

NBSIR 78-1355

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

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Concora test of medium

MCCA Color and Appearance (4 times per year)

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Color and color difference
Retroreflectivity

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Hardness
Mooney viscosity
Vulcanization properties

ASTM Textiles (3 times per year)

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ASTM Cement (2 times per year)

Chemical (11 chemical components)
Physical (8 characteristics)

AASHTO Bituminous

Asphalt cement (2 times per year)
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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**

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.

MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE R01		RED AT -4.2 DEGREES				SAMPLE 001		GRANGE AT -4.2 DEG				TEST D. = 4		
	MEAN	DEV	N.DEV	SDR	R.SDR		MEAN	DEV	N.DEV	SDR	R.SDR		VAR	F	LAB
C428	52.9	1.7	.31	.3	.41		207.7	3.0	.31	1.5	.67		72A	0	C428
C462	59.8	8.6	1.57	1.2	1.55		205.2	.5	.05	1.3	.55		72A	0	C462
C471	58.6	7.4	1.35	2.4	3.14		211.6	6.8	.70	3.3	1.48		72C	0	C471
C479	52.1	.9	.16	.4	.48		215.5	10.8	1.10	2.3	1.04		72A	0	C479
C480	53.8	2.6	.48	.5	.61		215.5	10.7	1.10	1.3	.57		72A	0	C480
C481	47.5	-3.7	-.68	.6	.75		192.5	-12.3	-1.25	3.0	1.33		72A	0	C481
C486	52.1	.9	.16	.9	1.21		208.1	3.4	.35	.5	.23		72A	0	C486
C488	53.5	2.3	.42	.6	.75		218.0	13.2	1.35	4.1	1.81		72C	0	C488
C490	39.3	-11.9	-2.17	1.3	1.62		188.9	-15.9	-1.62	4.5	2.01		72A	0	C490
C491	49.9	-1.3	-.24	.6	.80		199.7	-5.1	-.52	3.8	1.66		72A	0	C491
C522	45.8	-5.4	-.98	.5	.65		202.4	-2.4	-.24	1.0	.42		72A	0	C522
C611	46.4	-4.8	-.87	.2	.22		189.4	-15.4	-1.57	1.6	.73		72A	0	C611
C614	53.9	2.7	.50	.6	.83		207.3	2.5	.26	1.1	.49		72C	0	C614

GR. MEAN = 51.2 CF/FT-C/SQFT

SD MEANS = 5.5 CF/FT-C/SQFT

AVERAGE SDR = .8 CF/FT-C/SQFT

TOTAL NUMBER OF LABORATORIES REPORTING = 13

GRAND MEAN = 204.8 CF/FT-C/SQFT

SD OF MEANS = 9.8 CF/FT-C/SQFT

AVERAGE SDR = .8 CF/FT-C/SQFT

TEST DETERMINATIONS = 4

13 LABS IN GRAND MEANS

2.3 CF/FT-C/SQFT

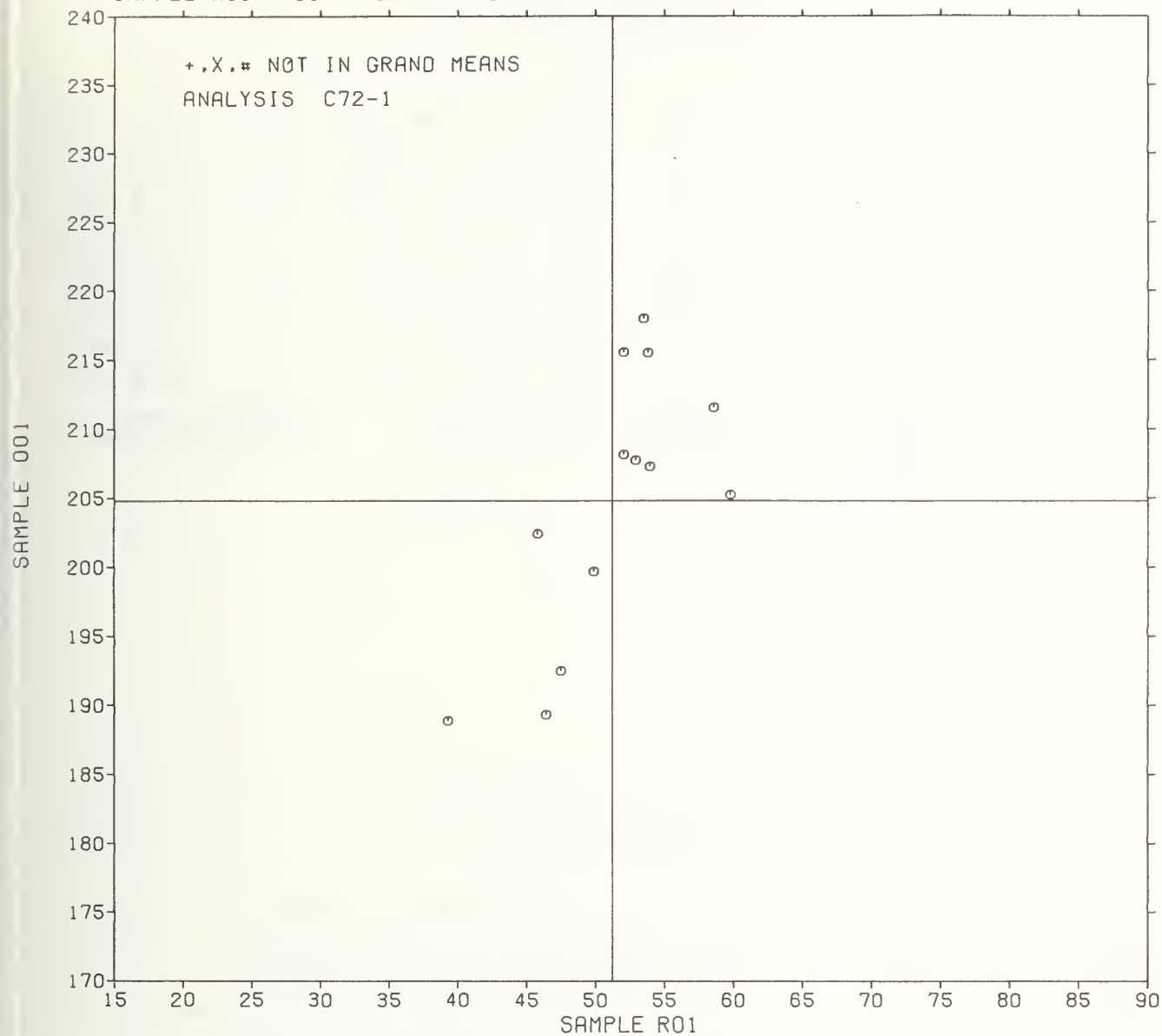
MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG R.SDR	VAR	PROPERTY	TEST	INSTRUMENT	CONDITIONS
		R01	001	MAJOR	MINOR						
C490	0	39.3	188.9	-19.4	4.1	1.82	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C522	0	45.8	202.4	-4.4	3.9	.54	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C611	0	46.4	189.4	-16.0	-2.1	.48	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C481	0	47.5	192.5	-12.7	-1.8	1.04	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C491	0	49.9	199.7	-5.2	-.9	1.23	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C486	0	52.1	208.1	3.4	.6	.72	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C479	0	52.1	215.5	10.2	3.7	.76	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C428	0	52.9	207.7	3.4	-.3	.54	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C488	0	53.5	218.0	13.0	3.5	1.28	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED	
C480	0	53.8	215.5	10.8	2.1	.59	72A	RETROREFLECTANCE,	METHOD	LS300A	OR LS300B
C614	0	53.9	207.3	3.5	-1.4	.66	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED	
C471	0	58.6	211.6	9.3	-3.8	2.31	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED	
C462	0	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



MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE R02		RED AT 30.2 DEGREES				SAMPLE G02		ORANGE AT 30.2 DEG				TEST D. = 4		
	MEAN	DEV	N. DEV	SDR	R. SDR		MEAN	DEV	N. DEV	SDR	R. SDR		VAR	F	LAB
C428	42.2	.5	.07	1.7	.98		156.7	-3.9	-.28	9.5	1.04		72A	Ø	C428
C462	50.5	8.8	1.42	2.5	1.47		163.9	3.3	.24	5.1	.56		72A	Ø	C462
C471	55.9	14.2	2.28	3.6	2.10		193.4	32.7	2.37	11.2	1.23		72C	Ø	C471
C479	41.1	-.6	-.09	1.9	1.11		169.3	8.7	.63	5.8	.63		72A	Ø	C479
C480	42.2	.5	.09	1.9	1.09		171.5	10.8	.78	18.9	2.07		72A	Ø	C480
C481	37.7	-4.0	-.63	1.5	.88		153.0	-7.7	-.56	7.7	.84		72A	Ø	C481
C486	41.3	-.4	-.07	.8	.49		159.6	-1.1	-.08	3.8	.42		72A	Ø	C486
C488	41.0	-.7	-.11	1.8	1.08		165.5	4.8	.35	8.5	.93		72C	Ø	C488
C490	30.9	-10.8	-1.74	1.3	.76		137.1	-23.6	-1.71	11.2	1.22		72A	Ø	C490
C491	38.1	-3.6	-.57	1.8	1.08		145.4	-15.3	-1.11	8.9	.98		72A	Ø	C491
C522	35.6	-6.1	-.98	1.7	1.00		150.4	-10.3	-.75	10.9	1.20		72A	Ø	C522
C611	42.8	1.1	.18	.2	.13		164.9	4.2	.30	11.2	1.22		72A	Ø	C611
C614	42.7	1.0	.16	1.4	.83		158.0	-2.7	-.19	6.0	.66		72C	Ø	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															

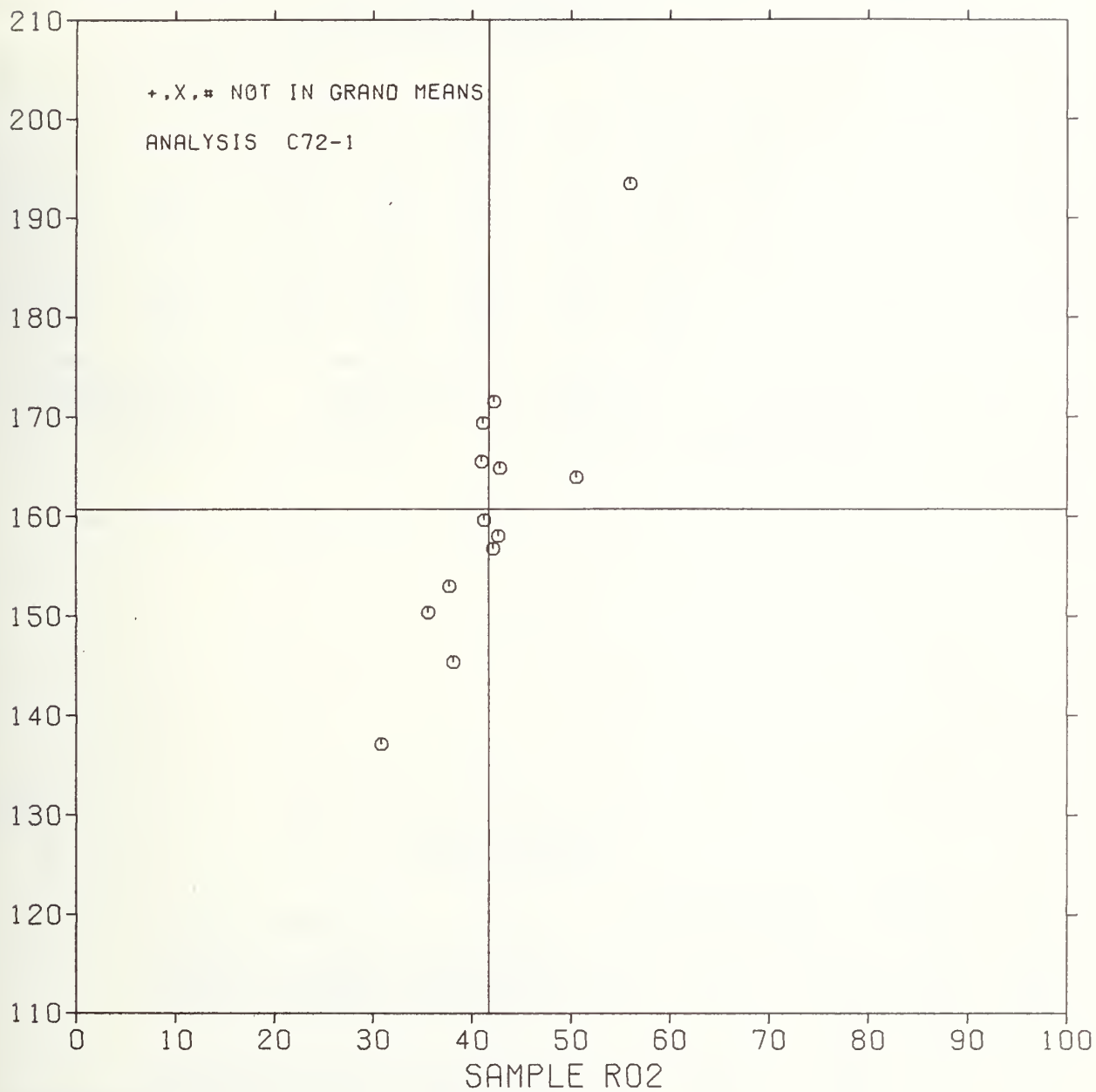
MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG		PROPERTY==TEST INSTRUMENT==CONDITIONS								
		R02	G02	MAJOR	MINOR	R. SDR	VAR									
C490	Ø	30.9	137.1	-25.9	1.1	.99	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C522	Ø	35.6	150.4	-11.8	1.8	1.10	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C481	Ø	37.7	153.0	-8.6	.8	.86	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C491	Ø	38.1	145.4	-15.5	-2.5	1.03	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C488	Ø	41.0	165.5	4.2	2.5	1.01	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED						
C479	Ø	41.1	169.3	7.8	3.8	.87	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C486	Ø	41.3	159.6	-1.2	.0	.45	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C428	Ø	42.2	156.7	-3.5	-1.9	1.01	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C480	Ø	42.2	171.5	10.2	3.6	1.58	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C614	Ø	42.7	158.0	-2.1	-1.9	.74	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED						
C611	Ø	42.8	164.9	4.3	.5	.68	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C462	Ø	50.5	163.9	6.4	-6.9	1.02	72A	RETROREFLECTANCE,	METHOD	LS300A	ØR	LS300B				
C471	Ø	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	WIDE GAMMA = 67 DEGREES										

