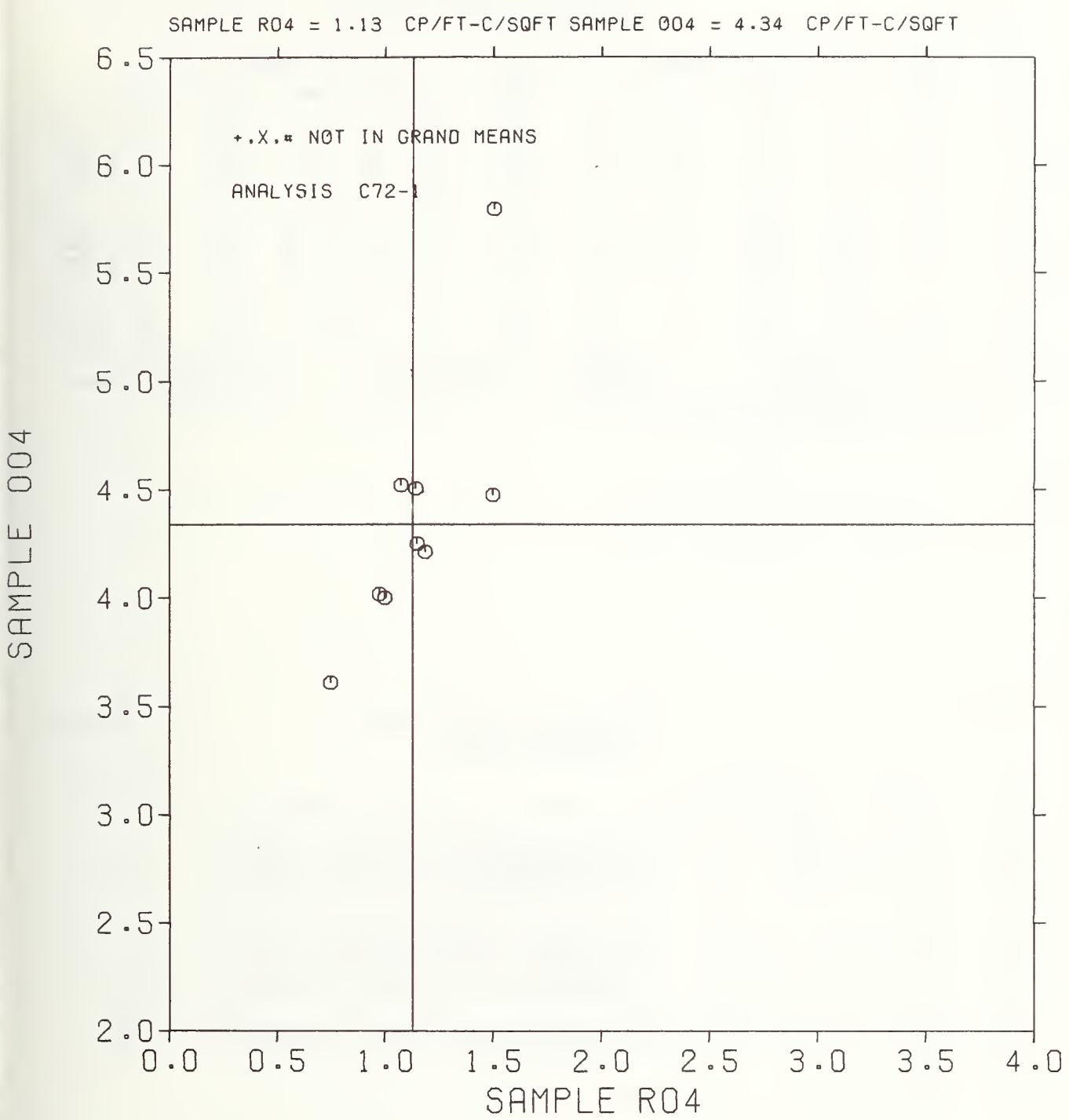
TOTAL NUMBER OF LABORATORIES REPORTING = 11

REPORT NO. 5 — MCCA COLLABORATIVE REFERENCE PROGRAM — 1977-1978

ANALYSIS C72-1 TABLE 2

RETROREFLECTANCE

LAB CODE	F	MEANS R04	604	COORDINATES MAJOR	MINOR	AVG R.SD	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	6	.747	3.610	-.812	.127	.6	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	6	.975	4.017	-.353	.042	1.2	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	6	1.000	4.000	-.362	.013	.9	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	6	1.000	4.000	-.362	.013	.0	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	6	1.075	4.520	.155	.109	1.1	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	6	1.142	4.505	.162	.040	1.0	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	6	1.150	4.250	-.077	-.049	1.5	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	6	1.187	4.212	-.100	-.097	.9	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C462	6	1.500	4.475	.249	-.308	.6	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	6	1.505	5.795	1.500	.111	1.9	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C614	#	20.500	68.100	66.605	2.138	8.6	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		1.128	4.338			1.0		
		95% ELLIPSE:		1.954	.410	WITH GAMMA = 71 DEGREES		


