Soil Tracking Paint Test

Final Report for MLR-89-13

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Highway Division

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ABSTRACT

A new paint testing device was built to determine the resistance of paints to darkening due to road grime being tracked onto them. The device consists of a tire rotating on a sample drum. Soil was applied to the tire and then tracked onto paint samples which were attached to the drum. A colorimeter was used to measure the lightness of the paints after being tracked. Lightness is measure from 0 (absolute black) to 100 (absolute white). Four experiments were run to determine the optimum time length to track a sample, the reproducibility, the effects of different soils, and the maximum acceptable level for darkening of a paint.

The following conclusions were reached:

1) The optimum tracking time was 10 minutes.
2) The reproducibility had a standard deviation of 1.5 lightness (L) units.
3) Different soils did not have a large effect on the amount of darkening on the paints.
4) A maximum acceptable darkness could not be established based on the limited amount of data.
5) A correlation exists between the paints which were darkening in the field and the paints which were turning the darkest on the tracking wheel.

Soil Tracking Paint Test

Introduction

In the summer of 1988, there was a problem with some of the traffic paints turning dark. There was strong evidence to suggest that the darkening was due to road soil and grime getting tracked onto the paint by traffic. Because of this problem, a new testing machine was built to simulate the soil tracking process. It is hoped that this machine can become a standard test to predict the resistance of a paint to darkening so that similar problems in the future can be avoided.

Four different experiments were run to determine the following operating parameters and performance characteristics of the tracking machine:

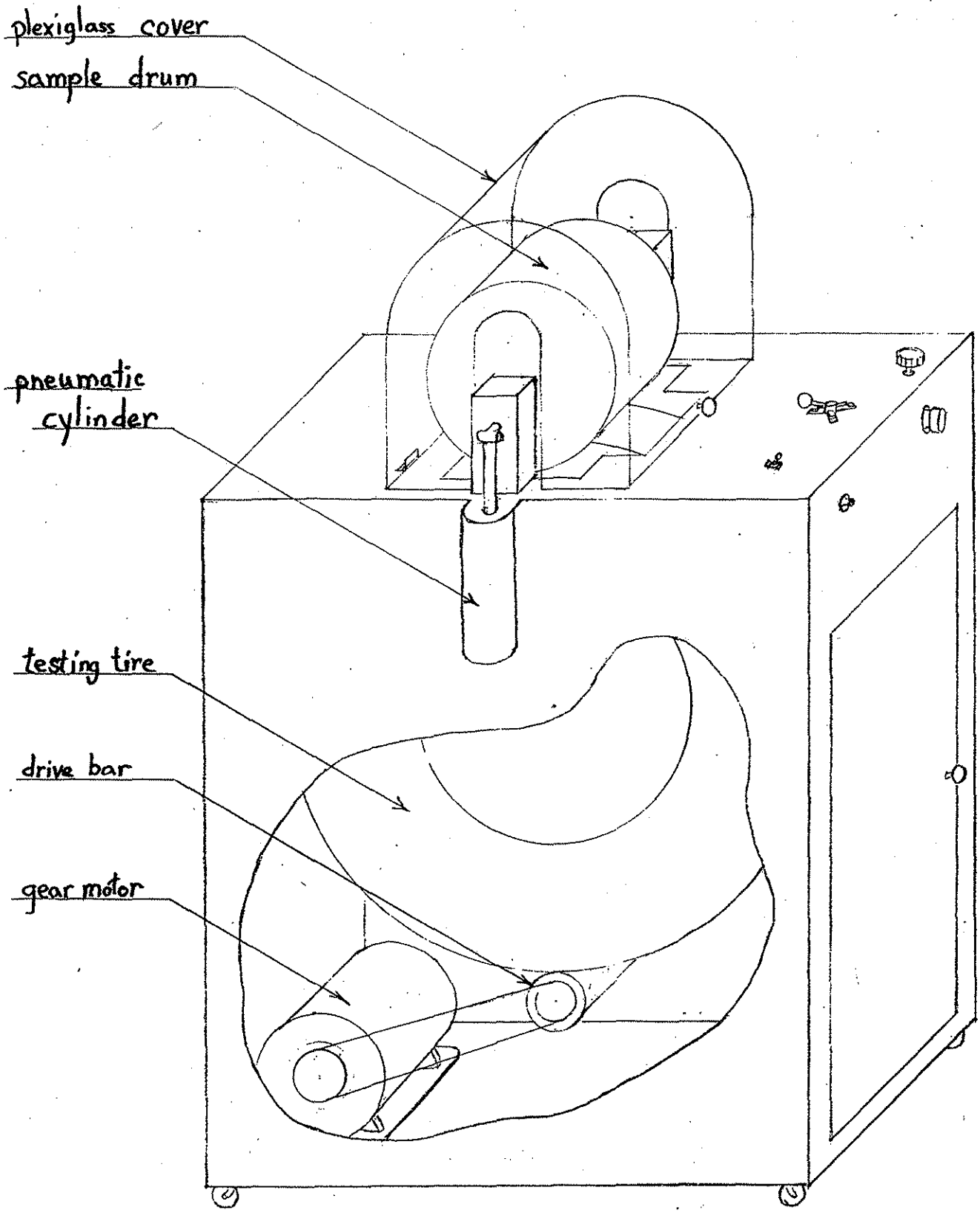
1. The optimum length of time for darkening
2. The reproducibility of darkening
3. The effects of different soils
4. The maximum darkening that is acceptable for a paint.

