IMPLEMENTATION OF THE PROSCAN SYSTEM IN OKLAHOMA

July, 1998

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16. ABSTRACT

The Oklahoma Department of Transportation (ODOT) conducted a Profilograph Operator's Training and Certification Course in November, 1995. Course exercises included testing one track of a roadway with six different profilographs. The profilographs used consisted of two each of three different types. Differences in results produced by the various instruments indicate that all profilographs to be used on ODOT projects should have their accuracy verified by testing a common track. In the past, controls on Profilograph accuracy have been limited to calibrating the machines to the manufacturer's recommendations.

In other exercises, students interpreted copies of the same profilogram manually and with the ProScan Computer Scanner System. Results from manual interpretation were significantly more variable than those from ProScan interpretations. This agrees with comparisons made by others and preliminary work by ODOT.

Time required by the students to complete both manual and ProScan interpretations was also recorded. Labor savings due to use of the ProScan System were calculated based on this information.

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SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units					Approximate Conversions from SI Units				
Symbol	**When you know**	**Multiply by**	**To Find**	**Symbol**	**Symbol**	**When you know**	**Multiply by**	**To Find**	**Symbol**
		LENGTH					**LENGTH**		
in	inches	25.40	millimeters	mm	mm	millimeters	0.0394	inches	in
ft	feet	0.3048	meters	m	m	meters	3.281	feet	ft
yd	yards	0.9144	meters	m	m	meters	1.094	yards	yds
mi	miles	1.069	kilometers	km	km	kilometers	0.6214	miles	mi
		AREA					**AREA**		
in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.00155	square inches	in^2
ft^2	square feet	0.0929	square meters	m^2	m^2	square meters	10.764	square feet	ft^2
yd^2	square yards	0.8361	square meters	m^2	m^2	square meters	1.196	square yards	yd^2
ac	acres	0.4047	hectacres	ha	ha	hectasres	2.471	acres	ac
mi^2	square miles	2.590	square kilometers	km^2	km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliters	0.0338	fluid ounces	fl oz
gal	gallon	3.785	liters	L	L	liters	0.2642	gallon	gal
ft^3	cubic feet	0.0283	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	ft^3
yd^3	cubic yards	0.7645	cubic meters	m^3	m^3	cuic meters	1.308	cubic yards	yd^3
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.0353	ounces	oz
lb	pounds	0.4536	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000 lb)	0.907	megagrams	Mg	Mg	megagrams	1.1023	short tons (2000 lb)	T
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C	°C	degrees Fahrenheit	9/5(°C)+32	degrees Celsius	°F
		FORCE and PRESURE or STRESS					**FORCE and PRESURE or STRESS**		
lbf	poundforce	4.448	Newtons	N	N	Newtons	0.2248	poundforce	lbf
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa	kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

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EXECUTIVE SUMMARY

In November, 1995, The Oklahoma Department of Transportation (ODOT) conducted a Profilograph Operator's Certification Course. The course included practical exercises on smoothness testing with the California Profilograph, profilogram, or profile trace, interpretation, using both the manual (blanking band) method and the ProScan System, and smoothness specifications.

During the exercise on smoothness testing, a common track was tested with six different profilographs. The six profilographs included two of each type currently used by ODOT. Resulting profilograms, or profile tapes, were then interpreted using the ProScan System and results of the two interpretations were compared. Comparisons were by type of profilograph and "across the board" where results of all six tests were compared. Comparison of results from the profilograph testing exercise indicated a need to verify accuracy of all profilographs by testing a common track. Up to now, ODOT has required only that profilographs be calibrated to the manufacturer's recommendations before using them to test ODOT construction projects.

Practical exercises on profilogram interpretation consisted of having each student interpret a copy of the same profilogram. Interpretations were done manually, following a class on that method. After a class on interpretation using the ProScan System, a new copy of the same profilogram was interpreted using the system. Students were timed for both interpretations, and time used by each student was recorded. Time for interpretation per unit of distance was calculated for each method. The practical exercise indicated that interpretation by the ProScan System is significantly less variable than that done manually. Results of this exercise also demonstrated that a considerable time savings (as compared to time required for manual interpretation) is attained when the ProScan System interprets the profilogram.

INTRODUCTION

The Oklahoma Department of Transportation (ODOT) has instituted a Quality Assurance/Quality Control (QA/QC) program. Essentially all of ODOT's construction projects are now subject to QA/QC requirements. ODOT's QA/QC program includes smoothness requirements for pavements and bridge decks measured using the California Profilograph as described in ODOT Special Provision (SP) 430-2QA(a-g)96 (Appendix A).

SP 430-2QA(a-g)96 requires that smoothness be described using the profile index (PI) resulting from interpretation of profilograms, or profile traces. Profilogram interpretation has been done manually for most of the time ODOT has been using smoothness requirements. Manual interpretation is somewhat subjective in that results can be affected by individual judgement in placing the blanking band and rounding off measurements. Also, manual profilogram interpretation is a labor intensive operation, often requiring as much time as the testing which produced the profilogram.

SP 430-2QA(a-g)96 provides for Contractor bonuses and penalties, based on the level of smoothness achieved. Because of this, variability in testing and interpretation must be minimized. Reports from other agencies have indicated that the ProScan System produces results which are less variable than those from manual interpretation (1). Significant reductions in time and effort required for interpretation have also been reported (2).

The ProScan Computer Scanner System was evaluated by the ODOT Office of Research to determine the time savings and reduction in data interpretation variability as compared to the manual method. The ProScan System uses a scanner to digitally record and interpret the data, providing a more consistent and repeatable profilogram interpretation. Additionally, early analysis and preliminary use showed the ProScan System to require substantially less time than that required to interpret similar profilograms manually. During the profilograph operator's training course discussed below, students interpreted the same profilogram twice. The first interpretation was done manually (using the blanking band). The second was done using the ProScan System. Manual interpretations required an average of 17.6 minutes. Those done with the ProScan System took an average of 5.0 minutes (manual interpretation took approximately 3.5 times as long as the ProScan System).

ODOT's current Special Provisions on Smoothness require that interpretation be done by ProScan or other automated systems.

PROFILOGRAPH OPERATOR'S COURSE

Between November 7 and 9, 1995, the ODOT Materials and Research Division conducted a Profilograph Operator's Certification Course at Arrowhead Lodge near Canadian, Oklahoma. Various aspects of smoothness testing with the profilograph were covered, including a review of current ODOT special provisions on smoothness, practical exercises on testing roadway and bridge floor surfaces, and profilogram interpretation. Both manual interpretation and interpretation using the ProScan System were discussed. ODOT owns three different types (brands) of profilographs. Various ODOT Field personnel have questioned whether or not the different types of profilographs measure such that the same PI results, where the same track is measured. Field testing and profilogram interpretation exercises were designed so that results could be compared and analyzed statistically. This was done to determine if there was a difference in measurements by different profilograph types, and to identify measures which might reduce these differences, if any. This report describes the tests, comparisons and analyses from this course. Individual profilographs are identified by brand name because questions regarding the various units typically include brands.

PRACTICAL EXERCISE ON USE OF AMES, COX, AND McCRACKEN PROFILOGRAPHS

During this exercise a common track was tested with six different profilographs. Two McCracken Manual Profilographs, two Ames Manual Profilographs, and two Cox and Sons automated (computerized) Profilographs participated in the tests. Each profilograph was to test the track three times, for a total of 18 tests. During the exercise, one unit experienced mechanical problems and completed only two tests. Because of this, the track was tested a total of 17 times, rather than 18, as planned.

TEST TRACK

The test track for the exercise contained both roadway and bridge surfaces, and was selected to include various levels of smoothness. These levels were intended to reflect the levels of smoothness generally encountered on roadway projects. ODOT's Special Provision on Smoothness (Appendix A)) provides for 100 percent pay, where newly constructed or milled and overlaid pavements are constructed, if smoothness is 7.0 in per mi or less. Smoothness on this type of project is often less than 2.0 in per mi. Pavements overlaid without milling are tested both before and after construction, and pay factors are based on percent improvement. Smoothness on these projects can cover a wide range. ODOT's Special Provisions provide for smoothness testing of bridge floors to cover the entire floor, including joints, and levels of smoothness on new bridge floors range from 205 mm/km (13.0 in/mi to 474 mm/km (30.0 in/mi), with corrective action required on any bridge floor with a smoothness exceeding 474 mm/km (30.0 in/mi).

The test track used in the course (Figure 1) was selected to include areas reflecting as many of these smoothness levels as possible. The 1.4 km (0.9 mi) long test track included 0.6 km (0.4 mi) of two year old, continuously reinforced PCC pavement, 0.3 km (0.2 mi) of thirty year old jointed PCC pavement, and a 0.3 km (0.2 mi) bridge. The bridge in the test track had a reinforced concrete deck supported by steel beams. The bridge was made up of three spans, with (two) expansion joints between them. At each end of the bridge, a 38 mm (1 ½ in) wide joint separated the end of the bridge from the approach slab.

The track was tested with the ODOT Materials and Research Division's McCracken Profilograph two weeks before the school was held to determine actual smoothness levels. Profilograms produced during this test were interpreted using the ProScan System. The results of this test were considered to be the "standard" for comparison with results of tests done during the certification course. Measurements by this profilograph are not necessarily more accurate than those by the other units. They do, however, provide a constant for comparison to results of tests made during the course. Results of the "standard" test are listed in Table 1.

TEST TRACK

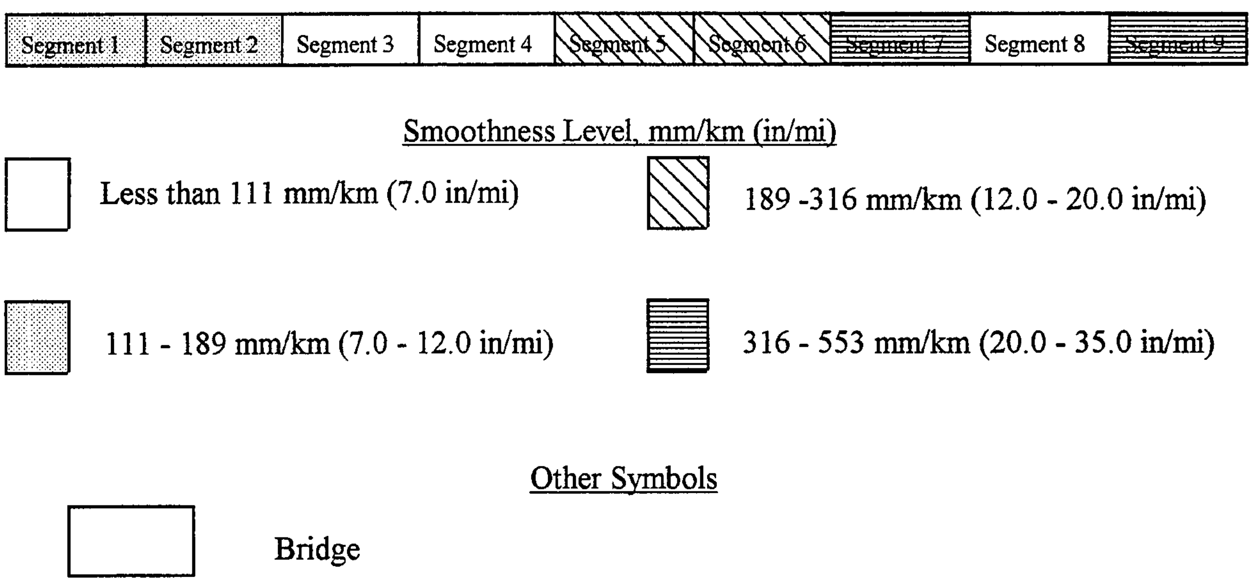

Figure 1. Test Track

Table 1. Smoothness Measured by Materials and Research "Standard" Profilograph, by Segment	
Segment	**Measured Smoothness, mm/km (in/mi)**
1	126 (8.0)
2	103 (6.5)
3	32 (2.0)
4	16 (1.0)
5	292 (18.5)
6	245 (15.5)
7	545 (34.5)
8	237 (15.0)
9	245 (15.5)

TESTING AND INTERPRETATION

Testing during the operator's course was done using two each of the three profilograph brands previously discussed. Each profilograph was used to test the same track three times (with one exception where mechanical problems prevented a third test). A different operator did the testing during each run. Profilograms produced during the testing were interpreted using the ProScan System.