RETROREFLECTANCE
SAMPLE R04 = 1.13 CP/FT-C/SQFT SAMPLE 004 = 4.34 CP/FT-C/SQFT
+.X.* NOT IN GRAND MEANS
ANALYSIS C72-1
SAMPLE 004
SAMPLE R04
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0

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ANALYSIS C72-1 TABLE 1

RETROREFLECTANCE

LAB CODE	SAMPLE R01 RED AT -4,.2 DEGREES MEAN	DEV	N.DEV	SDR	R.SDR	SAMPLE R02 RED AT 30,.2 DEGREES MEAN	DEV	N.DEV	SDR	R.SDR	TEST D.* 4 VAR	F	LAB
C428	52.9	1.7	.31	.3	.41	42.2	.5	.07	1.7	.98	72A	6	C428
C462	59.8	8.6	1.57	1.2	1.55	50.5	8.8	1.42	2.5	1.47	72A	6	C462
C471	58.6	7.4	1.35	2.4	3.14	55.9	14.2	2.28	3.6	2.10	72C	6	C471
C479	52.1	.9	.16	.4	.48	41.1	-.6	-.09	1.9	1.11	72A	6	C479
C480	53.8	2.6	.48	.5	.61	42.2	.5	.09	1.9	1.09	72A	6	C480
C481	47.5	-3.7	-.68	.6	.75	37.7	-4.0	-.63	1.5	.88	72A	6	C481
C486	52.1	.9	.16	.9	1.21	41.3	-.4	-.07	.8	.49	72A	6	C486
C488	53.5	2.3	.42	.6	.75	41.0	-.7	-.11	1.8	1.08	72C	6	C488
C490	39.3	-11.9	-2.17	1.3	1.62	30.9	-10.8	-1.74	1.3	.76	72A	6	C490
C491	49.9	-1.3	-.24	.6	.80	38.1	-3.6	-.57	1.8	1.08	72A	6	C491
C522	45.8	-5.4	-.98	.5	.65	35.6	-6.1	-.98	1.7	1.00	72A	6	C522
C611	46.4	-4.8	-.87	.2	.22	42.8	1.1	.18	.2	.13	72A	6	C611
C614	53.9	2.7	.50	.6	.83	42.7	1.0	.16	1.4	.83	72C	6	C614