RETROREFLECTANCE

SAMPLE R02 = 42. CP/FT-C/SQFT SAMPLE 002 = 161. CP/FT-C/SQFT



MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE R03		RED AT -4.2.0 DEGREES				SAMPLE G03		ORANGE AT -4.2.0 DEG				TEST D. " 4		
	MEAN	DEV	N. DEV	SDR	R. SDR		MEAN	DEV	N. DEV	SDR	R. SDR		VAR	F	LAB
C428	1.30	-.05	-.26	.00	.00		5.07	-.29	-.71	.05	.69		72A	Ø	C428
C462	1.70	.35	1.87	.00	.00		5.70	.34	.83	.00	.00		72A	Ø	C462
C471	1.57	.23	1.20	.05	.60		6.19	.83	2.03	.06	.80		72C	Ø	C471
C479	1.40	.05	.27	.00	.00		5.42	.06	.15	.21	2.85		72A	Ø	C479
C480	1.38	.04	.19	.14	1.65		5.58	.21	.53	.08	1.15		72A	Ø	C480
C481	1.25	-.10	-.53	.50	5.80		5.00	-.36	-.89	.00	.00		72A	Ø	C481
C490	1.04	-.31	-1.63	.12	1.35		4.82	-.54	-1.34	.11	1.54		72A	Ø	C490
C491	1.39	.04	.23	.02	.24		5.54	.18	.44	.10	1.31		72A	Ø	C491
C522	1.24	-.11	-.58	.01	.16		5.21	-.15	-.36	.08	1.05		72A	Ø	C522
C611	1.21	-.14	-.74	.02	.19		5.08	-.28	-.68	.04	.61		72A	Ø	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/SOFT GRAND MEAN = 5.36 CP/FT=C/SOFT TEST DETERMINATIONS = 4															
SD MEANS = .19 CP/FT=C/SOFT SD OF MEANS = .41 CP/FT=C/SOFT 10 LABS IN GRAND MEANS															
AVERAGE SDR = .09 CP/FT=C/SOFT AVERAGE SDR = .07 CP/FT=C/SOFT															
TOTAL NUMBER OF LABORATORIES REPORTING = 11															

MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

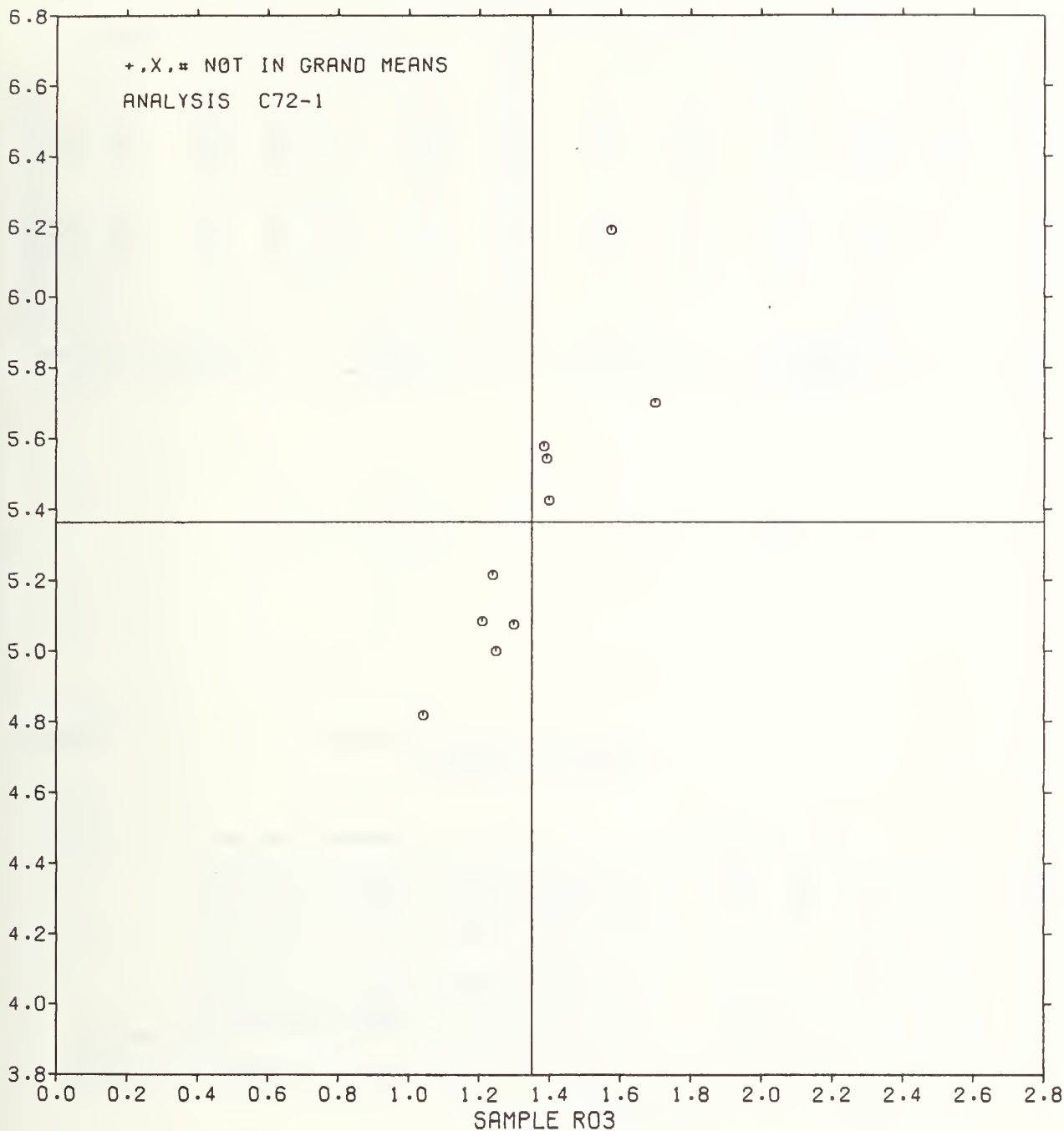
1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG		PROPERTY==TEST	INSTRUMENT==CONDITIONS
		R03	G03	MAJOR	MINOR	R. SDR	VAR		
C490	Ø	1.04	4.82	-.62	.07	1.45	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C611	Ø	1.21	5.08	-.31	.02	.40	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C522	Ø	1.24	5.21	-.18	.04	.61	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C481	Ø	1.25	5.00	-.37	-.05	2.90	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C428	Ø	1.30	5.07	-.28	-.07	.35	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C480	Ø	1.38	5.58	.21	.05	1.40	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C491	Ø	1.39	5.54	.18	.03	.78	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C479	Ø	1.40	5.42	.08	-.02	1.42	72A	RETROREFLECTANCE, METHOD	LS300A ØR LS300B
C471	Ø	1.57	6.19	.85	.11	.70	72C	RETROREFLECTANCE, METHOD	AND INSTRUMENTATION SPECIFIED
C462	Ø	1.70	5.70	.45	-.19	.00	72A	RETROREFLECTANCE, METHOD	LS300A ØR 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