COMPARISON OF TEST RESULTS

Results are tabulated in the following pages by profilograph unit and profilograph brand. The mean, standard deviation, and coefficient of variation are computed for each 0.16 km (0.1 mi) segment of the test track. Profile Indexes (PI) for each segment are compared graphically for three runs of each profilograph, and for all runs of each two profilographs of the same brand. Values of "standard" PI's are plotted as the horizontal coordinate and PI's determined by tests with the individual profilographs are plotted vertically.

AMES PROFILOGRAPHS

Profilographs

Two Ames brand manual profilographs were involved in the comparison. These units are designated "Ames1" and "Ames2" in Table 2. Both units were purchased under construction project contracts, to be used on a specific project, then become ODOT property upon project completion. "Ames1" is six years old and "Ames2" is five years old. "Ames1" has had considerably more use than "Ames2", beyond that proportional to difference in machine age. It has been transferred between residencies in a Field Division which includes a large metropolitan area. Also, "Ames1" does not have the upgrade-type features which were included in the "Ames2" unit (a different type rubber used in the averaging wheels, heavier cable, and a weight which fits on the front of the machine). The manufacturer has made additional improvements to their profilographs since ODOT purchased these units. Neither profilograph includes all of the upgrades which are currently standard features on this type of profilograph.

Results

Profile Indexes resulting from the test runs by the two profilographs are tabulated in Table 2. PI's for each segment are plotted against those from the "standard" profilograph for each unit and for both profilographs of this type in Figures 2, 3, and 4.

Profile Indexes resulting from measurements by profilograph "Ames1" showed deviations from those measured by the "standard" profilograph which were predominantly negative. Standard deviations generally increased as values of the profile index increased. Where the "standard" profilograph measured a PI of 15.5, variation was greater than that which would be expected by proportion to measured PI.

Profile indexes measured by "Ames2" were generally less than those in measured by "Ames1". Lines of best fit on the plots of results were below those from measurements by the "standard" profilograph. Wide variation at certain data points, such as where the "standard" profilograph measured a PI of 15.5, were noted.

Table 2. Comparison of Profile Indexes, Ames Profilographs.							
Profilograph	Segment	Profile Index (Inches per Mile)			Mean	Standard Deviation	Coefficient of Variation
		Run A	Run B	Run C			
Ames1	1	5.7	6.4	7.0	6.36667	0.65064	10.219
Ames1	2	4.6	6.1	7.0	5.90000	1.21243	20.549
Ames1	3	1.3	1.9	2.0	1.73333	0.37859	21.872
Ames1	4	0.0	0.4	0.0	0.13333	0.23094	173.205
Ames1	5	17.7	19.1	19.5	18.7667	0.94516	5.036
Ames1	6	9.9	11.9	14.5	12.1000	2.30651	19.062
Ames1	7	27.9	27.7	30.0	28.5333	1.27410	4.465
Ames1	8	10.2	14.5	17.0	13.9000	3.43947	24.744
Ames1	9	17.3	24.0	28.3	23.2000	5.54346	23.894
Ames2	1	5.8	5.2	4.6	5.2000	0.60000	11.538
Ames2	2	4.0	3.8	3.9	3.9000	0.10000	2.564
Ames2	3	0.8	0.7	0.7	0.7333	0.05773	7.872
Ames2	4	0.0	0.0	0.0	0.0000	0.00000	-
Ames2	5	15.7	14.4	14.9	15.0000	0.65574	4.372
Ames2	6	7.6	8.2	6.4	7.4000	0.91651	12.385
Ames2	7	25.3	25.1	24.0	24.8000	0.70000	2.822
Ames2	8	10.4	10.5	9.7	10.2000	0.43589	4.273
Ames2	9	20.6	17.5	17.2	18.4333	1.88237	10.212

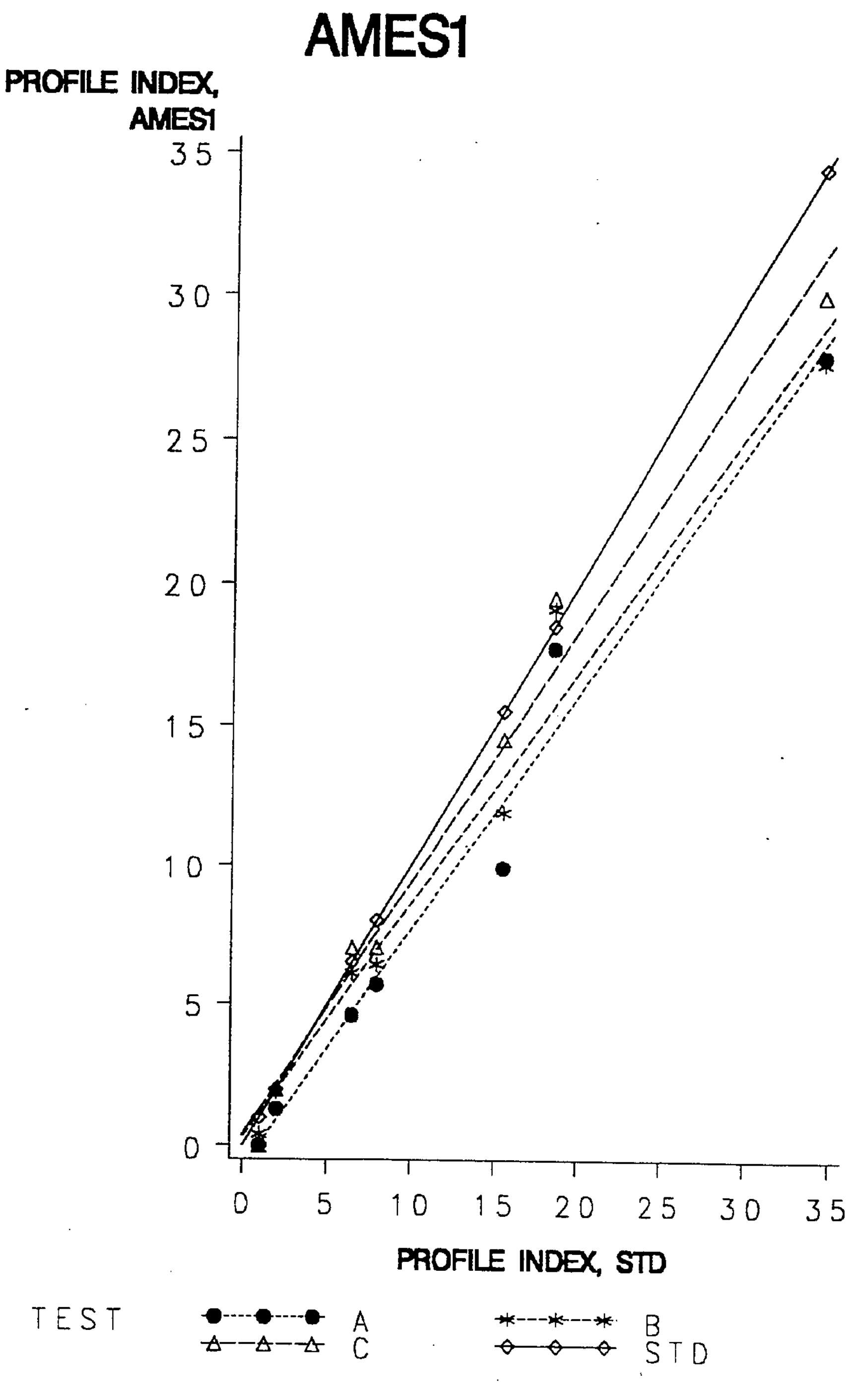

Figure 2. Comparison of Profile Indexes From Three Runs, Profilograph "Ames1".

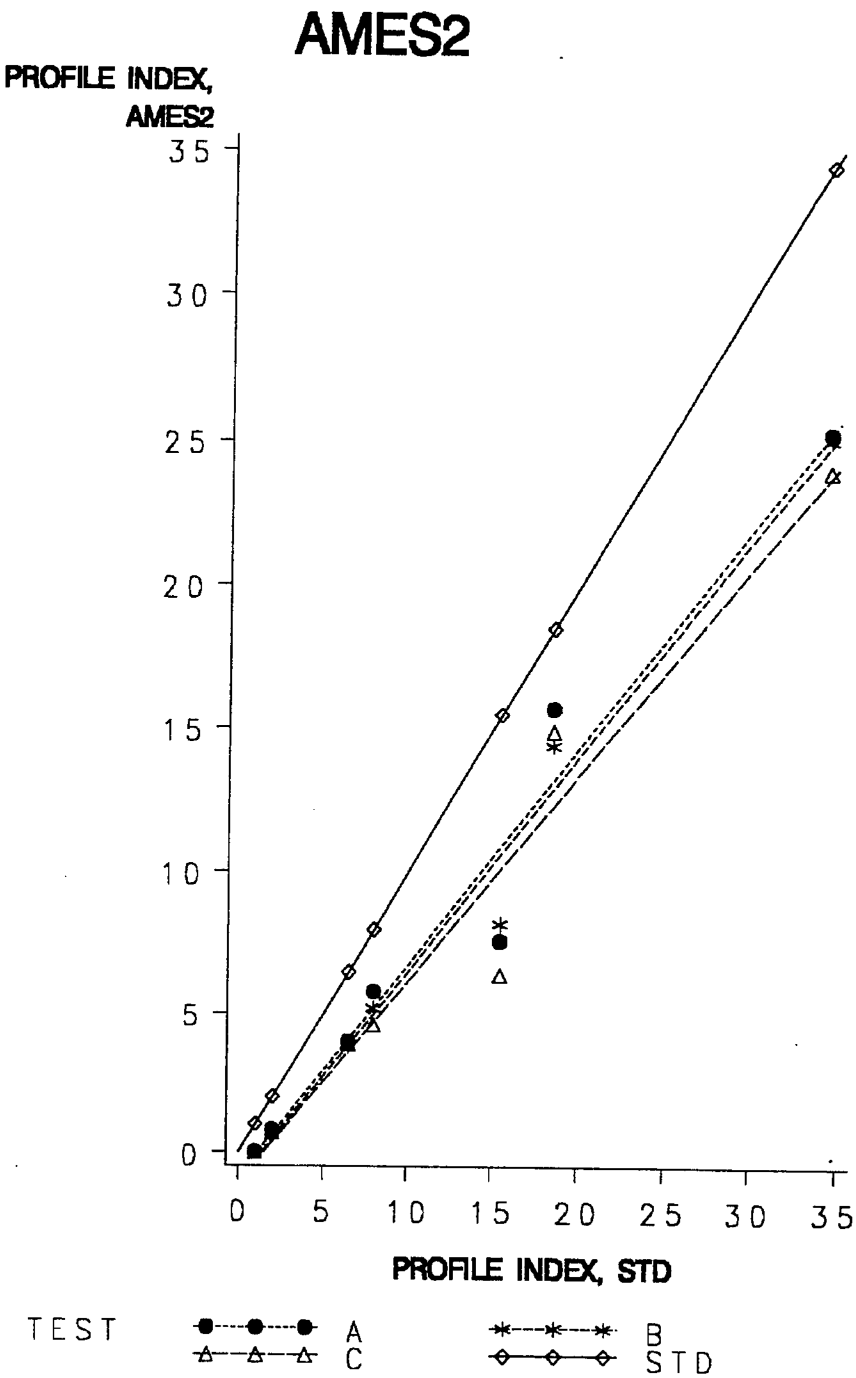

Figure 3. Comparison of Profile indexes From Three Runs, Profilograph "Ames2".