GR. MEAN = 51.2 CP/FT=C/SQFT — GRAND MEAN = 41.7 CP/FT=C/SQFT — TEST DETERMINATIONS = 4

SD MEANS = 5.5 CP/FT=C/SQFT — SD OF MEANS = 6.2 CP/FT=C/SQFT — 13 LABS IN GRAND MEANS

AVERAGE SDR = .8 CP/FT=C/SQFT — AVERAGE SDR = 1.7 CP/FT=C/SQFT

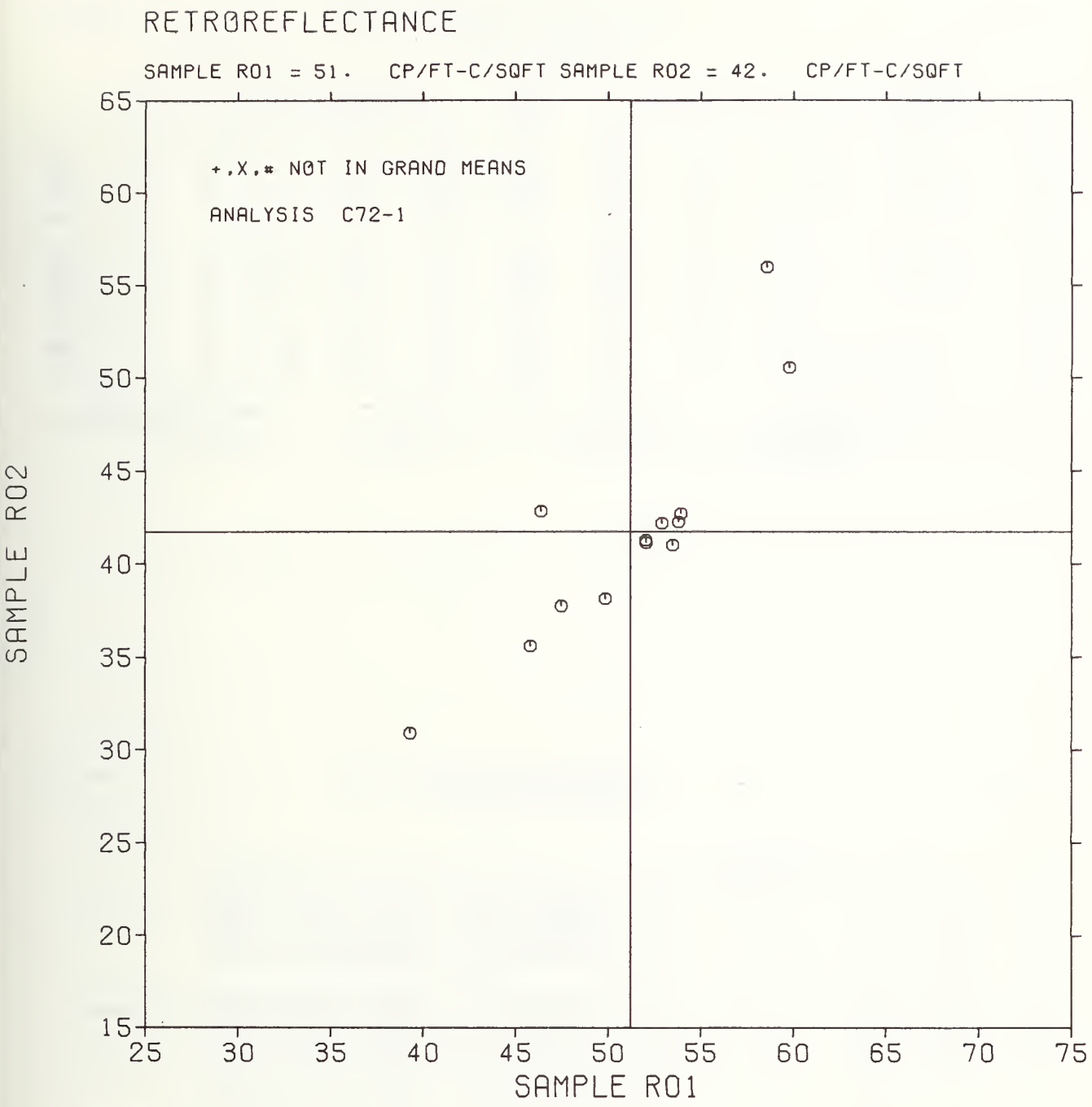
TOTAL NUMBER OF LABORATORIES REPORTING = 13

REPORT NO. 5 — MCCA COLLABORATIVE REFERENCE PROGRAM — 1977-1978

ANALYSIS C72-1 TABLE 2

RETROREFLECTANCE

LAB CODE	F	MEANS R01	R02	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	6	39.3	30.9	-16.0	1.9	1.19	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	6	45.8	35.6	-8.1	.1	.83	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	6	46.4	42.8	-2.3	4.4	.18	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	6	47.5	37.7	-5.4	.2	.81	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	6	49.9	38.1	-3.6	-1.3	.94	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C486	6	52.1	41.3	.2	-.9	.85	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	6	52.1	41.1	.1	-1.0	.79	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	6	52.9	42.2	1.5	-1.0	.69	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C488	6	53.5	41.0	1.0	-2.2	.91	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C480	6	53.8	42.2	2.1	-1.6	.85	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C614	6	53.9	42.7	2.5	-1.4	.83	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C471	6	58.6	55.9	15.6	3.7	2.62	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C462	6	59.8	50.5	12.3	-.7	1.51	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
GMEANS:		51.2	41.7			1.00		
		95% ELLIPSE:		23.7	6.1	WITH GAMMA = 49 DEGREES		


RETROREFLECTANCE
SAMPLE RO1 = 51. CP/FT-C/SQFT SAMPLE RO2 = 42. CP/FT-C/SQFT
+,X,* NOT IN GRAND MEANS
ANALYSIS C72-1
SAMPLE RO2
SAMPLE RO1
65
60
55
50
45
40
35
30
25
20
15
25
30
35
40
45
50
55
60
65
70
75