SAMPLE 003



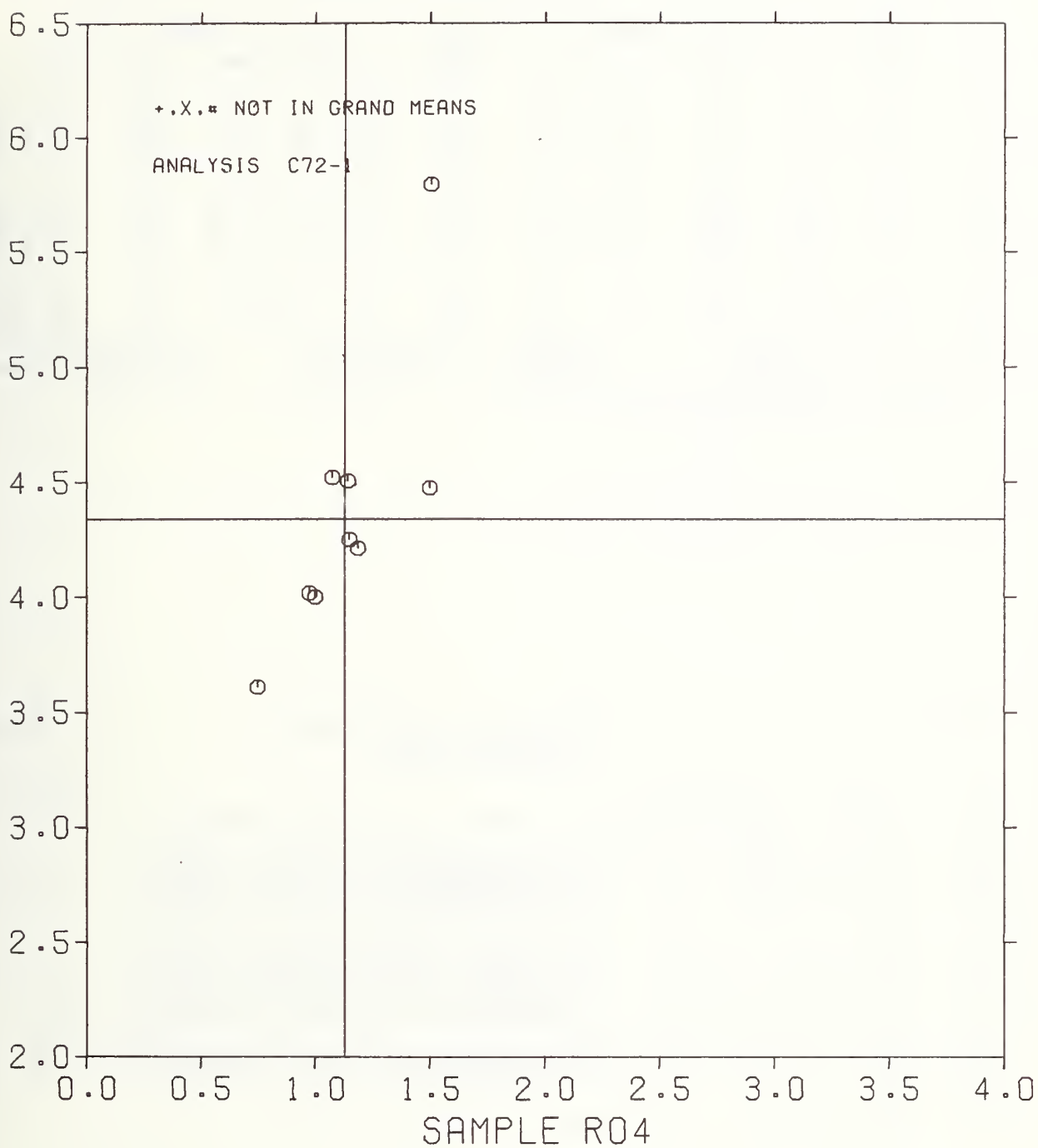
LAB CODE	SAMPLE R04		RED AT 30.2.0 DEGREES				SAMPLE G04		ORANGE AT 30.2.0 DEG				TEST D. = 4		
	MEAN	DEV	N.DEV	SDR	R.SDR		MEAN	DEV	N.DEV	SDR	R.SDR		VAR	F	LAB
C428	1.000	-.128	-.55	.000	.00		4.000	-.338	-.58	.216	1.89		72A	Ø	C428
C462	1.500	.372	1.60	.000	.00		4.475	.137	.23	.150	1.31		72A	Ø	C462
C471	1.505	.377	1.62	.064	2.75		5.795	1.456	2.49	.134	1.17		72C	Ø	C471
C479	1.150	.022	.09	.058	2.50		4.250	-.088	-.15	.058	.51		72A	Ø	C479
C480	1.075	-.053	-.23	.017	.75		4.520	.182	.31	.177	1.55		72A	Ø	C480
C481	1.000	-.128	-.55	.000	.00		4.000	-.338	-.58	.000	.00		72A	Ø	C481
C490	.747	-.381	-1.63	.017	.74		3.610	-.728	-1.24	.052	.46		72A	Ø	C490
C491	1.187	.059	.25	.030	1.29		4.212	-.126	-.22	.061	.54		72A	Ø	C491
C522	.975	-.153	-.66	.019	.83		4.017	-.321	-.55	.195	1.71		72A	Ø	C522
C611	1.142	.014	.06	.026	1.14		4.505	.167	.28	.098	.86		72A	Ø	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						G AND 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															