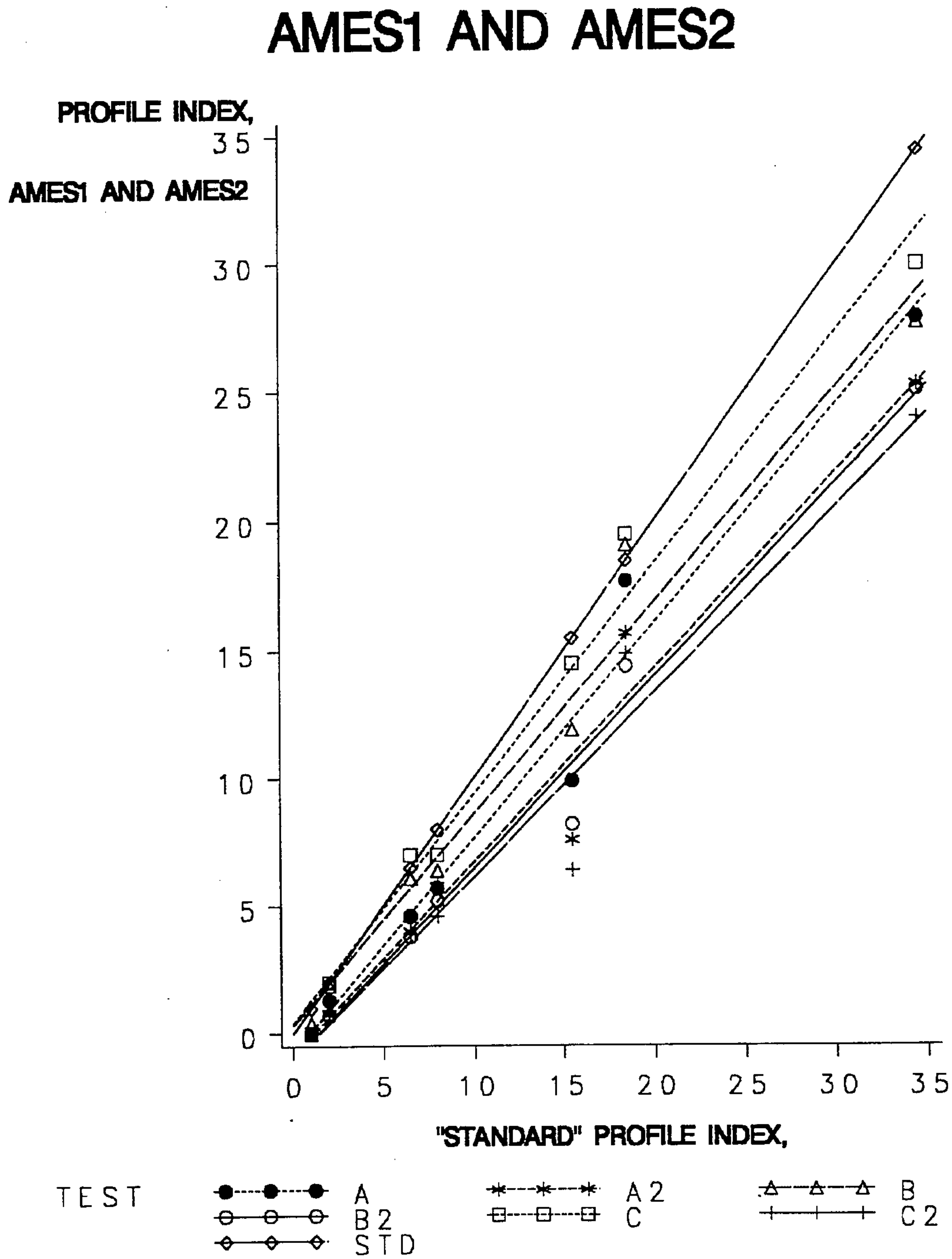

Figure 4. Comparison of Profile Indexes From Three Runs, Profilographs "Ames1" and "Ames2".

JAMES COX AND SONS (COX) PROFILOGRAPHS

Profilographs

ODOT owns two James Cox and Sons (Cox) automated, or computerized, profilographs. Both were used in the comparison. Both were purchased by ODOT contractors, to be used on specific projects, then became ODOT property upon project completion. The profilograph designated "Cox1" is three years old, "Cox2" is four years old. Both have had moderate use and appear to be in good condition. "Cox1" developed data for only eight segments of the test track due to entering an inaccurate value for the ending station on the test track. The two Cox profilographs were the only automated units which participated in the comparison.

Results

Profile Indexes developed by the two Cox Profilographs had the lowest standard deviations of any of the profilograph types (Table 3). The first run with each machine, designated "RunA", had negative deviations from the "standard" measurements. Results from the second and third runs agreed closely with the "standard" and with each other (Figures 5,6, and 7).

The two Cox units tested together, with "Cox2" directly behind "Cox1", and should have tested essentially the same track.

Table 3. Comparison of Profile Indexes, Cox Profilographs.							
Profilograph	Segment	Profile Index (Inches per Mile)			Mean	Standard Deviation	Coefficient of Variation
		RunA	RunB	RunC			
Cox1	1	7.0	8.0	7.5	7.50000	0.50000	6.667
Cox1	2	5.0	6.0	5.5	5.50000	0.50000	9.091
Cox1	3	1.5	2.0	2.0	1.83333	0.28868	15.746
Cox1	4	0.0	0.0	0.0	0.00000	0.00000	-
Cox1	5	20.0	18.0	20.5	19.50000	1.32288	6.784
Cox1	6	12.5	11.5	12.0	12.0000	0.50000	4.167
Cox1	7	34.0	34.5	33.5	34.0000	0.50000	1.471
Cox1	8	16.5	16.0	15.5	16.0000	0.50000	3.125
Cox2	1	9.0	8.5	9.0	8.8333	0.28868	3.268
Cox2	2	6.5	6.5	7.0	6.6667	0.28868	4.330
Cox2	3	1.5	1.5	2.5	1.8333	0.57735	31.492
Cox2	4	0.5	0.0	0.5	0.3333	0.28868	86.603
Cox2	5	19.5	19.5	20.5	19.8333	0.57735	2.911
Cox2	6	12.5	12.0	13.5	12.6667	0.76376	6.030
Cox2	7	34.5	33.0	34.0	33.8333	0.76376	2.257
Cox2	8	16.5	17.5	15.5	16.5000	1.00000	6.061
Cox2	9	23.1	28.2	-	25.6500	3.60624	14.059

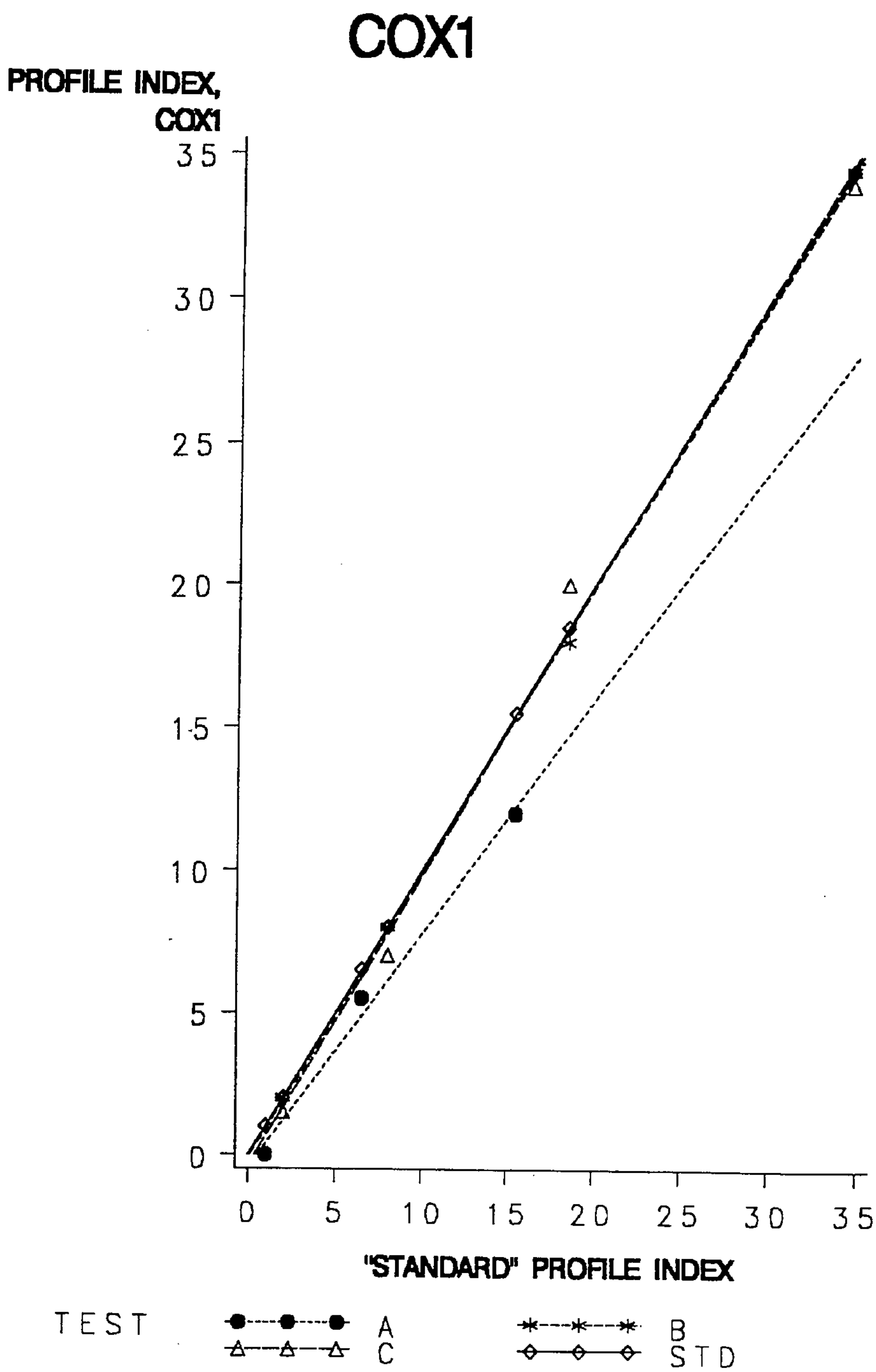

Figure 5. Comparison of Profile Indexes From Three Runs, Profilograph "Cox1".