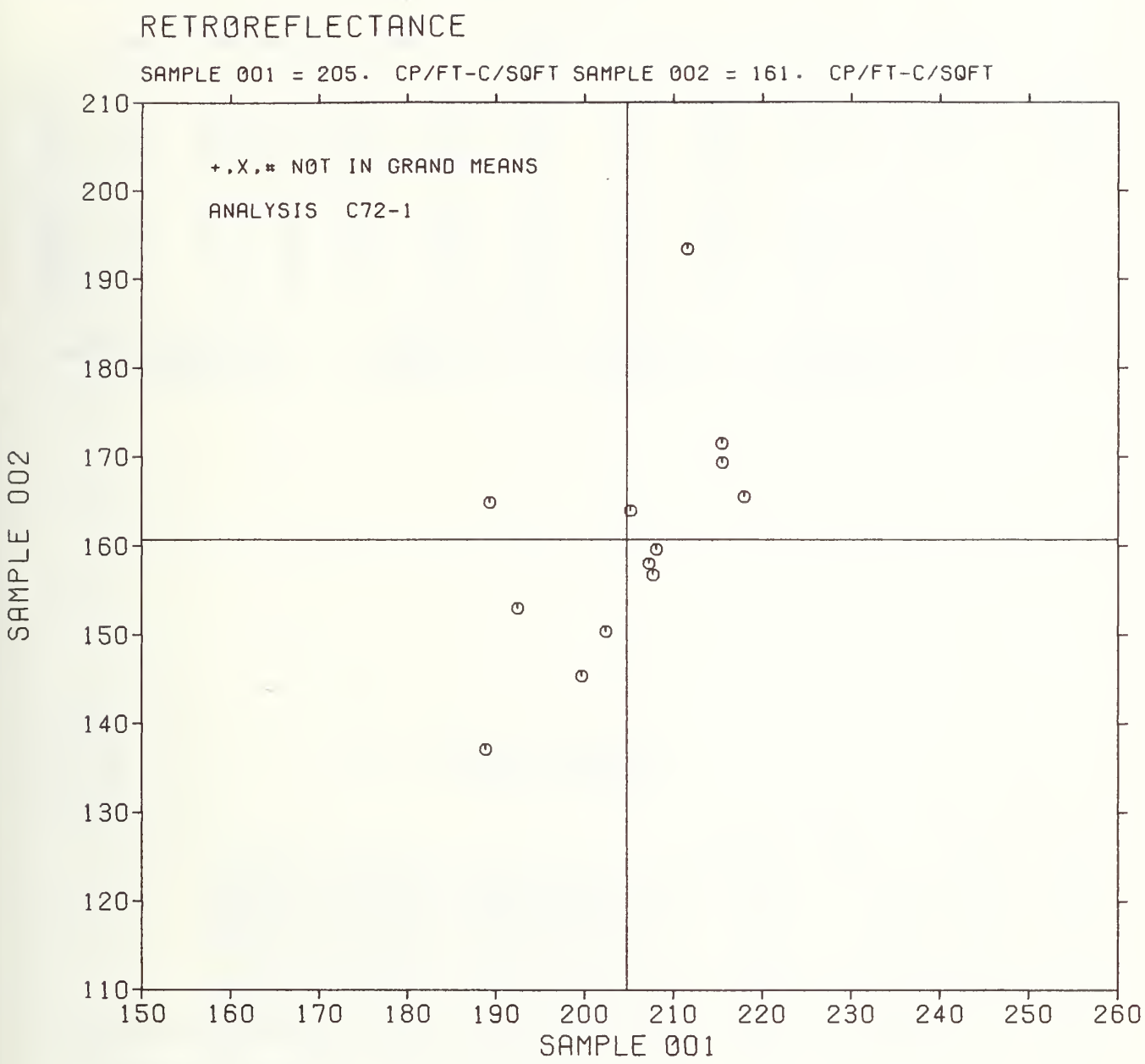
REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

LAB CODE	SAMPLE 601 MEAN	ORANGE AT -4,.2 DEG DEV	N.DEV	SDR	R.SDR	SAMPLE 602 MEAN	ORANGE AT 30,.2 DEG DEV	N.DEV	SDR	R.SDR	TEST D.- 4 VAR	F	LAB
C428	207.7	3.0	.31	1.5	.67	156.7	-3.9	-.28	9.5	1.04	72A	6	C428
C462	205.2	.5	.05	1.3	.55	163.9	3.3	.24	5.1	.56	72A	6	C462
C471	211.6	6.8	.70	3.3	1.48	193.4	32.7	2.37	11.2	1.23	72C	6	C471
C479	215.5	10.8	1.10	2.3	1.04	169.3	8.7	.63	5.8	.63	72A	6	C479
C480	215.5	10.7	1.10	1.3	.57	171.5	10.8	.78	18.9	2.07	72A	6	C480
C481	192.5	-12.3	-1.25	3.0	1.33	153.0	-7.7	-.56	7.7	.84	72A	6	C481
C486	208.1	3.4	.35	.5	.23	159.6	-1.1	-.08	3.8	.42	72A	6	C486
C488	218.0	13.2	1.35	4.1	1.81	165.5	4.8	.35	8.5	.93	72C	6	C488
C490	188.9	-15.9	-1.62	4.5	2.01	137.1	-23.6	-1.71	11.2	1.22	72A	6	C490
C491	199.7	-5.1	-.52	3.8	1.66	145.4	-15.3	-1.11	8.9	.98	72A	6	C491
C522	202.4	-2.4	-.24	1.0	.42	150.4	-10.3	-.75	10.9	1.20	72A	6	C522
C611	189.4	-15.4	-1.57	1.6	.73	164.9	4.2	.30	11.2	1.22	72A	6	C611
C614	207.3	2.5	.26	1.1	.49	158.0	-2.7	-.19	6.0	.66	72C	6	C614