LAB		MEANS		COORDINATES		AVG		PROPERTY---TEST INSTRUMENT---CONDITIONS					
CODE	F	R04	G04	MAJOR	MINOR	R.SDR	VAR						
C490	Ø	.747	3.610	-.812	.127	.60	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C522	Ø	.975	4.017	-.353	.042	1.21	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C428	Ø	1.000	4.000	-.362	.013	.91	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C481	Ø	1.000	4.000	-.362	.013	.00	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C480	Ø	1.075	4.520	.155	.109	1.11	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C611	Ø	1.142	4.505	.162	.040	1.00	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C479	Ø	1.150	4.250	-.077	-.049	1.50	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C491	Ø	1.187	4.212	-.100	-.097	.91	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C462	Ø	1.500	4.475	.249	-.308	.60	72A	RETROREFLECTANCE,	METHOD	LS300A	OR	LS300B	
C471	Ø	1.505	5.795	1.500	.111	1.90	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED			
C614	#	20.500	68.100	66.605	2.138	8.61	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED			
GMEANS:		1.128	4.338			1.00							
		55% 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

SAMPLE 004



LAB CODE	RED AT -4.2 DEGREES					RED AT 30.2 DEGREES					TEST D. = 4		
	SAMPLE R01 MEAN	DEV	N. DEV	SDR	R. SDR	SAMPLE R02 MEAN	DEV	N. DEV	SDR	R. SDR	VAR	F	LAB
C428	52.9	1.7	.31	.3	.41	42.2	.5	.07	1.7	.98	72A	Ø	C428
C462	59.8	8.6	1.57	1.2	1.55	50.5	8.8	1.42	2.5	1.47	72A	Ø	C462
C471	58.6	7.4	1.35	2.4	3.14	55.9	14.2	2.28	3.6	2.10	72C	Ø	C471
C479	52.1	.9	.16	.4	.48	41.1	-.6	-.09	1.9	1.11	72A	Ø	C479
C480	53.8	2.6	.48	.5	.61	42.2	.5	.09	1.9	1.09	72A	Ø	C480
C481	47.5	-3.7	-.68	.6	.75	37.7	-4.0	-.63	1.5	.88	72A	Ø	C481
C486	52.1	.9	.16	.9	1.21	41.3	-.4	-.07	.8	.49	72A	Ø	C486
C488	53.5	2.3	.42	.6	.75	41.0	-.7	-.11	1.8	1.08	72C	Ø	C488
C490	39.3	-11.9	-2.17	1.3	1.62	30.9	-10.8	-1.74	1.3	.76	72A	Ø	C490
C491	49.9	-1.3	-.24	.6	.80	38.1	-3.6	-.57	1.8	1.08	72A	Ø	C491
C522	45.8	-5.4	-.98	.5	.65	35.6	-6.1	-.98	1.7	1.00	72A	Ø	C522
C611	46.4	-4.8	-.87	.2	.22	42.8	1.1	.18	.2	.13	72A	Ø	C611
C614	53.9	2.7	.50	.6	.83	42.7	1.0	.16	1.4	.83	72C	Ø	C614

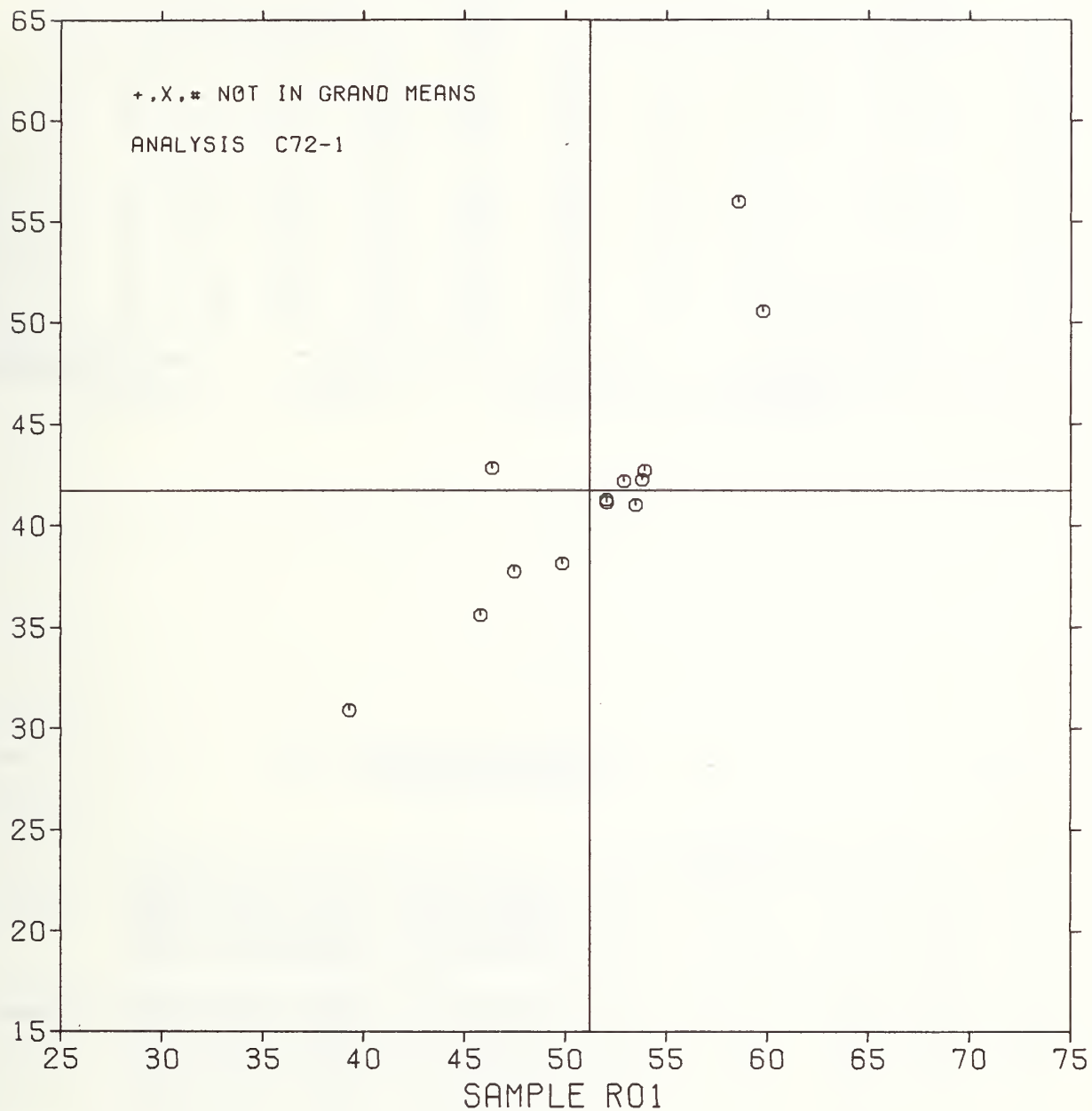
GR. MEAN = 51.2 CP/FT-C/SQFT GRAND MEAN = 41.7 CP/FT-C/SQFT TEST DETERMINATIONS = 4
SD MEANS = 5.5 CP/FT-C/SQFT SD OF MEANS = 6.2 CP/FT-C/SQFT 13 LABS IN GRAND MEANS
AVERAGE SDR = .8 CP/FT-C/SQFT AVERAGE SDR = 1.7 CP/FT-C/SQFT
TOTAL NUMBER OF LABORATORIES REPORTING = 13