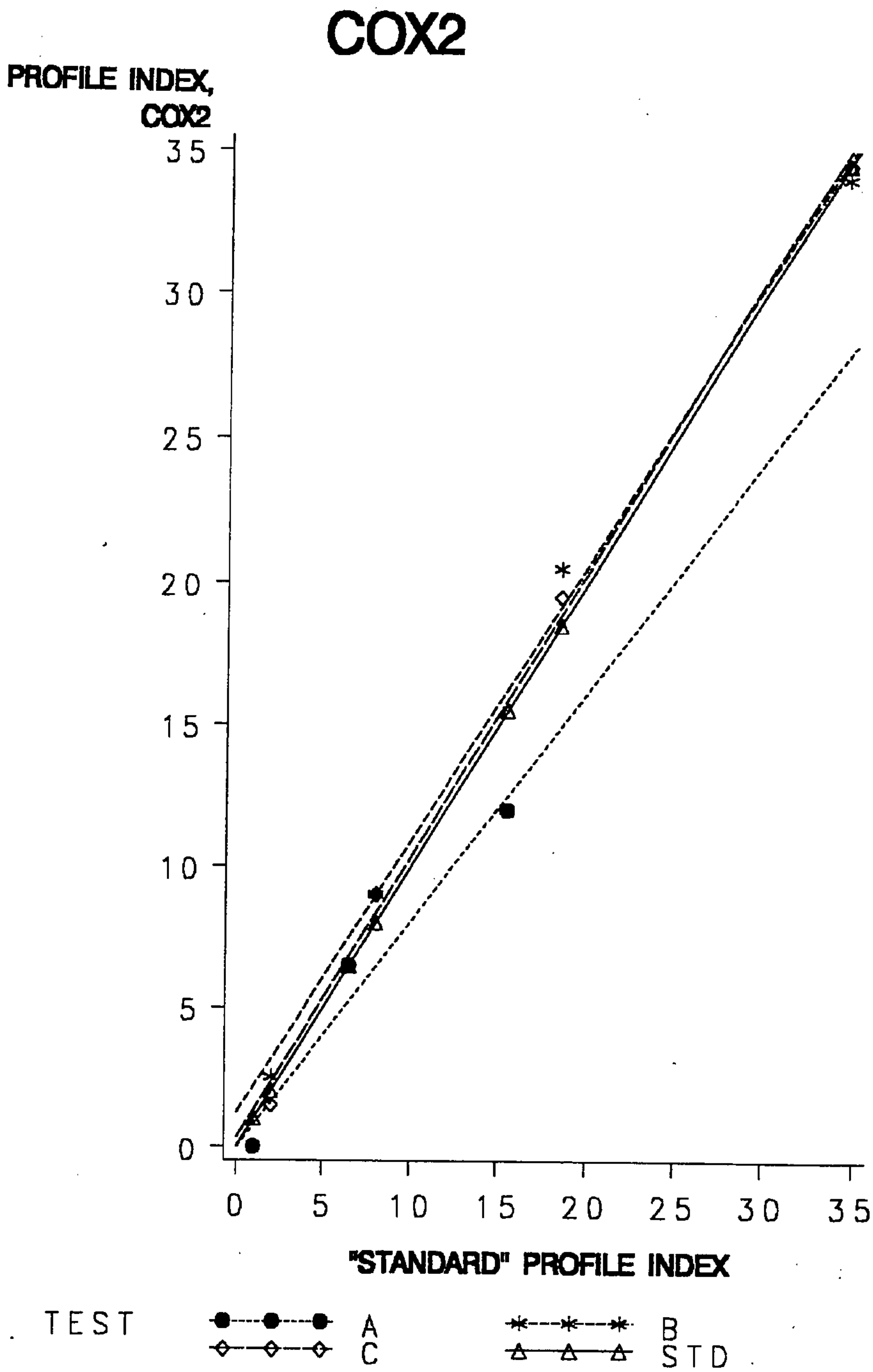

Figure 6. Comparison of Three Profile Indexes From Three Runs, Profilograph "Cox2".

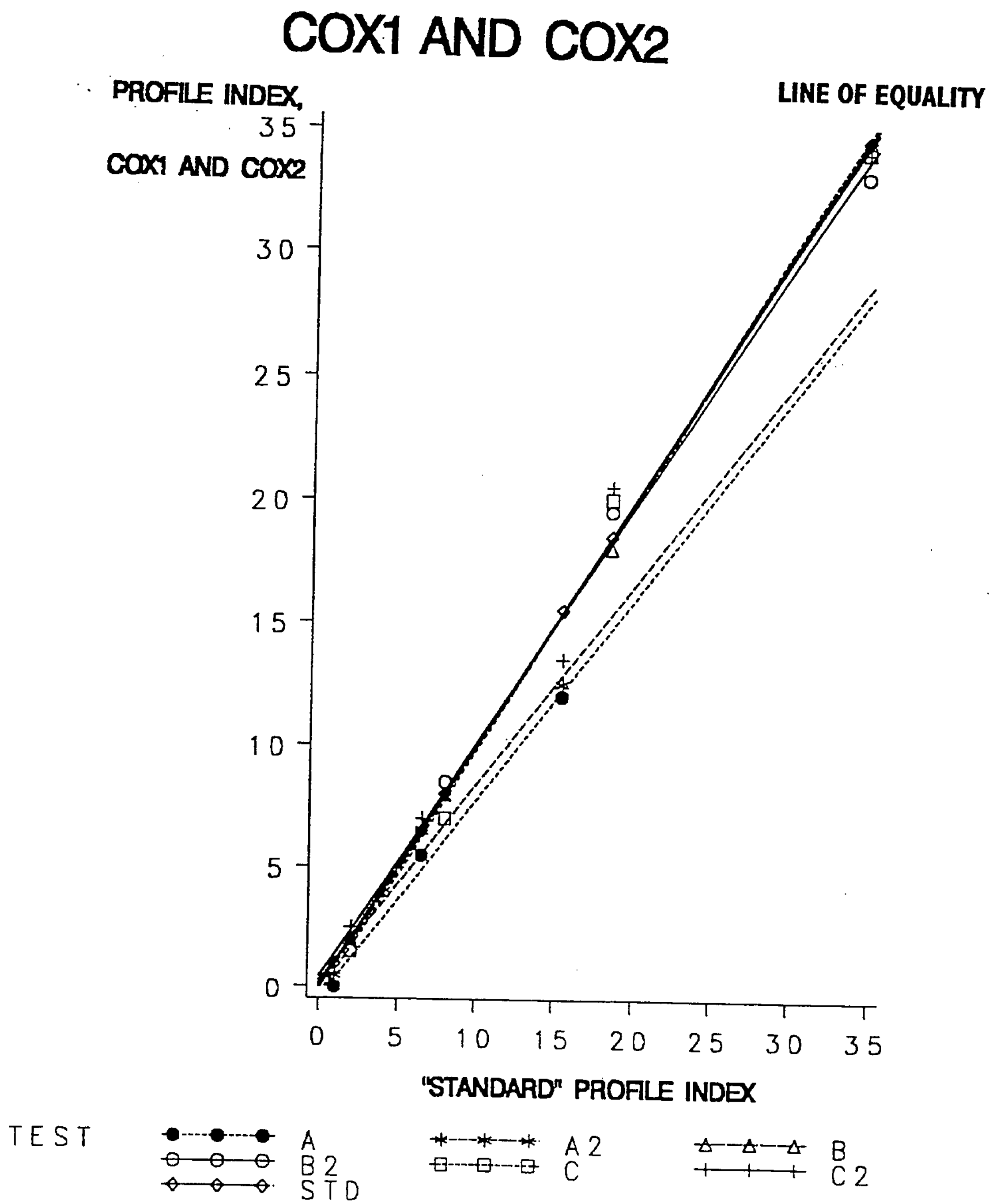

Figure 7. Comparison of Profile Indexes From Three Runs, Profilographs "Cox1" and "Cox2".

McCRACKEN PROFILOGRAPHS

Profilographs

Both McCracken manual profilographs participating in the comparison were manufactured and sold by the former McCracken Pipe Machinery Company. This company is now called International Pipe Machinery Corporation (IPMC). ODOT owns one McCracken manual profilograph, designated "McCracken1" in the comparison. "McCracken1" is eight years old . This machine was the first profilograph owned by ODOT, and is assigned to ODOT's Materials and Research Division. It has had extensive use in all eight ODOT Field Divisions, on both construction and research projects. It is still in good mechanical condition. The second McCracken unit ("McCracken2") used in the comparison was loaned to ODOT by a contractor so that at least two of these machines could be included. This machine is five years old and has also had extensive use.

Results

The unit designated "McCracken2" developed a mechanical problem during its second test run ("RunB"). Because of this, data was developed for only six of the nine test strip segments on that run, and there was no third run. According to the students operating this unit, by the end of the second test run ("RunB") it was obvious that the chart drive was not moving constantly. As far as the students operating it, and personnel observing the test could tell, it tested properly on segments numbered 3 through 8. The data for those segments are tabulated and plotted, as is the other data from these units in Table 4, and Figures 8, 9, and 10. Data from the six segments tested in "RunB" generally shows PI's with higher values than those developed by the other units (and the first run of this profilograph). Profilograph "McCracken1" was used to develop the "standard" profilograph run, so close agreement with it would be expected, even though different operators were used.

Data from tests by both McCracken profilographs showed wide variations at some data points, as did the other units. This is most obvious where the "standard" profilograph measured a PI of 15.5.