GR. MEAN = 204.8 CP/FT-C/SQFT GRAND MEAN = 160.7 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = 9.8 CP/FT-C/SQFT SD OF MEANS = 13.8 CP/FT-C/SQFT 13 LABS IN GRAND MEANS
AVERAGE SDR = 2.3 CP/FT-C/SQFT AVERAGE SDR = 9.1 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 13

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

LAB CODE	F	MEANS 601	602	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	6	188.9	137.1	-28.3	2.0	1.62	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	6	189.4	164.9	-4.1	15.4	.98	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	6	192.5	153.0	-12.8	6.8	1.08	72A	RETROREFLECTANCE, METHOD LS3C0A OR LS300B
C491	6	199.7	145.4	-15.8	-3.2	1.32	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	6	202.4	150.4	-10.1	-3.1	.81	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C462	6	205.2	163.9	3.1	1.2	.56	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C614	6	207.3	158.0	-1.0	-3.5	.58	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C428	6	207.7	156.7	-1.9	-4.5	.85	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C486	6	208.1	159.6	.8	-3.5	.32	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	6	211.6	193.4	31.8	10.4	1.35	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C480	6	215.5	171.5	14.7	-3.9	1.32	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	6	215.5	169.3	12.9	-5.0	.84	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C488	6	218.0	165.5	10.8	-9.1	1.37	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		204.8	160.7			1.00		
		95% ELLIPSE:		45.5	20.6	WITH GAMMA = 60 DEGREES		


RETROREFLECTANCE
SAMPLE 001 = 205. CP/FT-C/SQFT SAMPLE 002 = 161. CP/FT-C/SQFT
+,X,* NOT IN GRAND MEANS
ANALYSIS C72-1
SAMPLE 002
SAMPLE 001
210
200
190
180
170
160
150
140
130
120
110
150
160
170
180
190
200
210
220
230
240
250
260

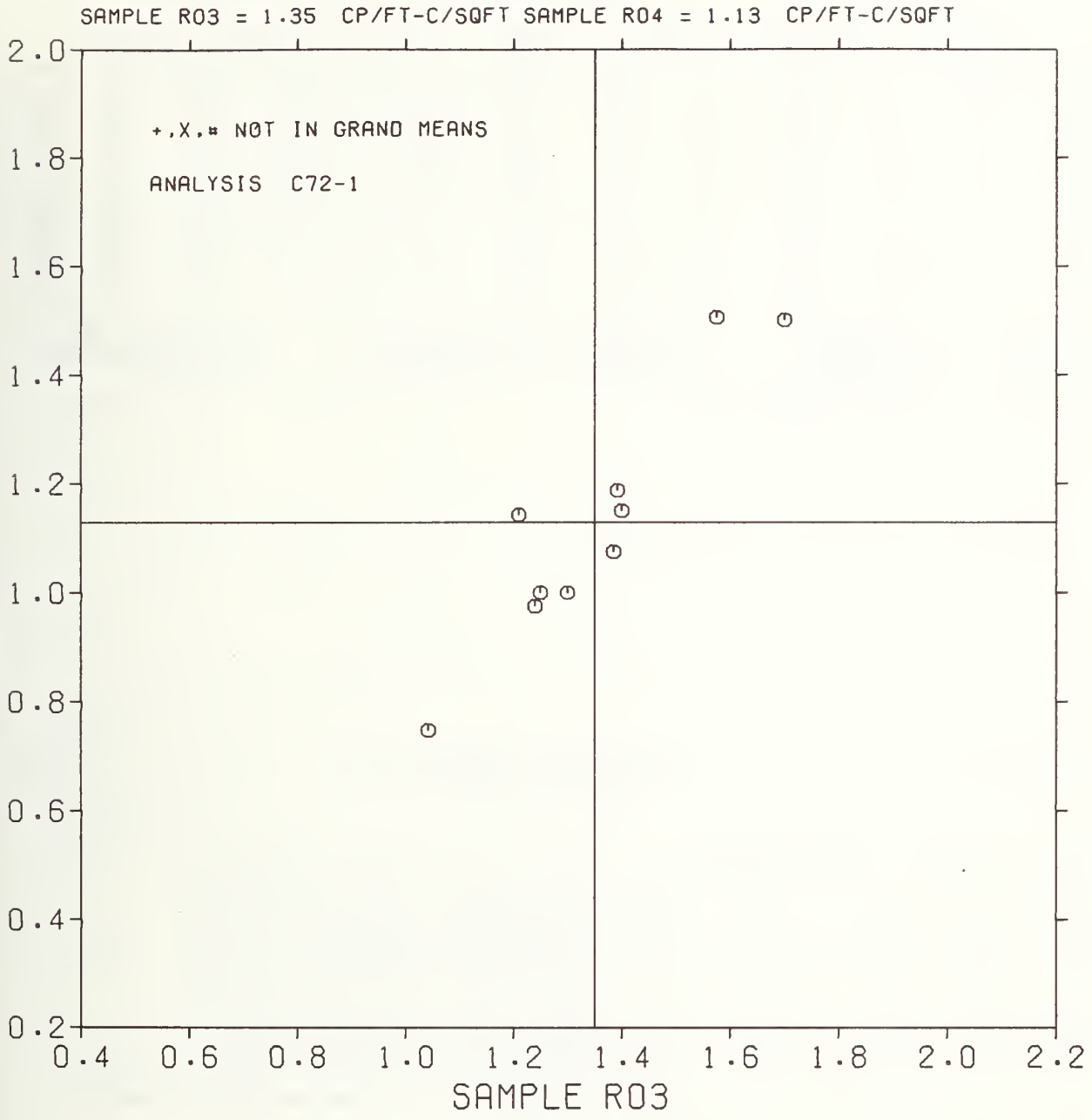
REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