Equipment

A Hunter Lab Colorimeter, model D25 was used to obtain the lightness level of the paint. The L,a,b mode was used which gives a reflective reading called "lightness" and uses the symbol 'L'. The lightness is closely related to diffuse reflectance (Rd) by the equation $L=10*\sqrt{Rd}$, where Rd is the percentage of light reflected by the sample relative to a magnesium oxide standard. Lightness ranges from 0 to 100 where 0 is perfect black and 100 is perfect white.

The soil tracking wheel is a new device designed specifically for testing the darkening of paints. Figure 1 shows a sketch of the machine. It is approximately 2' wide 3' deep and 4' high. The wheel is powered by a 1/3 hp gear motor which is coupled by belt to a 3" diameter knurled drive bar. The drive bar rotates an ASTM E524 pavement test tire. The drive bar is offset at an angle of 0.8 degrees from being square with the tire to increase the scrubbing action of the drive bar on the smooth tire. The 10" diameter aluminum sample drum sits directly on top of the tire and rotates due to friction between the test tire and sample drum. There are two pneumatic cylinders which raise and lower the sample drum for contact against the tire. These pneumatic cylinders maintain the desired pressure against the tire. To increase the safety of the soil tracking wheel, all the moving parts are contained within a cabinet, except for the sample drum. A plexiglass cover is

Figure 1: Soil Tracking Wheel



used to enclose the sample drum when running but can be easily opened to change the samples. A safety switch insures that the plexiglass cover is closed before the motor will start.

Paint Samples

Sixteen batches of paint from four different manufactures were used in a study of white and yellow paint. All of these were a chlorinated-rubber fast-dry paint. Six batches of paint were from company A. Company A supplied paint for the 1988 painting season, and the paint was experiencing problems of unusual darkening due to an accumulation of traffic dirt. Six batches were from company B. Company B supplied paint for the 1989 painting season, and no problems have been observed with darkening. Two batches were from company C. Company C supplied the paint for the 1987 painting season and no problems were encountered with darkening. Two batches were from company D. Only laboratory batches were ordered from company D so none of their paint was applied in the field.