Table 4. Comparison of Profile Indexes, McCracken Profilographs.							
Profilograph	Segment	Profile Index (Inches per Mile)			Mean	Standard Deviation	Coefficient of Variation
		RunA	RunB	RunC			
McCracken1	1	8.6	9.6	8.0	8.73333	0.80829	9.255
McCracken1	2	6.0	5.9	7.5	6.4667	0.89629	13.860
McCracken1	3	1.4	1.6	2.5	1.8333	0.58595	31.961
McCracken1	4	0.3	0.3	1.0	0.5333	0.404145	75.777
McCracken1	5	17.4	18.5	18.5	18.1333	0.635085	3.502
McCracken1	6	10.6	11.6	14.5	12.2333	2.025669	16.559
McCracken1	7	30.5	32.2	29.5	30.7333	1.365040	4.442
McCracken1	8	12.1	14.5	17.0	14.5333	2.450170	16.859
McCracken1	9	19.5	24.7	25.9	23.3667	3.401960	14.559
McCracken2	1	-	9.7	-	9.7000	-	-
McCracken2	2	-	5.7	-	5.7000	-	-
McCracken2	3	2.4	1.6	-	2.0000	0.565685	28.284
McCracken2	4	1.6	0.0	-	0.8000	1.1313708	141.421
McCracken2	5	24.5	18.4	-	21.4500	4.3133514	20.109
McCracken2	6	18.9	11.0	-	14.9500	5.5861436	37.366
McCracken2	7	32.9	29.5	-	31.2000	2.4041631	7.706
McCracken2	8	19.1	14.2	-	16.6500	3.4648232	20.810
McCracken2	9		24.2	-	24.20000	-	-

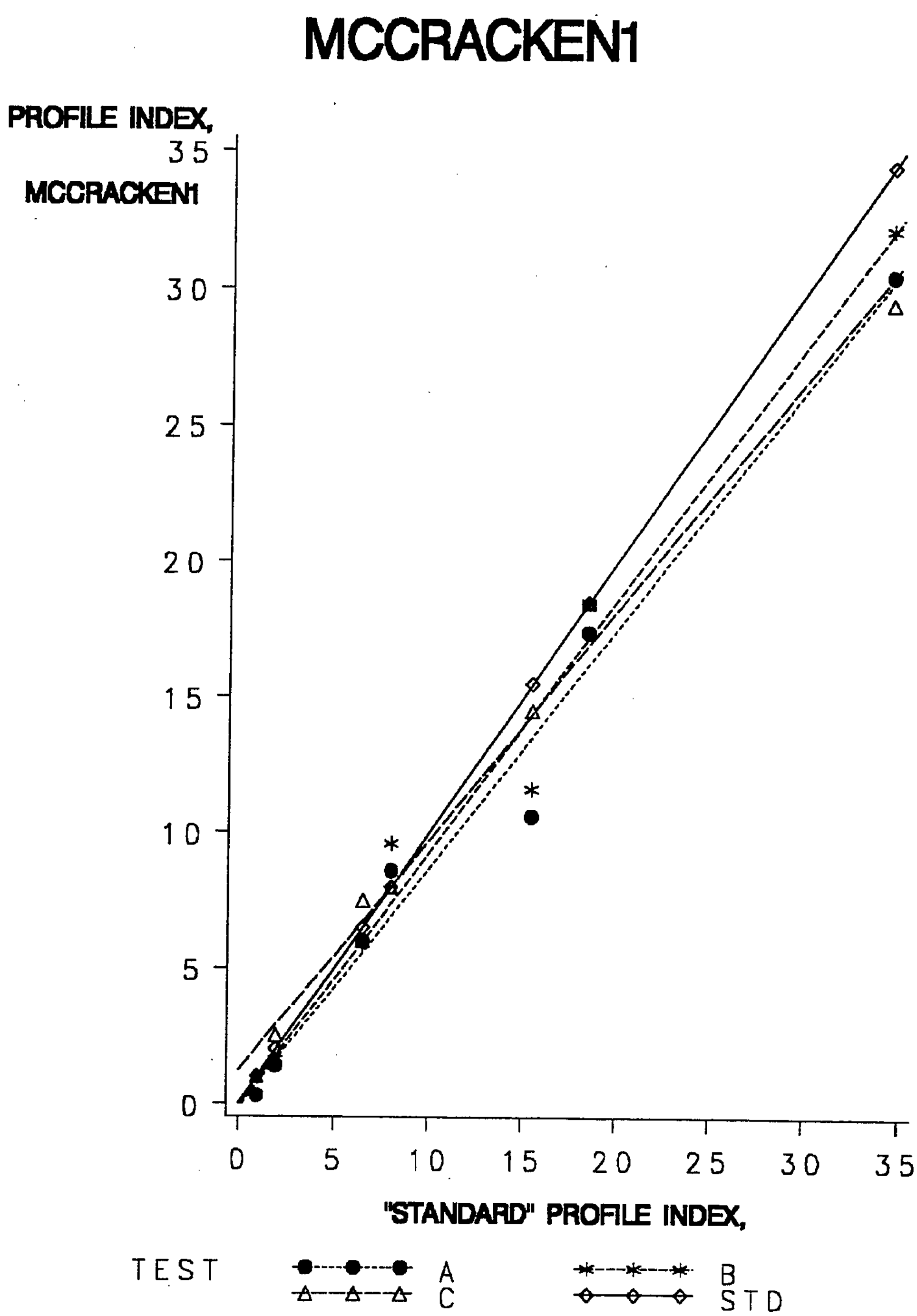

Figure 8. Comparison of Profile Indexes From Three Runs, Profilograph "McCracken1"

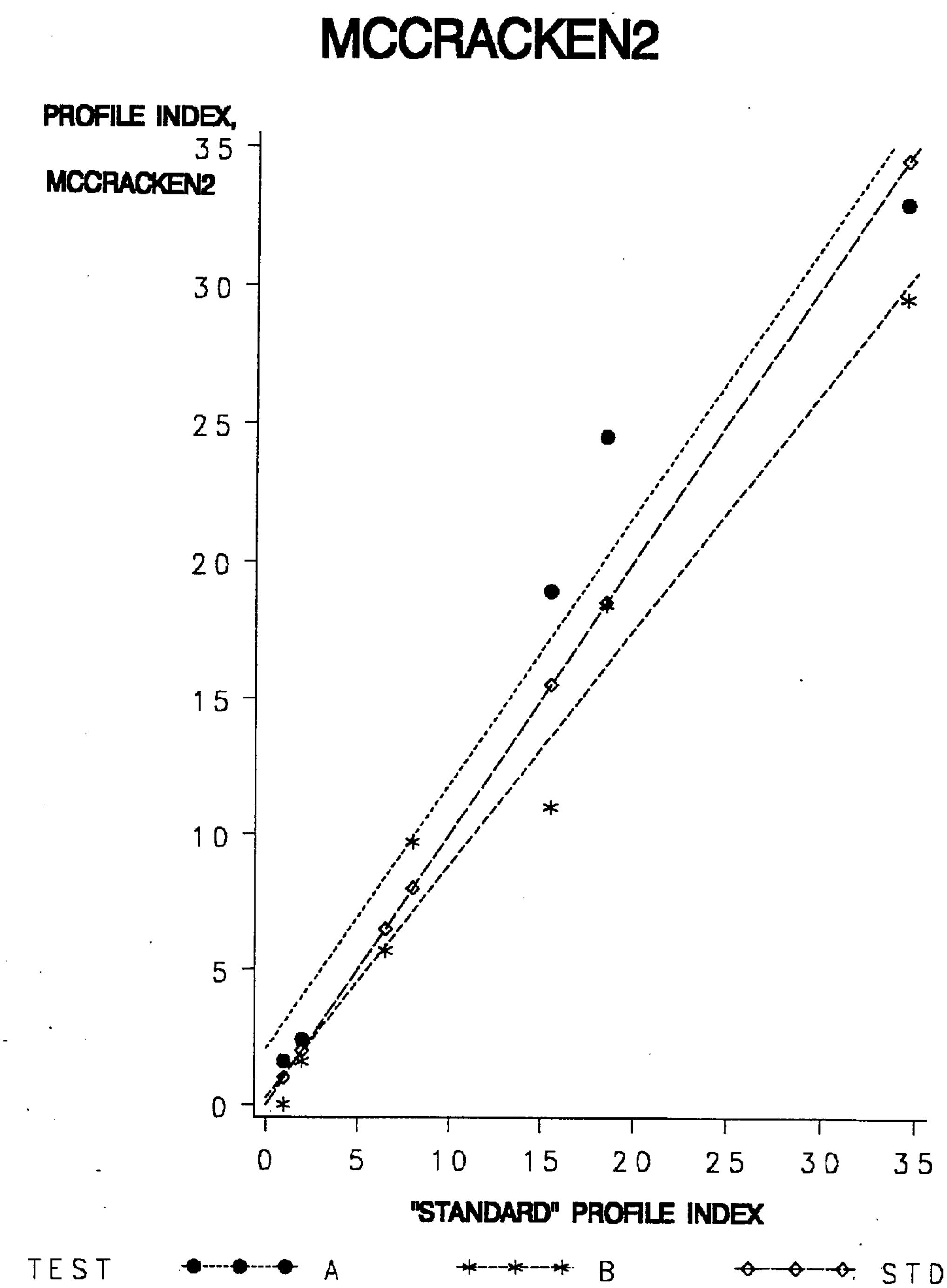

Figure 9. Comparison of Profile Indexes From Three Runs, Profilograph "McCracken2".

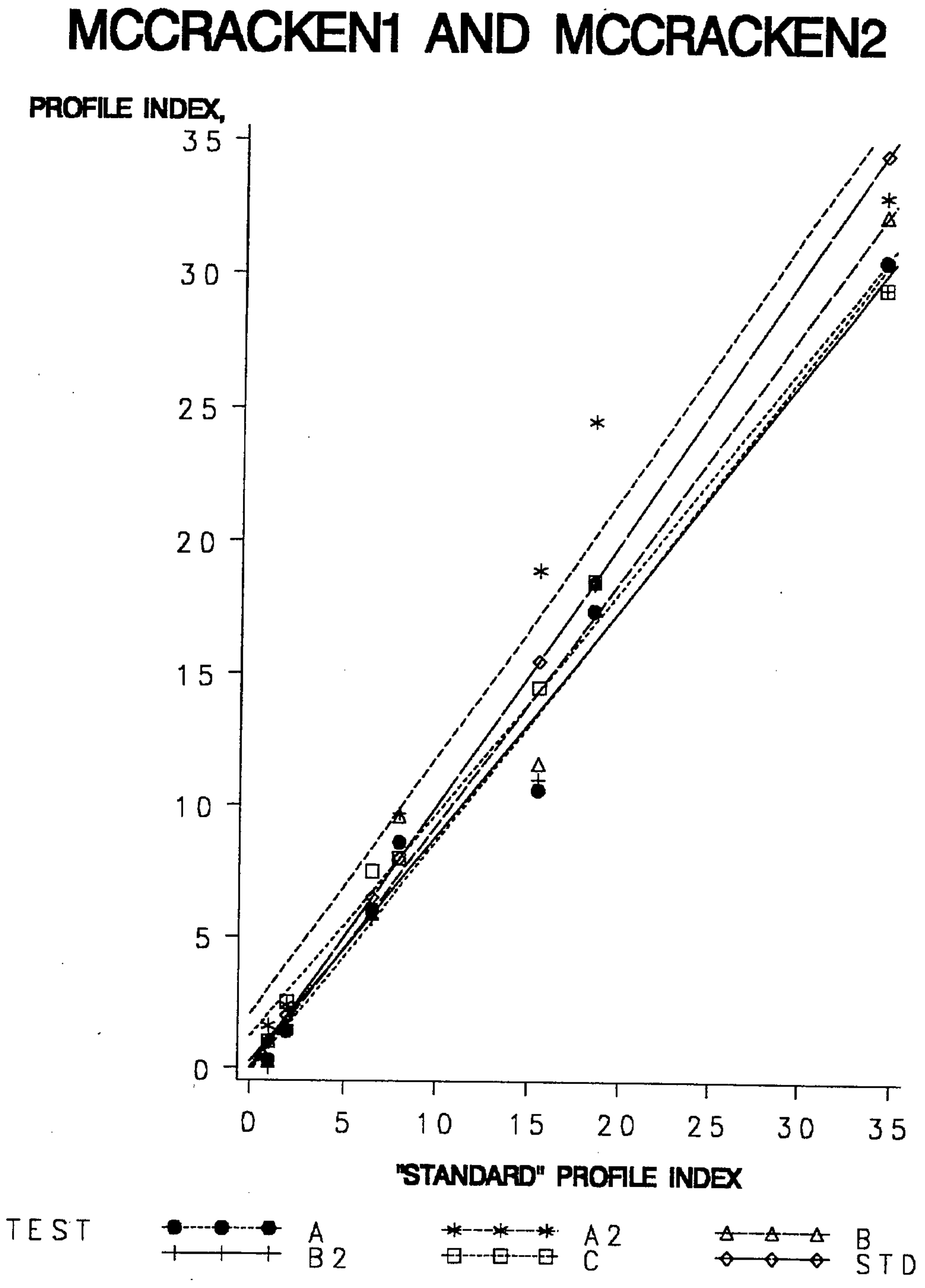

Figure 10. Comparison of Profile Indexes From Three Runs, Profilographs "McCracken1" and "McCracken2".