LAB CODE	SAMPLE R03 MEAN	RED AT -4,2.0 DEGREES DEV	N.DEV	SDR	R.SDR	SAMPLE R04 MEAN	RED AT 30,2.0 DEGREES DEV	N.DEV	SDR	R.SDR	TEST D.= 4 VAR	F	LAB
C428	1.300	-.049	-.26	.000	.00	1.000	-.128	-.55	.000	.00	72A	O	C428
C462	1.700	.351	1.87	.000	.00	1.500	.372	1.60	.000	.00	72A	O	C462
C471	1.575	.226	1.20	.052	.60	1.505	.377	1.62	.064	2.75	72C	O	C471
C479	1.400	.051	.27	.000	.00	1.150	.022	.09	.058	2.50	72A	O	C479
C480	1.385	.036	.19	.142	1.65	1.075	-.053	-.23	.017	.75	72A	O	C480
C481	1.250	-.099	-.53	.500	5.80	1.000	-.128	-.55	.000	.00	72A	O	C481
C490	1.042	-.307	-1.63	.116	1.35	.747	-.381	-1.63	.017	.74	72A	O	C490
C491	1.392	.043	.23	.021	.24	1.187	.059	.25	.030	1.29	72A	O	C491
C522	1.240	-.109	-.58	.014	.16	.975	-.153	-.66	.019	.83	72A	O	C522
C611	1.210	-.139	-.74	.016	.19	1.142	.014	.06	.026	1.14	72A	O	C611
C614	24.025	22.675	120.74	.206	2.39	20.500	19.372	83.15	.271	11.73	72C	#	C614

GR. MEAN = 1.349 CP/FT-C/SQFT GRAND MEAN = 1.128 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = .188 CP/FT-C/SQFT SD OF MEANS = .233 CP/FT-C/SQFT 10 LABS IN GRAND MEANS
AVERAGE SDR = .086 CP/FT-C/SQFT AVERAGE SDR = .023 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 11

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

LAB CODE	F	MEANS R03	R04	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	O	1.042	.747	-.489	.004	1.05	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	O	1.210	1.142	-.076	.118	.66	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	O	1.240	.975	-.188	-.010	.50	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	O	1.250	1.000	-.162	-.002	2.90	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	O	1.300	1.000	-.131	-.041	.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	O	1.385	1.075	-.020	-.061	1.20	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	O	1.392	1.187	.073	.003	.77	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	O	1.400	1.150	.048	-.026	1.25	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	O	1.575	1.505	.435	.058	1.68	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C462	O	1.700	1.500	.509	-.043	.00	72A	RETROREFLECTANCE, METHOD LS300A OR L8300B
C614	#	24.025	20.500	29.272	-5.711	7.06	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		1.349	1.128			1.00		
		95% ELLIPSE:		.933	.168	WITH GAMMA = 51 DEGREES		


RETROREFLECTANCE
SAMPLE R03 = 1.35 CP/FT-C/SQFT SAMPLE R04 = 1.13 CP/FT-C/SQFT
+,X,* NOT IN GRAND MEANS
ANALYSIS C72-1
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8 2.0 2.2
SAMPLE R03