Paints from companies B, C, D were all made according to the same specification. Paint A was a similar specification, however the amount of TiO_2 in the white paint was 1.75 lb/gal for company A and only 1.5 lb/gal for companies B,C,& D. Also the yellow for company A had 1.0 lb/gal of chrome

yellow and 0.45 lb/gal of TiO_2 where the yellow from B,C,& D had 1.45 lb/gal of chrome yellow and no TiO_2.

Experimental Procedure

A thin film of paint was applied to 4"X9" glossy white cardboard. This was done by using a doctor blade with a 0.010 inch gap to draw the paint down the length of the cardboard. The draw downs were then allowed to dry for at least one hour, but were often left over night, more than 16 hours. The draw downs were checked for a uniform surface to make sure there weren't any large bubbles or scratches.

The lightness was measured on the clean paint samples using a colorimeter. When taking the lightness readings on clean paint samples, three spots on each draw down were measured, a reading 2"-3" from each end and one in the middle of the draw down. Then the three readings were averaged to get the clean paint reading.

The samples were then taped onto the sample drum of the traffic simulator using drafting tape. Soil was applied to the wheel of the traffic simulator using a nylon brush. The soil was picked up in the brush and then patted against the tire so that it would stick to the tire. The clumps were then brushed off so that there was a light uniform film of the soil left on the wheel. The pressure of the pneumatic cylinders was adjusted so that 750 lbs. was applied between the tire and the sample drum to simulate an average car.

Then the machine was turned on and the samples were tracked for a given length of time, usually ten minutes. Three more readings were taken from each sample after being run. One reading across the center line of the tire track and one on each end of the track, approximately where the readings were taken for the clean samples.