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

RETROREFLECTANCE

SAMPLE R01 = 51. CP/FT-C/SQFT SAMPLE R02 = 42. CP/FT-C/SQFT

SAMPLE R02



MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE 001		ORANGE AT -4.2 DEG				SAMPLE 002		ORANGE AT 30.2 DEG				TEST D. = 4		
	MEAN	DEV	N.DEV	SDR	R.SDR		MEAN	DEV	N.DEV	SDR	R.SDR		VAR	F	LAB
C428	207.7	3.0	.31	1.5	.67		155.7	-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 CF/FT-C/SQFT

GRAND MEAN = 160.7 CF/FT-C/SQFT

TEST DETERMINATIONS = 4

SD MEANS = 9.8 CF/FT-C/SQFT

SD OF MEANS = 13.8 CF/FT-C/SQFT

13 LABS IN GRAND MEANS

AVERAGE SDR = 2.3 CF/FT-C/SQFT

AVERAGE SDR = 9.1 CF/FT-C/SQFT

TOTAL NUMBER OF LABORATORIES REPORTING = 13

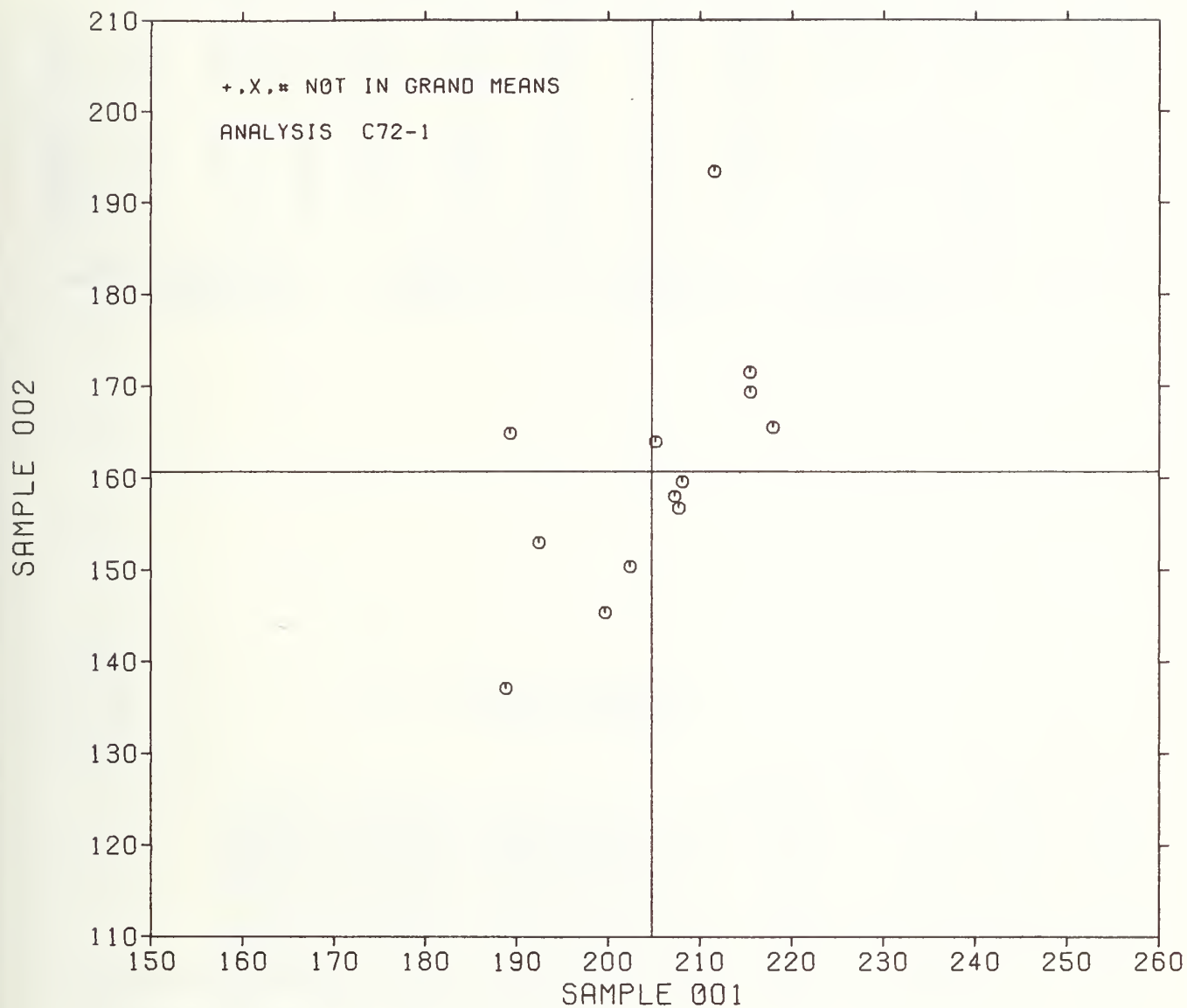
MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG		PROPERTY---TEST INSTRUMENT---CONDITIONS							
		001	002	MAJOR	MINOR	R.SDR	VAR								
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 LS300A 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



MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE R03		RED AT -4.2.0 DEGREES				SAMPLE R04		RED AT 30.2.0 DEGREES				TEST D. = 4		
	MEAN	DEV	N. DEV	SDR	R. SDR		MEAN	DEV	N. DEV	SDR	R. SDR		VAR	F	LAB
C428	1.300	-.049	-.26	.000	.00		1.000	-.128	-.55	.000	.00		72A	Ø	C428
C462	1.700	.351	1.87	.000	.00		1.500	.372	1.60	.000	.00		72A	Ø	C462
C471	1.575	.226	1.20	.052	.60		1.505	.377	1.62	.064	2.75		72C	Ø	C471
C479	1.400	.051	.27	.000	.00		1.150	.022	.09	.058	2.50		72A	Ø	C479
C480	1.385	.036	.19	.142	1.65		1.075	-.053	-.23	.017	.75		72A	Ø	C480
C481	1.250	-.099	-.53	.500	5.80		1.000	-.128	-.55	.000	.00		72A	Ø	C481
C490	1.042	-.307	-1.63	.116	1.35		.747	-.381	-1.63	.017	.74		72A	Ø	C490
C491	1.392	.043	.23	.021	.24		1.187	.059	.25	.030	1.29		72A	Ø	C491
C522	1.240	-.109	-.58	.014	.16		.975	-.153	-.66	.019	.83		72A	Ø	C522
C611	1.210	-.139	-.74	.016	.19		1.142	.014	.06	.026	1.14		72A	Ø	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

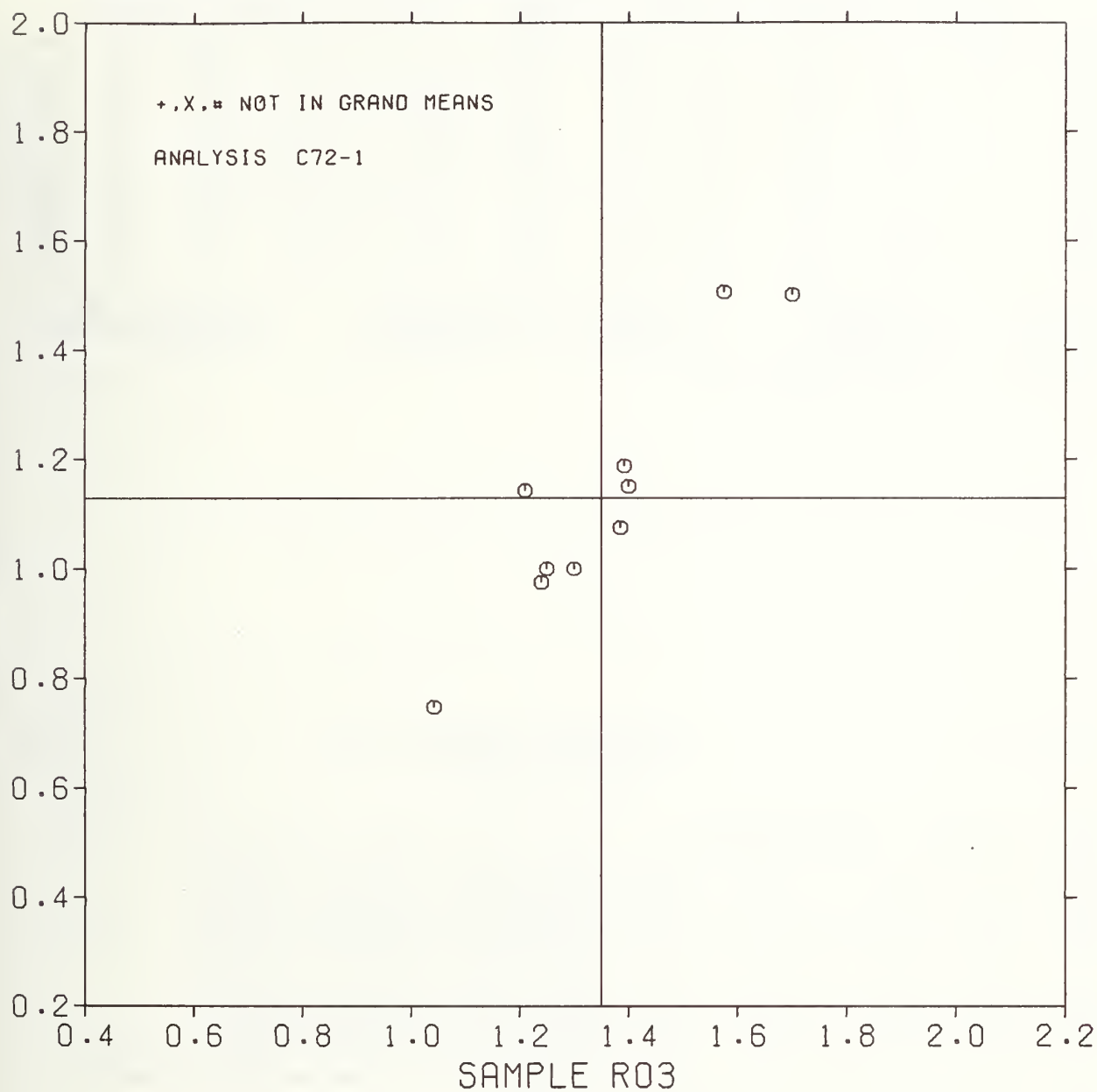
MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG		PROPERTY	TEST INSTRUMENT	CONDITIONS
		R03	R04	MAJOR	MINOR	R. SDR	VAR			
C490	Ø	1.042	.747	-.489	.004	1.05	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C611	Ø	1.210	1.142	-.076	.118	.66	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C522	Ø	1.240	.975	-.188	-.010	.50	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C481	Ø	1.250	1.000	-.162	-.002	2.90	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C428	Ø	1.300	1.000	-.131	-.041	.00	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C480	Ø	1.385	1.075	-.020	-.061	1.20	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C491	Ø	1.352	1.187	.073	.003	.77	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C479	Ø	1.400	1.150	.048	-.026	1.25	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
C471	Ø	1.575	1.505	.435	.058	1.68	72C	RETROREFLECTANCE,	METHOD	AND INSTRUMENTATION SPECIFIED
C462	Ø	1.700	1.500	.509	-.043	.00	72A	RETROREFLECTANCE,	METHOD	LS300A ØR LS300B
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



MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 1
RETROREFLECTANCE

1977-1978

LAB CODE	SAMPLE 003		GRANGE AT -4.2.0 DEG				SAMPLE 004		GRANGE AT 30.2.0 DEG				TEST D. = 4		
	MEAN	DEV	N. DEV	SDR	R. SDR		MEAN	DEV	N. DEV	SDR	R. SDR		VAR	F	LAB
C428	5.07	-.29	-.71	.05	.69		4.00	-.34	-.58	.22	1.89		72A	Ø	C428
C462	5.70	.34	.83	.00	.00		4.47	.14	.23	.15	1.31		72A	Ø	C462
C471	6.19	.83	2.03	.06	.80		5.79	1.46	2.49	.13	1.17		72C	Ø	C471
C479	5.42	.06	.15	.21	2.85		4.25	-.09	-.15	.06	.51		72A	Ø	C479
C480	5.58	.21	.53	.08	1.15		4.52	.18	.31	.18	1.55		72A	Ø	C480
C481	5.00	-.36	-.89	.00	.00		4.00	-.34	-.58	.00	.00		72A	Ø	C481
C490	4.82	-.54	-1.34	.11	1.54		3.61	-.73	-1.24	.05	.46		72A	Ø	C490
C491	5.54	.18	.44	.10	1.31		4.21	-.13	-.22	.06	.54		72A	Ø	C491
C522	5.21	-.15	-.36	.08	1.05		4.02	-.32	-.55	.20	1.71		72A	Ø	C522
C611	5.08	-.28	-.68	.04	.61		4.50	.17	.28	.10	.86		72A	Ø	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/FT=C/SQFT AVERAGE SDR = .11 CP/FT=C/SQFT															
TOTAL NUMBER OF LABORATORIES REPORTING = 11															

MCCA COLLABORATIVE REFERENCE PROGRAM
ANALYSIS C72-1 TABLE 2
RETROREFLECTANCE

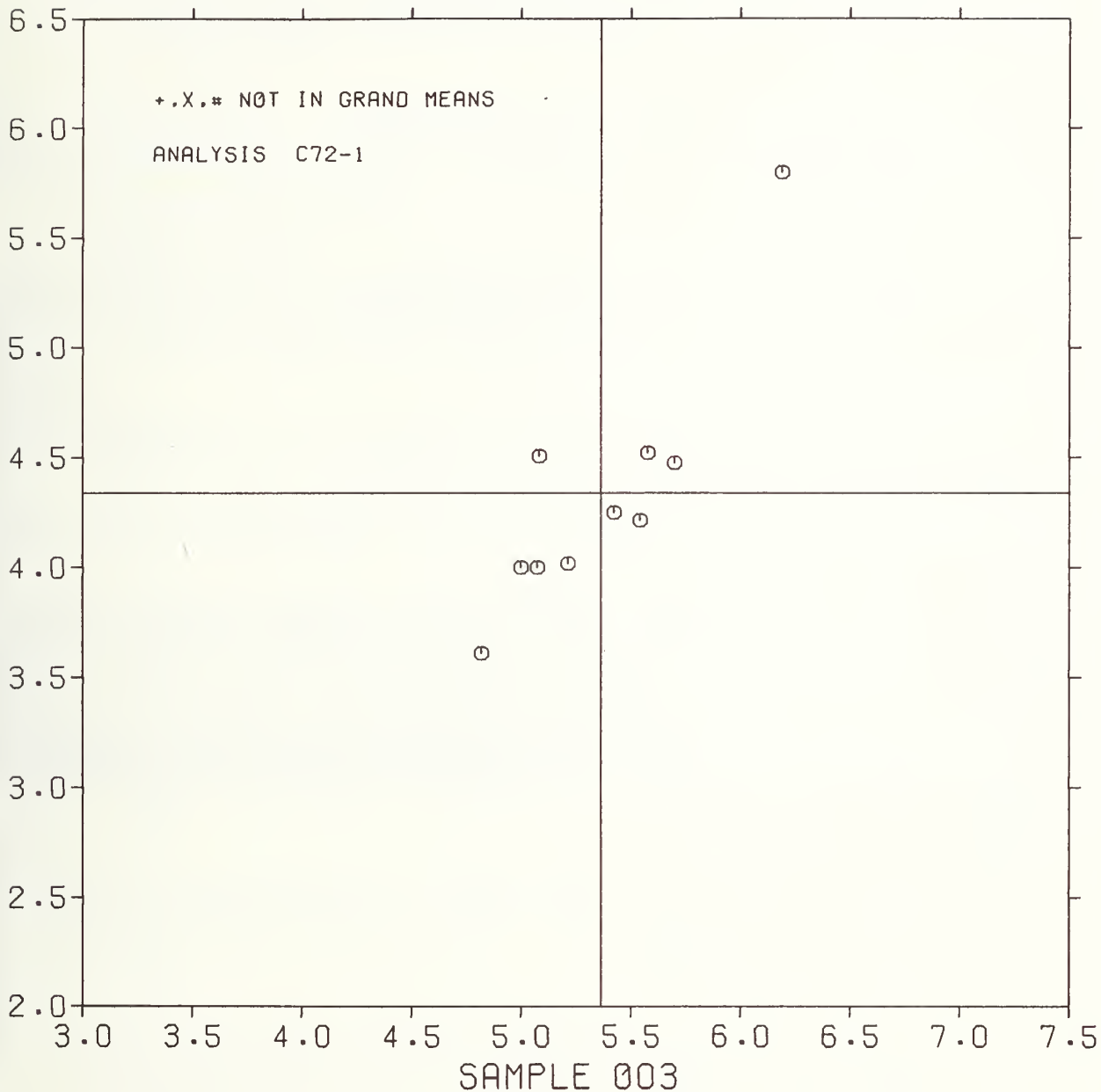
1977-1978

LAB CODE	F	MEANS		COORDINATES		AVG		PROPERTY==TEST INSTRUMENT==CONDITIONS
		003	004	MAJOR	MINOR	R. SDR	VAR	
C490	Ø	4.82	3.61	-.91	.05	1.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C481	Ø	5.00	4.00	-.48	.12	.00	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C428	Ø	5.07	4.00	-.44	.05	1.29	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C611	Ø	5.08	4.50	-.01	.32	.74	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C522	Ø	5.21	4.02	-.35	-.05	1.38	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C479	Ø	5.42	4.25	-.04	-.10	1.68	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C491	Ø	5.54	4.21	-.01	-.22	.92	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C480	Ø	5.58	4.52	.27	-.08	1.35	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C462	Ø	5.70	4.47	.30	-.21	.66	72A	RETROREFLECTANCE, METHOD LS300A OR LS300B
C471	Ø	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

SAMPLE 004



PERCENT DIFFERENCE BETWEEN
LABORATORY MEANS AND GRAND MEANS

Sheeting	Red	Orange	Red	Orange	Red	Orange	Red	Orange	Red	Orange
Incidence Angle	-4°	-4°	30°	30°	-4°	-4°	30°	30°	30°	30°
Divergence Angle	.2°	.2°	.2°	.2°	2.0°	2.0°	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	-9.6	-6.9	-	-	-	-		
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	*	*	*	*		

$$\text{PERCENT DIFFERENCE} = \frac{\text{Laboratory Mean} - \text{Grand Mean}}{\text{Grand Mean}} \times 100$$

* Lab C614 measured at other than specified divergence angle

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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.			
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