DISCUSSION

Differences in profile indexes between individual profilographs could be seen from the tabulated data. Of the six profilographs participating in the comparison, two produced results which stood out from the other units. Profilograph "McCracken2" which completed only two of the three test runs, produced results which were generally high. Profilograph "Ames2" completed all three test runs, and had no obvious mechanical problems. However, the results it produced were generally low. This can be seen in Table 5 and Figure 11, where mean values for each unit are tabulated and plotted.

Results from all of the profilographs were divided into three groups, based on level of roughness measured. Levels used were; 1) Less than or equal to 158 mm/km (10.0 in/mi). 2) 159 to 316 mm/km (10.1 to 20.0 in/mi), and 3) 317 mm/km (20.1 in/mi) or greater.

The first group (less than 158 mm/km (10.0 in/mi)) includes levels of smoothness common on newly constructed and milled-and-overlaid roadways. Experience has shown that the majority of ODOT projects of this type have pay factors which result in the Contractor getting a bonus. 79 mm/km (5.0 in/mi) is the highest profile index eligible for a bonus. New roadways with profile indexes exceeding 189 or 253 mm/km (12.00 or 16.00 in/mi) depending on the roadway class, must be corrected under ODOT's Special Provision on Smoothness. Very few projects (less than one per year) have profile indexes this high. All profilographs, with the exception of "Ames2", identified segments 1,2,3 and 4 as having roughness below 10.0 in/mi. "Ames2" measured roughness below 10.0 in/mi in segments 1,2,3,4 and 6. The in/mi of roughness measured by this unit was the lowest of that measured by all six units in segments 1, 3, and 4, while "McCracken2" measured the highest of the six units in segments 1, 3 and 4. Mean values resulting from tests by "McCracken2" did not exceed those from the units by unusual amounts except in Segment 1, where only two of the six units agreed closely with each other.

ODOT Special Provisions on Smoothness also provide a variable pay factor where overlays are placed, but milling is not required. Smoothness on projects of this type is influenced to a large degree by the condition of the existing roadway before the overlay is placed. The Special Provision addresses this by basing pay factors on percent improvement, regarding smoothness. Smoothness of these projects is measured before and after the overlay. Many of the measurements before construction, and in some cases after, are in the 159 to 316 mm/km (10.1 to 20.0 in/mi) range. All profilographs, except "Ames2" and "McCracken2", identified segments 5, 6 and 8 as having roughness in this range. The mean profile Indexes from measurements by "Ames2" were the lowest of the six units in segments 5 and 8. In segments 6 and 8, "McCracken2" measured the highest profile indexes of the six profilographs in the comparison.

ODOT Special Provisions on Smoothness also cover bridge decks, including smoothness of expansion and construction joints. Profile indexes of bridge decks are often in excess of 317 mm/km (20.1 in/mi). For this reason, segments with profile indexes in this range were included in the comparison.

Where results showed profile indexes of more than 317 mm/km (20.1 in/mi), three ("Ames1", "Cox2", and "McCracken1") of the six profilographs were in agreement as to which segments were in this range. The three profilographs named above recorded over 317 mm/km (20.0 in/mi) for segments 7 and 9. In segment 7, profilograph "Ames2" recorded the low mean 392 mm/km (24.8 in/mi) measurement, while the highest mean was 537 mm/km (34.00 in/mi) by "Cox1". In segment 9, the low mean was 366 mm/km (23.2 in/mi) by "Ames1". "Cox2" recorded the highest mean in this segment, 404 mm/km (25.65 in/mi).

Overall, the unit which tended toward low measurements (relative to the others), "Ames2", had the lowest mean measurement of the six profilographs in each of the nine segments. "McCracken2", the unit which tended toward relatively high measurements, had the highest mean measurement in six of the nine segments.

Projects tested under the requirements for newly constructed and milled and overlaid surfaces account for the majority of the projects tested for smoothness by ODOT. Results are typically below 79 mm/km (5.0 in/mi). Below 158 mm/km (10.0 in/mi), all of the units were generally in agreement. As profile indexes increase, results tend to vary by greater amounts. However, less testing is done on roads with the higher profile indexes. Some state DOT's apply smoothness specifications to overlays, others do not. At this time, most state DOT's do not apply smoothness requirements to bridge decks. In short, the two groups where variations are the largest are the least used.

Coefficients of variation were generally higher for both types of manual profilographs than for the (Cox) automated units. The two Cox automated profilographs were the only automated units included in the comparison, as they were the only automated units (of any brand) owned by ODOT at the time the comparison was done. There are several other brands of automated profilograph on the market. Other studies, which used manual profilogram interpretation, have determined that the automated units were more repeatable, relative to manual units (4).

The comparison was done mainly to determine whether or not a significant difference in test results would be observed where testing of the same track was done by different profilographs, and to make recommendations to minimize any differences identified. Each test run was done by a different profilograph operator. It is likely that differences in machine operation (staying on the exact track, units operated by operators who may not have been familiar with them, etc.) Affected the results produced. Only two units of each profilograph type were used. Because of the small number of profilographs involved, and the likelihood of other factors affecting measurements, results of this comparison should not be considered representative of any profilograph type or brand.

Table 5 Smoothness Level Less Than 10.0 in/Mi						
Segment	RunA (in/mi)	RunB (in/mi)	RunC (in/mi)	Mean	Standard Deviation	Coefficient of Variation
Ames1						
1	5.7	6.4	7.0	6.3667	0.65064	10.219
2	4.6	6.1	7.0	5.90000	1.21243	20.549
3	1.3	1.9	2.0	1.73333	0.37859	21.872
4	0.0	0.4	0.0	0.13333	0.23094	173.205
Ames2						
1	5.8	5.2	4.6	5.20000	0.60000	11.538
2	4.0	3.8	3.9	3.90000	0.10000	2.564
3	0.8	0.7	0.7	0.73300	0.05773	7.872
4	0.0	0.0	0.0	0.00000	0.00000	
6	7.6	8.2	6.4	7.40000	0.91651	12.385
Cox1						
1	7.0	8.0	7.5	7.5000	0.50000	6.667
2	5.0	6.0	5.5	5.5000	0.50000	9.091
3	1.5	2.0	2.0	1.8333	0.28868	15.746
4	0.0	0.0	0.0	0.0000	0.00000	
Cox2						
1	9.0	8.5	9.0	8.8333	0.28868	3.268
2	6.5	6.5	7.0	6.6667	0.28868	4.330
3	1.5	1.5	2.5	1.8333	0.57735	31.492
4	0.5	0.0	0.5	0.3333	0.28868	86.603
McCracken1						
1	8.6	9.6	8.0	8.7333	0.80829	9.255
2	6.0	5.9	7.5	6.4667	0.89629	13.86
3	1.4	1.6	2.5	1.8333	0.58595	31.961
4	0.3	0.3	1.0	0.5333	0.404145	75.777
McCracken2						
1		9.7		9.7000		
2		5.7		5.7000		
3	2.4	1.6		2.0000	0.56585	28.284
4	1.6	0.0		0.8000	1.131371	141.421

Table 6 Smoothness Level Greater Than 10.1 , Equal to orLess than 20.00 in/mi						
Segment	RunA (in/mi)	RunB (in/mi)	RunC (in/mi)	Mean	Standard Deviation	Coefficient of Variation
Ames1						
5	17.7	19.1	19.5	18.7667	0.94516	5.036
6	9.9	11.9	14.5	12.1000	2.30651	19.062
8	10.2	14.5	17.0	13.9000	3.43947	24.744
Ames2						
5	15.7	14.4	14.9	15.0000	0.65574	4.372
8	10.4	10.5	9.7	10.2000	0.43589	4.273
9	20.6	17.5	17.2	18.4333	1.88237	10.212
Cox1						
5	20.0	18.0	20.5	19.5000	1.32288	6.784
6	12.5	11.5	12.0	12.0000	0.50000	4.167
8	16.5	16.0	15.5	16.0000	0.50000	3.125
Cox2						
5	19.5	19.5	20.5	19.8333	0.57735	2.911
6	12.5	12.0	13.5	12.6667	0.76376	6.030
8	16.5	17.5	15.5	16.5000	1.00000	6.061
McCracken1						
5	17.4	18.5	18.5	18.1333	0.635085	3.502
6	10.6	11.6	14.5	12.2333	0.202567	16.559
8	12.1	14.5	17.0	14.5333	2.450170	16.859
McCracken2						
6	18.9	11.0		14.9500	5.586144	37.366
8	19.1	14.2		16.6500	3.464823	20.810

Table 7 Smoothness Level Equal to or Greater Than 20.1 in/Mi						
Segment	**RunA (in/mi)**	**RunB (in/mi)**	**RunC (in/mi)**	**Mean**	**Standard Deviation**	**Coefficient of Variation**
Ames1						
7	27.9	27.7	30.0	28.5333	1.2741	4.465
9	17.3	24.2	28.3	23.2000	5.54346	23.894
Ames2						
7	25.3	25.1	24.0	24.8000	0.70000	2.822
Cox1						
7	34.0	34.5	33.5	34.0000	1.32288	6.784
Cox2						
7	34.5	33.0	34.0	33.8333	0.763765	2.257
9	23.1	28.2		25.6500	3.60624	12.059
McCracken1						
7	30.5	32.2	29.5	30.7333	1.36504	4.442
9	19.5	24.7	25.9	23.3667	3.40196	14.559
McCracken2						
5	24.5	18.4		21.4500	4.313351	20.109
7	32.9	29.5		31.200	2.404163	7.706
9		24.2		24.200		

Table 8 Mean Profile Index by Individual Profilograph (Inches per Mile)						
	Profilograph					
Segment	Ames1	Ames2	Cox1	Cox2	McCracken1	McCracken2
1	6.4	5.2	7.5	8.8	8.7	9.7
2	5.9	3.9	5.5	6.7	6.5	5.7
3	1.7	0.7	1.8	1.8	1.8	2.0
4	0.1	0.0	0.0	0.3	0.5	0.8
5	18.8	15.0	19.5	19.8	18.1	21.5
6	12.1	7.4	12.0	12.7	12.2	15.0
7	28.5	24.8	34.0	33.8	30.7	31.2
8	13.9	10.2	16.0	16.5	14.5	16.7
9	23.2	18.4	-	25.7	23.4	24.2