Results and Discussion

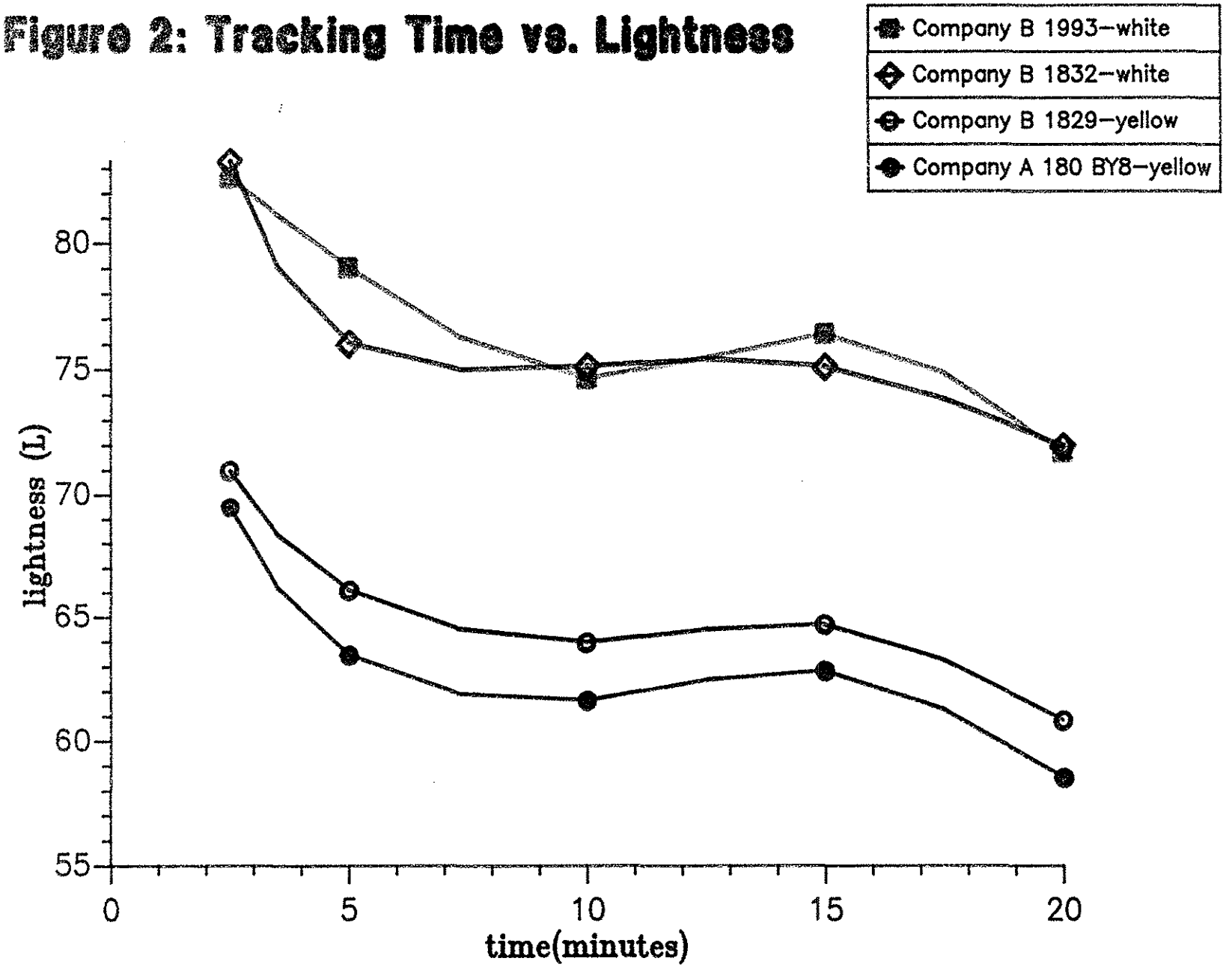
Optimum length of time for darkening

A time variation test was done to determine an optimum time length to run the samples. Company B paints 1829(yellow) and 1832(white) were used to make the draw downs. A minimum of two runs were made at each of the following time intervals: 2.5, 5, 10, 15, and 20 minutes. This tracking time verses lightness information is shown on Figure 2. In each run one white and one yellow draw down were used. Ten minutes gave a maximum darkening while still keeping the time interval at a relatively short time span. Figure 2 shows the change in lightness stabilizes with a local minimum at ten minutes and then after fifteen minutes continues to decrease, but at a slower rate than the initial decrease.

Reproducibility

When performing the reproducibility experiments, five yellow and five white draw downs were tested. The yellow draw downs were from batch 1829 and the white draw downs were

Figure 2: Tracking Time vs. Lightness



from batch 1832. For each test, one white and one yellow draw down was taped to the sample drum, soil was applied to the tire and the samples were run for five minutes. New soil was applied for each pair of paints and the tire was not cleaned between runs. The paints showed gradual darkening for each successive run. By the fifth run, both the white and the yellow paint were markedly darker than the first run. The readings of lightness from the yellow paints for the first sample was 64.14 and for the fifth was 57.66, while for the white paints the first reading was 74.19 and for the fifth was 61.57. This drop of nearly 14 L units indicated that soil was building up on the tire and transferring more soil to the draw downs with each successive run.

In order to make the runs more reproducible, the tire was cleaned before each run. The tire was wiped down with a wet paper towel and then dried with clean dry paper towels so that the surface was dry to touch. A uniform film of soil was applied to the wheel using a nylon bristle brush. Again five draw downs of both white and yellow were run, but this time for ten minutes.

For the reproducibility experiment the lightness values for the clean paints averaged 85.77 and 71.78 for the white and yellow colors respectively. The standard deviation was 0.03 L units for the five clean white samples, and was 0.03 L

units for the five clean yellow samples. The standard deviation here and throughout this paper has been calculated using the equation $\sqrt{\Sigma(x_i-\bar{x})^2}/(n-1)$. The following table shows the results for the reproducibility experiment. The soiled paint samples have lightness readings ranging from 80.14 to 77.04 for the white and 68.27 to 64.28 for the yellow. This gives an average lightness reading of 66.22 for the yellow with a standard deviation of 1.48. Likewise, for the white samples the average lightness reading is 77.86 with a standard deviation of 1.47. Therefore at the 95% confidence level, the lightness values would have a range of ± 2.96 for the yellow and ± 2.94 for the white.