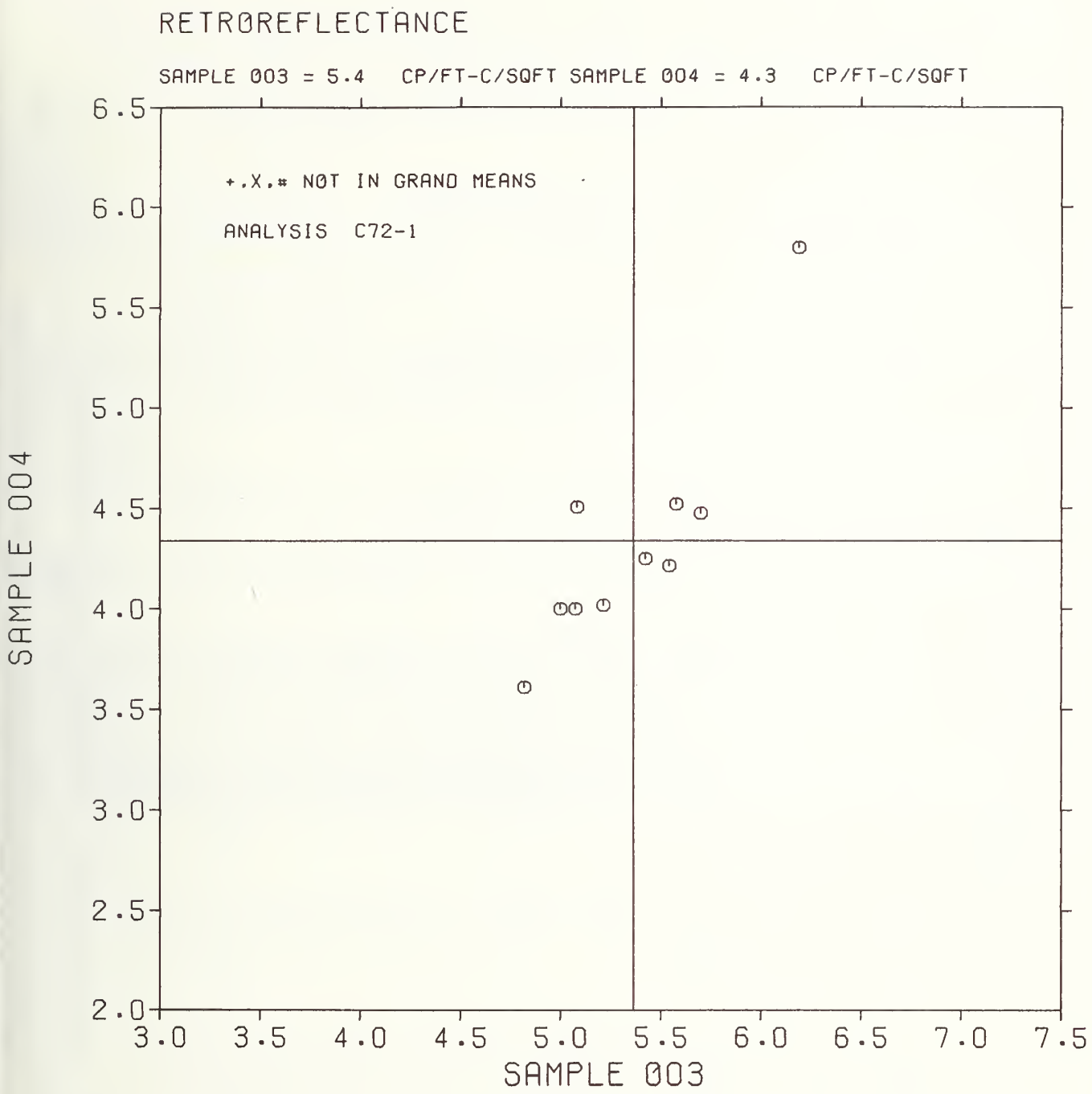
REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

LAB CODE	SAMPLE 603 MEAN	ORANGE AT -4.2.0 DEG DEV	N.DEV	SDR	R.SDR	SAMPLE 604 MEAN	ORANGE AT 30.2.0 DEG DEV	N.DEV	SDR	R.SDR	TEST D.= 4 VAR	F	LAB
C428	5.07	-.29	-.71	.05	.69	4.00	-.34	-.58	.22	1.89	72A	O	C428
C462	5.70	.34	.83	.00	.00	4.47	.14	.23	.15	1.31	72A	O	C462
C471	6.19	.83	2.03	.06	.80	5.79	1.46	2.49	.13	1.17	72C	O	C471
C479	5.42	.06	.15	.21	2.85	4.25	-.09	-.15	.06	.51	72A	O	C479
C480	5.58	.21	.53	.08	1.15	4.52	.18	.31	.18	1.55	72A	O	C480
C481	5.00	-.36	-.89	.00	.00	4.00	-.34	-.58	.00	.00	72A	O	C481
C490	4.82	-.54	-1.34	.11	1.54	3.61	-.73	-1.24	.05	.46	72A	O	C490
C491	5.54	.18	.44	.10	1.31	4.21	-.13	-.22	.06	.54	72A	O	C491
C522	5.21	-.15	-.36	.08	1.05	4.02	-.32	-.55	.20	1.71	72A	O	C522
C611	5.08	-.28	-.68	.04	.61	4.50	.17	.28	.10	.86	72A	O	C611
C614	77.10	71.74	176.41	.36	4.92	68.10	63.76	108.87	.63	5.49	72C	#	C614