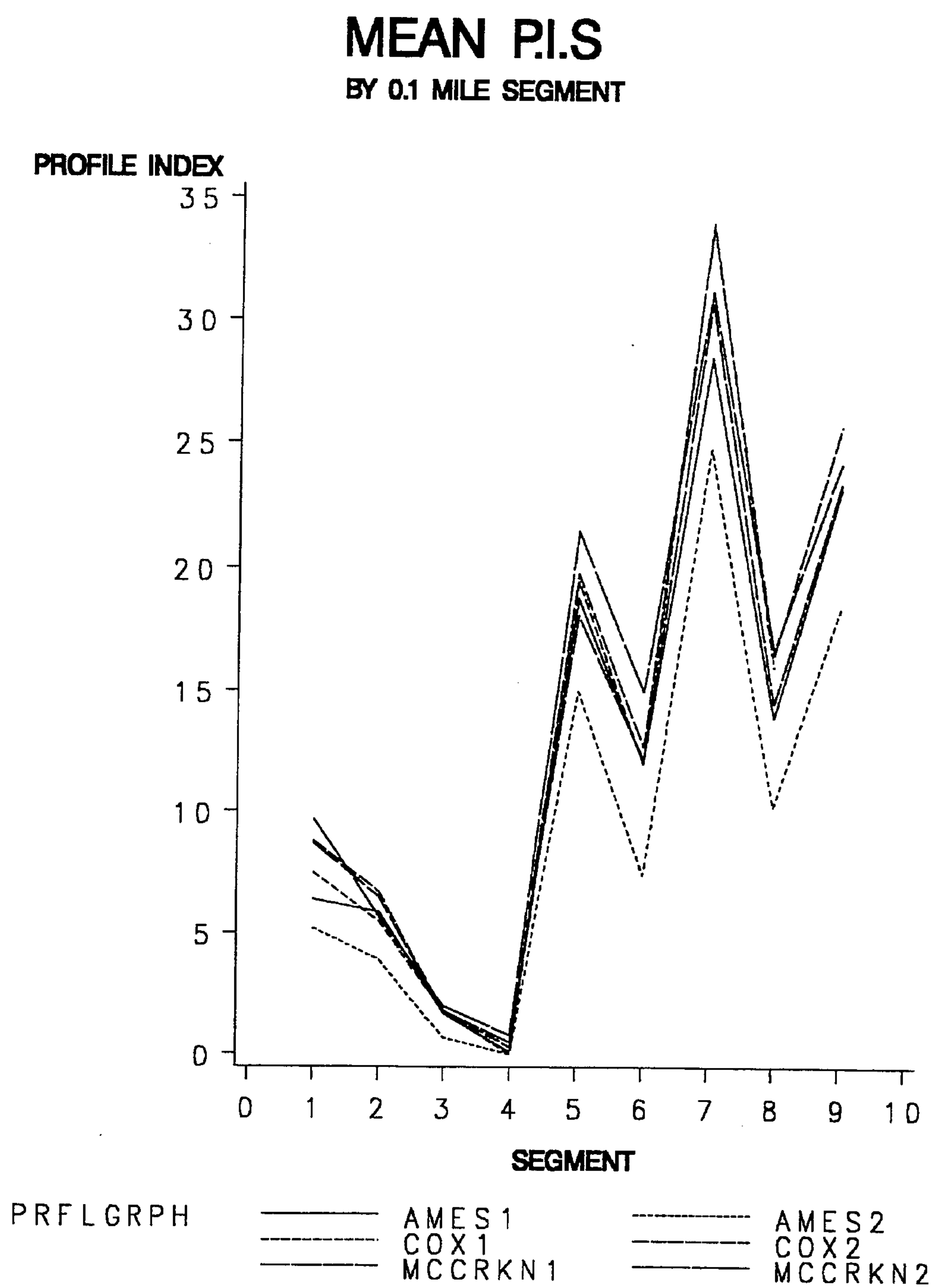

Figure 11. Mean Profile Indexes Resulting From Tests By Each of the Six Profilographs in the Comparison.

EXERCISES ON PROFILOGRAM INTERPRETATION

In the interpretation exercise, each of the students interpreted a "standard" profilogram section. Interpretations were first done manually, using the 10 mm (0.2 in) blanking band and 20 mm (0.4 in) bump template. Length of the profilogram section was 0.9 m (36 in). This length profilogram represents 274 m (900 ft) of roadway. "Standard" profilograms consisted of copies of part of an actual profilogram. Length of the copies was limited to 0.9 m (36 in), the maximum size ODOT reproduction equipment could copy in large numbers.

Following classroom instruction on manual interpretation, students interpreted copies of the standard profilogram using the 0.2 inch blanking band and 0.4 inch bump template. The number of students completing manual interpretations was limited by a shortage of blanking bands and limited time. Some of the students were experienced in manual interpretation, while others had little or no experience.

After instruction on use of the ProScan System, each of the 28 students interpreted a copy of the standard profilogram using one of eight ProScan Systems. Profile Indexes resulting from both interpretations are listed in Table 6.

DISCUSSION

Other agencies have noted a considerable variation in manually interpretted profilograph test results (1). While manual interpretation is not the only factor affecting variation, it does have a substantial effect on results (3). Interpretations by the ProScan System have been shown to be less variable than manual interpretations (1).

The mean, standard deviation, and coefficient of variation for the profile indexes resulting from interpretations by the students are listed in Table 7. For the profilograms interpreted in the practical exercise, the coefficient of variation for results determined by manual interpretation was considerably higher than that for interpretation by the ProScan System.

Time required for interpretation using the ProScan System was less than that for manual interpretation. Manual interpretation times varied from 12 to 32 minutes, with an average time of 17.6 minutes. Experience of the operator appeared to be the main factor affecting manual interpretation time. In the exercise where students used the ProScan System to interpret the same profilogram they had done manually, the time required was approximately 5 minutes per student. Preliminary tasks, such as putting the profilogram in the paper transport unit, recording initial information, etc. made up a larger percentage of the total time than would be required where profilograms from actual roadway construction projects were interpreted. Interpretation time, from both the ProScan and manual interpretation exercises, is listed in Table 6.

Each ODOT Field Division now has a ProScan System, with one individual assigned as the primary operator. These individuals will be recording the amount of time actually used for each project where profilogram interpretation is done with the ProScan System, and the number of lane-kilometers (lane-miles) tested when the profilogram was produced. This information will be reported to The Office of Research and used to estimate the labor savings due to the expected reduction in time required for interpretation.

Table 6. Time Required for Interpretation of Standard Profilogram		
Student	**ProScan System (Minutes)**	**Manual (Minutes)**
1	4.2	14.2
2	4.2	20.1
3	4.2	
4	4.2	
5	4.2	
6	4.4	18.0
7	4.5	16.6
8	4.5	14.1
9	4.5	32.0
10	4.6	13.7
11	4.6	18.3
12	4.6	16.5
13	4.8	
14	4.8	
15	5.1	26.9
16	5.2	
17	5.2	
18	5.4	
19	5.5	12.1
20	5.5	15.7
21	5.5	14.9
22	5.6	
23	5.6	20.2
24	5.6	13.3
25	5.7	15.3
26	5.8	16.5
27	5.8	18.4
28	5.8	

Table 7. Results, Interpretation of "Standard" Profilograph (Inches per Mile)		
Student	**ProScan**	**Manual**
1	28.1	34.5
2	26.7	26.1
3	28.6	
4	26.6	
5	25.6	
6	27.0	33.5
7	28.5	23.4
8	27.0	32.5
9	26.2	30.5
10	26.3	28.5
11	26.3	28.0
12	27.7	25.5
13	26.0	
14	27.2	
15	27.3	26.4
16	27.7	
17	27.5	
18	28.2	
19	27.7	54.0
20	26.7	31.4
21	27.1	38.0
22	26.6	
23	26.8	34.4
24	26.5	35.4
25	26.9	31.6
26	28.0	26.7
27	27.3	31.0
28	26.2	

The mean, standard deviation, and the coefficient of variation for the profile indexes resulting from interpretation of the "standard" profilogram are listed below. The coefficient of variation for manual interpretation is roughly 7.5 times that for the interpretation by the ProScan System. Time required for interpretation using the ProScan System was considerably less than that for manual interpretation. In the interpretation exercise, the time required to put the profilogram in the machine, record initial information, etc. took as long, or longer, than it took the ProScan system to evaluate the profilogram. This made up a percentage of the total time that would not reflect that for most actual projects (the longer the project, the greater the expected time savings).

Table 7. Profile Indexes, "Standard" Profilogram

	Mean	Standard Deviation	Coefficient of Variation
Manual Interpretation	**31.7**	**6.81**	**21.44**
Interpretation by ProScan System	**27.1**	**0.78**	**2.86**

CONCLUSIONS

1. Of the three profilograph types compared, the Cox automated units had the lowest average Coefficient of Variability (CV). (Ames (manual) Average CV = 19.949, Cox (automated) Average CV = 12.004, McCracken (manual) Average CV = 29.498.

2. Differences in measurements between the six profilographs compared indicate a need to test all ODOT profilographs on a common track at some specified period (annually, prior to testing a project for acceptance, etc.).

3. Profile indexes resulting from interpretation by the ProScan System produced coefficients of variability which were considerably lower than those resulting from manual interpretation. CV from ProScan Interpretations = 2.84. CV from manual interpretation = 21.44.

4. Time required for profilogram interpretation using the ProScan System was substantially lower than that required for manual interpretation. During the interpretation exercises, The average time required for manual interpretation was 17.6 minutes. Average time required for interpretation using the ProScan System was 5.0 minutes.

RECOMMENDATIONS

1. All profilographs to be used for acceptance testing on ODOT projects should be required to test a common track to verify the accuracy of their measurements. This should be done at least once a year.

2. Profilogram interpretation by the ProScan System should be the method required by ODOT on future special provisions on smoothness.

3. Where (smoothness) retesting is done due to disputed test results, multiple tests should be done. The mean value of the tests should then be used as the "official" PI for each segment.

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2. DeVore, J.J. and Hossain, M., *An Automated System for Determination of Pavement Profile Index and Location of Bumps for Grinding From the Profilograph Traces*, Kansas Department of Transportation, Kansas State University, and The University of Kansas, May, 1994.

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APPENDIX A

CURRENT ODOT SPECIAL PROVISIONS FOR PAVEMENT AND BRIDGE FLOORS SMOOTHNESS

CE4302QM 430-2QA(a-g)96 PAVEMENT AND BRIDGE DECK SMOOTHNESS (METRIC)
2-20-98

430-2QA(a)96
2-20-98

The Special Provisions revise, amend, and where in conflict, supersede applicable sections of the 1996 Standard Specifications for highway construction (METRIC).

Except as noted herein,The Special Provisions apply to all types Portland Cement and asphalt concrete pavements as well as bridge decks constructed as part of this contract or as specified on the Plans.

430.01 DESCRIPTION.

This section establishes procedures for determining acceptability and pay adjustments as they relate to smoothness requirements of pavements and bridge decks.

The equipment and testing applicable to this section shall be provided and/or operated by the party or parties specificied in Special Provision 431-QA.

430.03 EQUIPMENT.

(a) Profilograph. A California type profilograph will be used for determination of pavement and bridge deck smoothness. This device produces a smoothness profilogram (or profile trace) of the surface tested. The equipment used shall be supported on multiple wheels having no common axel. The wheels shall be arranged in a staggered pattern such that no two wheels cross the same bump at the same time. The profile is recorded from the vertical movement of a sensing wheel attached to the frame at midpoint and is in reference to the mean elevation of the twelve points of contact with the road surface established by the support wheels.

The strip chart recorder shall be mounted on a lightweight frame 7.62 meters long. The relative smoothness/roughness of the pavement or bridge deck shall be measured by recording the vertical movement of a 152 millimeter or larger diameter sensing wheel attached to the midpoint of the frame.