Table 1: Reproducibility Results

	L		L
yellow 1829	68.27	white 1832	80.14
	66.12		77.04
	64.28		76.22
	66.86		78.05
	65.59		77.87
Average	66.22	Average	77.86
Std Dev	1.48	Std Dev	1.47

Effects of Different Soils

To test the effects of soils on the amount of tracking, seven different soil types were run on the paint batches 1829(yellow) and 1832(white) from company B. The soil samples were dried at 140 degrees Fahrenheit so that they were 'air dry'. Then they were ground down to break apart the solid clumps of soil and passed through a No. 40 sieve.

One 10 minute run was done for each soil sample with cleaning between each run. Table 2 lists the different soils, the percent composition and their dry color, relative to the Munsell Soils Chart.

Table 2: Composition of soils in weight percent.

No.	Sand	Silt	Clay	Color	yellow	white
630	12	52	36	Dark Grey Brown	69.50	80.86
640	21	60	19	Grey	67.61	79.31
1627	4	67	29	Very Pale Brown	66.19	77.34
1642	1	75	24	Yellow	65.21	75.99
1649	14	76	10	Light Yellow Brown	66.88	77.86
1654	2	78	20	Light Olive Brown	66.22	77.86
1655	1	79	20	Pale Yellow	64.00	75.16

The lightness readings of the yellow and white paints after being run with the respective soils are listed in the right two columns of table 2. The lightness of the white paint after tracking averaged 77.83 with a standard deviation of 1.93 and the yellow paint averaged 66.49 with a standard deviation of 1.75. These standard deviations for the various soils are close to the deviations for the reproducibility experiment (1.46 and 1.48) indicating that the type of soil does not have a large effect on the amount of darkening.

Maximum Acceptable Darkening

Figure 3 and 4 show the darkening results of the white and yellow paints respectively. The lightness of the clean and tracked paints are shown. The clean white paints range in lightness from about 88 to 84. The brightest white paints