GR. MEAN = 5.36 CP/FT-C/SQFT GRAND MEAN = 4.34 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = .41 CP/FT-C/SQFT SD OF MEANS = .59 CP/FT-C/SQFT 10 LABS IN GRAND MEANS
AVERAGE SDR = .07 CP/PT-C/SQFT AVERAGE SDR = .11 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 11

REPORT NO. 5 MCCA COLLABORATIVE REFERENCE PROGRAM 1977-1978
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

LAB CODE	F	MEANS 603	604	COORDINATES MAJOR	MINOR	AVG R.SDR	VAR	PROPERTY---TEST INSTRUMENT---CONDITIONS
C490	O	4.82	3.61	-.91	.05	1.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	O	5.00	4.00	-.48	.12	.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	O	5.07	4.00	-.44	.05	1.29	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	O	5.08	4.50	-.01	.32	.74	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	O	5.21	4.02	-.35	-.05	1.38	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	O	5.42	4.25	-.04	-.10	1.68	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	O	5.54	4.21	-.01	-.22	.92	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	O	5.58	4.52	.27	-.08	1.35	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C462	O	5.70	4.47	.30	-.21	.66	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	O	6.19	5.79	1.67	.11	.98	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
C614	#	77.10	68.10	92.75	-24.67	5.21	72C	RETROREFLECTANCE, METHOD AND INSTRUMENTATION SPECIFIED
GMEANS:		5.36	4.34			1.00		
		95% ELLIPSE:		2.20	.52	WITH GAMMA = 56 DEGREES		


RETROREFLECTANCE
SAMPLE 003 = 5.4 CP/FT-C/SQFT SAMPLE 004 = 4.3 CP/FT-C/SQFT
+.X.* NOT IN GRAND MEANS
ANALYSIS C72-1
SAMPLE 004
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5
SAMPLE 003

PERCENT DIFFERENCE BETWEEN
LABORATORY MEANS AND GRAND MEANS

Sheeting	Red	Orange	Red	Orange	Red	Orange	Red	Orange
Incidence Angle	-4°	-4°	30°	30°	-4°	-4°	30°	30°
Divergence Angle	.2°	.2°	.2°	.2°	2.0°	2.0°	2.0°	2.0°
GRAND MEAN	51.2	204.8	41.7	160.7	1.35	5.36	1.13	4.34
Lab Code								
C428	3.32	1.47	1.20	-2.43	-3.70	-5.41	-11.35	-7.83
C462	16.80	.24	21.10	2.05	25.93	6.34	32.98	3.23
C471	14.45	3.32	34.05	20.35	17.04	15.49	33.42	33.64
C479	1.76	5.27	-1.44	5.41	3.70	1.12	1.95	-2.07
C480	5.08	5.23	1.20	6.72	2.96	3.92	-4.70	4.14
C481	-7.23	-6.01	-9.59	-4.79	-7.41	-6.72	-11.35	-7.83
C486	1.76	1.66	-.96	-.69	- - -	- - -	- - -	- - -
C488	4.49	6.45	-1.68	2.99	- - -	- - -	- - -	- - -
C490	-23.24	-7.76	-25.90	-14.69	-22.96	-10.08	-33.78	-16.82
C491	-2.54	-2.49	-8.63	-9.52	2.96	3.36	5.23	-3.00
C522	-10.55	-1.17	-14.63	-6.41	-8.15	-2.80	-13.56	-7.37
C611	-9.38	-7.52	2.64	2.61	-10.37	-5.22	1.24	3.92
C614	5.27	1.22	2.40	-1.68	*	*	*	*

$$\text{PERCENT DIFFERENCE} = \frac{\text{Laboratory Mean - Grand Mean}}{\text{Grand Mean}} \text{ X100}$$

* Lab C614 measured at other than specified divergence angle

NBS-114A (REV. 7-73)

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6. Performing Organization Code:

7. AUTHOR(S)

J. Horlick, J. Stevenson

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DEPARTMENT OF COMMERCE
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10. Project/Task/Work Unit No. 7825578

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12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)*

Collaborative Testing Services, Inc., 9241 Wood Glade Drive, Great Falls, VA 22066; and Manufacturers Council on Color and Appearance.

13. Type of Report & Period Covered: Final

14. Sponsoring Agency Code:

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Collaborative Reference Programs provide participating laboratories with the means for checking periodically the level and uniformity of their testing in comparison with that of other participating laboratories. An important by-product of the programs is the provision of realistic pictures of the state of the testing art. This is one of the periodic reports showing averages for each participant, within and between laboratory variability, and other information for participants and standards committees.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Collaborative reference program; Gloss; Laboratory evaluation; Precision; Reference samples; Testing calibration.

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