The recorded graphical traces of the profile (termed the "profilogram") shall be on a scale of 1 millimeter equals 1 millimeter for the vertical motion of the sensing wheel. The profilogram shall be driven by the chart drive on a scale of 1 centimeter of chart paper equal to 3 meters of longitudinal movement of the profilograph.

(b) Calibration. The profilograph shall be calibrated within the following limits. Horizontal measurements shall be within +/- 5 meters per 1,000 meters of distance tested. Vertical measurements shall be the same as those of the calibration blocks measured. A Profilograph Calibration Report shall be submitted to the Engineer each time the calibration is performed. This will be provided to the Contractor by the Engineer. Calibration shall be repeated at the Engineer's direction at any time during the project.

(b) Profilograph Operator. When specified in Special Provision 431-QA the Contractor shall provide a profilograph operator, qualified to perform all profilograph measurements as well as interpreting and analyzing produced profilograms.

430.04 CONSTRUCTION.

(a) Surface Testing. The Contractor shall provide traffic control as necessary for all profilograph operations regardless of who provides and/or operates the equipment. When specified in Special Provision 431-QA the Contractor shall use an acceptable and approved profilograph for measurement of pavement smoothness. The surface will be tested as soon as possible after completion of the work. For overlay projects when milling is not required, the surface will be tested immediately before construction and as soon as possible after completion of the work in order to determine the percent reduction in the profile index.

Testing shall include all mainline paving and bridge decks. Smoothness deviations occurring at construction and expansion joints will be considered in calculations of profile index and in identification of bumps. Bridge approach slabs will be evaluated in accordance with bridge deck smoothness requirements.

All objects and foreign material on the surface will be removed by the Contractor prior to testing. Protective covers, if used, shall be removed prior to testing and will be properly replaced by the Contractor after testing. Testing for smoothness shall produce a final trace; a second trace shall be made on segments on which surface corrections have been made.

The profilograph shall be propelled at a speed not to exceed 5 kilkometers per hour. Data shall be gathered at lower speeds if the pavement is rough or profilograms are not being produced clearly.

The sequence of positions of the pavement or bridge deck to be tested will be one pass per driving lane in the area most representative of the smoothness in either wheel path.

Additional profiles will be taken only to define the limits of an out-of-tolerance surface variation.

When the Contractor is required by Special Provision 431-QA to operate the profilograph he shall furnish the profilogram evaluations to the Department. The testing and evaluation will be done by a trained and qualified operator and the evaluation will be so certified. In case of differences the Department's results will be considered final.

430-2QA(c)96
2-20-98

(b) Evaluation.

1. Profile Index. A profile index shall be caluclated from the profilogram for pavement or bridge deck 15.85 meters or more in length. Pavement extents shall be 161 meters long. The index shall be calculated using a computerized profilogram reduction system. It is understood that stations reflected by automated profilogram reduction systems are approximate and further survey in them field may be required to establish bump locations. The index is calculated by summing the vertical deviations outside a 5 millimeter blanking band as indicated on the profile trace. The units of this measure will be converted into millimeters per kilometer. A pavement extent is defined as the amount of pavement placed by each 161 meter pass of a paving machine or finisher. When the quantity represented is 0.8 kilometers (80.5 meters) or less in length, it will be combined with an adjacent extent. When it is over 0.08 kilometers in length, it will be treated as a separate extent.

2. Bumps. Bumps will appear as high or low points on the profile trace and correspond to high or low points on the pavement or bridge deck surfaces. Unacceptable bumps are defined as those with vertical deviations in excess of 10 millimeters (without using a blanking band) in a 7.62 meter span.

3. Exceptions. Deviations occurring within 7.62 meters of the beginning and ending stations of the project will be excluded from profile index calculations. Also excluded from these calculations will be deviations occurring on pavements or bridge decks with horizontal centerline curves with a radius of less than 305 meters and the super elevation transitions of such curves. SHOULDERS ON PAVEMENT WILL BE EXEMPT FROM PROFILOGRAPH TESTING REQUIREMENTS.

(c) Surface correction. All new or milled and overlaid pavement and bridge deck surfaces having profile indices in excess of the acceptable limits in Tables I, II and III and all surfaces having deviations in excess of 10 millimeters in a 7.62 meter span shall be corrected by the Contractor at no additional cost to the Department. The Contractor may at his option perform additional corrective action in order to improve the smoothness pay factor. All corrective action, including the identification and correction of bumps, shall be in accordance with the requirements of the Standard Specifications and shall be subject to the approval of the Engineer. The surfaces of corrected areas shall be retextured to be similar to that of adjacent sections of pavement or bridge deck and shall exhibit good workmanship and be neat in appearance. After all required corrective work is completed, the profile index will be redetermined and recorded as the final profile index for that segment. CORES FOR THICKNESS DETERMINATION AND MEASUREMENTS OF COVER ON REINFORCING STEEL WILL BE TAKEN SUBSEQUENT TO ALL CORRECTIVE WORK.

430.06. BASIS OF PAYMENT.

Pay factors for smoothness of pavement and bridge decks will be determined based on final average profile indices or calculated percent reduction in average profile index, after all corrective actions have been completed for each extent. Grinding of the surface within a one meter wide band on either side of expansion joints will not adversely affect the pay factors. However, grinding of the surface in excess of these amounts will limit the pay factors for those extents to a maximum of 1.00.

The smoothness pay adjustment will be determined for each extent in accordance with the following formula:

PA = (SM-1) (CUP) (Qe)

DEFINITION OF ABBREVIATIONS

PA = Smoothness Pay Adjustment ($)
CUP = Contract Unit Price ($/METRIC TON, OR $/CU. M.) for each pay item
SM = Pay Factor for Smoothness
Qe = Quantity of Contract Pay Item in an extent (METRIC TON, SQ. M., or CU. M.

The quantity of P.C. concrete pavement in the extent will be the square meters of concrete in the driving lanes.

The quantity of asphalt pavement in the extent will be the tonnage in the full depth or pverlay tonnage of new asphalt concrete in the driving lane as covered in Section 400 of the Standard Specifications. It will not include base materials materials of any type as covered in Section 300 of the Standard Specifications. Driving lane is defined as a thoroughfare with a lane width of 3.6 meters. Tonnage will be determined from densities from the project job mix formula and typical sections as shown on the Plans.

The quantity of bridge deck in the extent will be the theoretical volume in cubic meters of concrete which is in the driving lanes.

Determination of the resulting smoothness pay factors will be in accordance with the tables shown below:

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TABLE I
ROADWAY (METRIC TONS OR SQ. M. OF PAVEMENT)
For Newly Constructed or Milled and Overlaid Surfaces

PAY FACTOR SM	PROFILE INDEX (MM/KM) CLASS I*	CLASS II*	CLASS III*
1.03	Less than 47	Less than 79	Less than 110
1.02	47 thru 62	79 thru 93	110 thru 125
1.01	63 thru 77	94 thru 109	126 thru 140
1.00	78 thru 110	110 thru 142	141 thru 174
.99	111 thru 126	143 thru 158	175 thru 189
.97	127 thru 142	159 thru 174	190 thru 205
.95	143 thru 158	175 thru 189	206 thru 221
.90	159 thru 174	190 thru 205	222 thru 237
.80	175 thru 189	206 thru 221	238 thru 252
Unacceptable	More than 189	More than 221	More than 252

*CLASS I roads are rural in nature and/or have few, if any, intersecting roads, drainage inlets, or other features which significantly increase the difficulty in obtaining a smooth roadway surface. CLASS II and CLASS III roads are urban in nature and/or do have these features which significantly increase the difficulty. The roadway classification, when applicable, is specified in Special Provision 431-QA, a part of this contract. THE CLASSIFICATION SPECIFIED IS FINAL AND WILL BE USED AS A BASIS FOR PAYMENT.

TABLE II

ROADWAY (METRIC TONS OR SQ.M. OF PAVEMENT)
For Overlays When Milling is Not Required

PAY FACTOR SM	REDUCTION IN PROFILE INDEX (PERCENT)	
1.00	75 to 79	70 to 74
.99	70 to 74	65 to 69
.97	65 to 69	60 to 64
.90	60 to 64	55 to 59
.80	50 to 54	45 to 49
Unacceptable	Less than 50	Less than 45

NOTE: In the event that the pay factor from TABLE II is less than the pay factor that would be established by using TABLE I, the pay factor will be derived from TABLE I.

TABLE III
BRIDGE DECK (CUBIC METERS OF CONCRETE)

PAY FACTOR SM	CLASS I*	CLASS II*
1.05	Less than 237	Less than 284
1.04	237 thru 257	284 thru 305
1.03	258 thru 276	306 thru 323
1.02	277 thru 297	324 thru 344
1.01	298 thru 316	345 thru 363
1.00	317 thru 395	364 thru 442
.99	396 thru 442	443 thru 489
.98	443 thru 458	490 thru 505
.97	459 thru 473	506 thru 521
.96	474 thru 489	522 thru 537
.95	490 thru 505	538 thru 552
.94	506 thru 521	553 thru 568
.92	522 thru 537	569 thru 584
.90	538 thru 552	585 thru 600
Unacceptable	More than 552	More than 600

AS A BASIS FOR PAYMENT.

INCENTIVE FOR CONSISTENTLY SMOOTH PAVEMENT AND BRIDGE DECKS

In addition to the pay adjustments on pavement and bridge deck extents, a 2 percent bonus will be paid for mainline pavement and bridge decks that are consistently smooth throughout the entire project length. To be eligible for the bonus a pavement project must have no extents with pay factors less than 1.00 AND no more than 10 percent of the total number of extents with any grinding

*CLASS I bridge decks are those that do not present significant special problems in obtaining desired smoothness due to geometry of the bridges. CLASS II bridge decks are those that do present significant special problems due to geometry. Geometric features considered in classifying bridge decks include but are not limited to skews, changes in widths, changes in super elevations and very sharp vertical or horizontal curves. The bridge deck classification, when applicable, is specified in Special Provision 431-2QA, a part of this contract. THE CLASSIFICATION SPECIFIED IS FINAL AND WILL BE USED

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This Special Provision revises, amends and where in conflict, supersedes applicable sections of the 1996 Standard Specifications for Highway Construction (METRIC).

Except as noted herein this Special Provision applies to all types of Portland cement and asphalt concrete pavements as well as bridge decks.

431.01 DESCRIPTION.

This Special Provision supplements Special Provision 430-2QA by furnishing project specific requirements not covered by that Specification. Specific requirements that are selected are applicable to Project.

431.03 EQUIPMENT.

The profilograph shall be provided by:

DEPARTMENT ______

CONTRACTOR ______

The profilograph shall be operated by:

DEPARTMENT ______

CONTRACTOR ______

431.06 BASIS OF PAYMENT.

In TABLE I of Special Provision 430-2QA the roadway classification shall be:

CLASS I ______ STATIONS: ALL STATIONS

CLASS II ______ STATIONS: ______

CLASS III ______ STATIONS: ______

ROADWAY REQUIREMENTS DO NOT APPLY ______

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In TABLE III of Special Provision 430-2QA the bridge deck classification shall be:

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE # _____ CLASS I _____ OR CLASS II _____

BRIDGE REQUIREMENTS DO NOT APPLY _____