Figure 3: White Paint Lightness

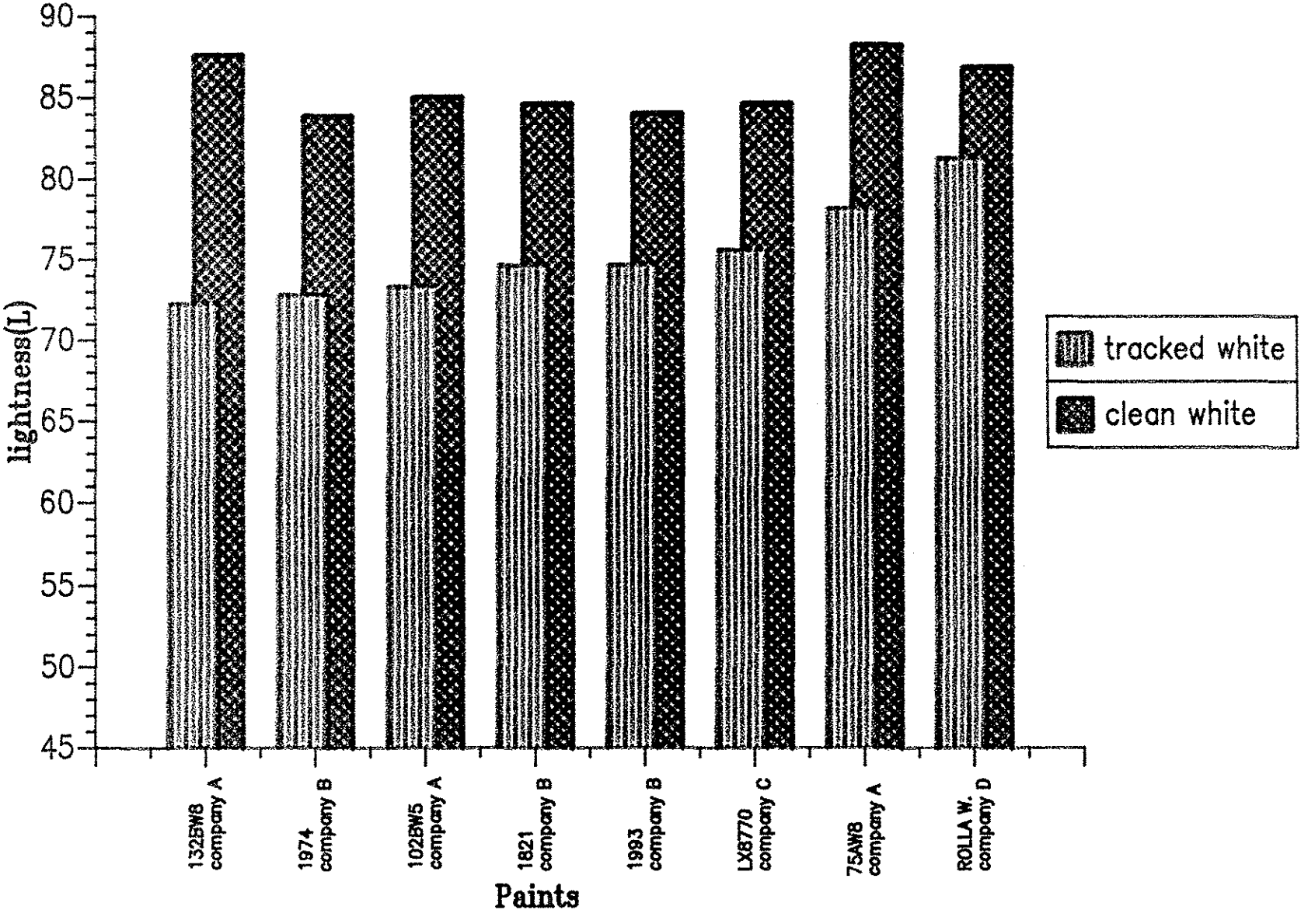
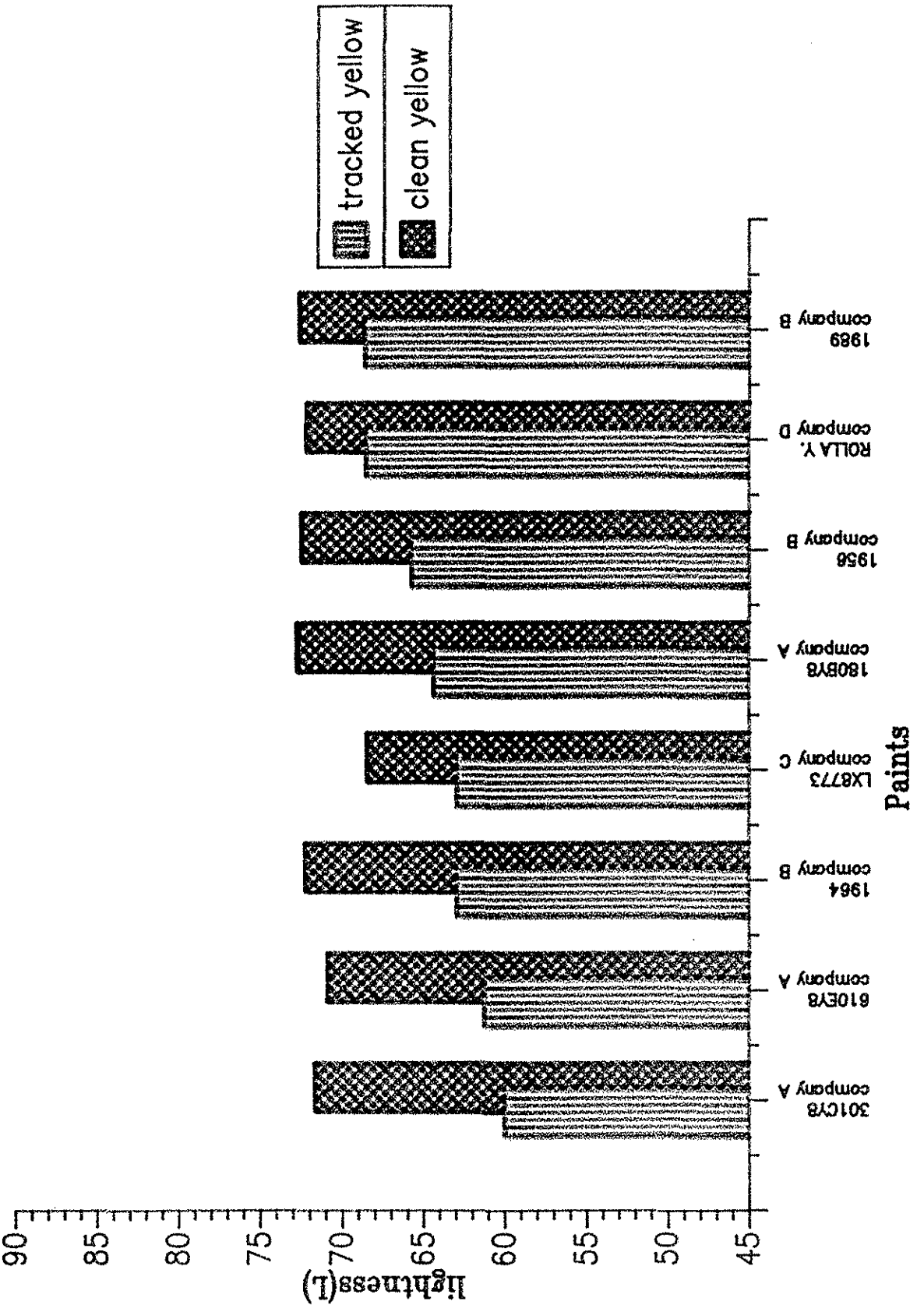


Figure 4: Yellow Paint Lightness



are batches 132BW8 and 75AW8 both from company A. The darkest clean paints are batches 1974 and 1993 from company B. After the paints have been tracked for 10 minutes, the lightness ranges from about 72 to 81. The best performing paint was from company D at a lightness of 81 almost 3 units above the next brightest. The worst performer was batch 132BW8 from company A.

The clean yellow paints ranged in lightness from 68 to 73. All the clean paints started at approximately the same lightness level of 73 except batch LX8773 from company C which was 68. After being tracked for 10 minutes, the paints ranged in lightness from 60 to 68. The brightest tracked paints were batch 1989 from company B and the yellow from company D with lightness readings of 68. The darkest tracked paints were batches 310CY8 and 610EY8 from company A with lightness readings of 60 and 61 respectively.

Both the white and the yellow paints that were turning the darkest in the laboratory were from company A. This is consistent with field observations which showed that paint from company A was turning unusually dark after several weeks on the pavement. Paints from company B and C were not experiencing the darkening problems in the fields. Company D paint was not applied in the field.

At this time, there is not enough data to pick a minimum acceptable lightness level. More data will be collected to

try to establish a threshold value for acceptable lightness after tracking.

Also, the question of dry time must be addressed to see if paints darken differently when the dry time is varied.

Conclusions

1. The optimal time for tracking was chosen as 10 minutes, striking a balance between darkening and the amount of time required for a test.

2. The tire must be cleaned before each tracking test to ensure reproducible results.

3. The standard deviation in lightness for the paints from the same batch which were tracked for 10 minutes was 1.47 for the white and 1.48 for the yellow.

4. Different soils do not have a large effect on the level of darkening.

5. There is a correlation between the paints darkening in the field and the paints which were darkened by the soil tracking wheel.