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COMPARISON OF HIGHWAY STRIPING MATERIALS

by

F. D. Shepard
Research Scientist

(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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SUMMARY

This study was undertaken to investigate problems relating to the durability of pavement striping materials used by the Department. The research was limited to an evaluation of the durability and retroreflectance characteristics of selected paints, thermoplastics, and preformed tapes recommended by the Materials Division for use as centerline and edgeline striping. The report details the installation procedure and presents the results of the evaluation of the selected materials. Included is a recommendation that the state adopt a performance specification wherein suppliers would be required to submit their traffic paints for on-the-road evaluation and the product exhibiting the best overall performance, considering general appearance, durability, night visibility, and cost, would be purchased.

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INTRODUCTION

As a result of a discussion of various problems relating to the durability of the traffic paint used by the Department at the May 31, 1978, meeting of the Traffic Research Advisory Committee, it was recommended that a task force be formed to study the problems. Upon meeting, the task force recommended that field tests of selected traffic striping materials be initiated. Also, it was thought that an investigation should be made into questions concerning paint specifications, drying times, and performance versus materials specifications. At subsequent meetings of the task force, it was established that the Materials Division would select the materials to be tested and the Research Council would perform the evaluation and prepare a final report.

PURPOSE

The state has used various highway striping materials with varying degrees of success; however, at no time have all the various materials been applied at the same time and place for comparisons. The primary purpose of this study was to field test traffic striping paints to investigate questions concerning the overall performance with emphasis on durability, appearance, and night visibility. As an afterthought it was decided to include various thermoplastic formulations and preformed tapes to compare categories of materials. Also, it was hoped that the investigation would provide a basis for evaluating the Department's specifications for the composition and purchasing of such materials and lead to improvements if warranted.

SCOPE

The study was limited to the testing of those highway striping materials recommended by the Materials Division as used for centerline and edgeline striping. The materials were applied at one location on bituminous pavement and one on concrete pavement.

PROCEDURE

Site

The site chosen for placement of the materials was on Interstate 95 southbound, just south of the Route 301 exit in Richmond. The pavement in this area transitions from concrete to bituminous and thereby allowed placement of materials on both surface types under almost identical traffic conditions. This site has an average annual daily traffic of approximately 25,000 vehicles.

Selection of Marking Materials

Recommendations by the Materials Divison and subsequent consideration by the task force led to the selection of 14 traffic paints, 6 thermoplastics, and 7 tapes. A list of these materials in the order they are placed on the road is given below.

Traffic Paints

1. A-702: Virginia's conventional white. A 20-30 minute conventional paint with a soya-tung oil vehicle.

2. TM-5368: New Jersey's type IV chlorinated rubber white. A cold applied paint.

3. TM-9216: Virginia's fast-drying white. Has a 50-second drying time and linseed oil vehicle.

4. TM-9216: Virginia's fast-drying white (thick). Same as #3, but with double thickness.

5. 284-270: Virginia's fast-drying white. Has soya oil rather than linseed oil in the alkyd.

6. 284-272: High durability two-minute dry white. Same as #3, but with 2-minute drying time.

7. TM-9217: Virginia's fast-drying yellow. Same as #3, but in yellow.

8. TM-9217: Virginia's fast-drying yellow (thick). Same as #7, but with double thickness.

9. 284-271: Virginia's fast-drying yellow. Same as #5, but in yellow.

10. 284-273: High durability two-minute dry yellow. Same as #6, but in yellow.

11. A-701: Virginia's conventional yellow. Same as #1, but in yellow.

12. TM-5367: New Jersey's type IV chlorinated rubber yellow. Same as #2, but in yellow.

13. 284-275: Fast dry waterborne yellow. Water emulsion or latex acrylic.

14. 284-274: Fast dry waterborne white. Same as #13, but in white.

Thermoplastics. 2-component — hard resin and color

15. 9HM31: Yellow conforming to the current Virginia specifications.

16. 9HM32: Same as #15, but in white.

17. 9HM33: High performance white. Supposedly a high performance thermoplastic.

18. 9HM30: Lower cost white. Lower than Virginia specification.

19. 9HM35: Polamide experimental. Different resin; not as thick. "Between a paint and a thermoplastic."

20. 9HM34: Federal Highway Administration's epoxy thermoplastic. A 2-component epoxy. Is precatalized, i.e., pre-coated and only when heat is applied do the components mix and react. It can be applied to damp roads. Also, it is basically the same type material as that applied around Williamsburg.

Tapes

21. 257 : 3M Durable tape, yellow.

22. 5361: 3M Scotchlane tape, yellow.

23. 5731: 3M Sta-Mark tape, yellow.

24. 5730: 3M Sta-Mark tape, white.

25. 256 : 3M Durable tape, white.

26. 5360: 3M Scotchlane tape, white.

27. 5730: 3M Sta-Mark tape (Va.), white.

Placement

Because of the variety of materials selected for test, coupled with the desired location, the uniform and controlled application of the materials presented a problem, especially if state forces were to be used. However, it was learned that the Baltimore Paint and Chemical Company had the equipment and expertise to apply all the desired materials, and they were contracted to install all the test sections with the exception of the pavement tapes. Since the tapes are preformed, no special apparatus was required for their placement. It is noted that the pavement was primed prior to the placement of the thermoplastics and preformed tapes.

The equipment used for application of the paint striping is shown in Figure 1 (all figures are attached). Calibration of the equipment for the desired paint coverage, paint film thickness (approximately 16 mils, wet) and glass bead coverage is shown in Figures 2 and 3. After calibration of the equipment, paint stripes were applied to the pavement as shown in Figures 4 and 5. Figure 6 shows the equipment used for placement of the thermoplastic materials and Figure 7 shows the thermoplastic being applied. Figure 8 shows the preformed tapes being applied to the pavement.

As shown in Figure 9, two lines 12 inches apart were applied for each type material. Figures 10 and 11 show the test stripes placed on concrete and bituminous pavements, respectively. Close-ups of the lines are shown in Figures 12 and 13.

Evaluation

The lines were evaluated by inspecting each line and wheel path. The field observations were made periodically from September 24, 1979, by members of the Research Council and Materials Division personnel. The characteristics evaluated were (1) general appearance, (2) durability, and (3) night visibility. The general appearance was judged by viewing the lines from the side of the road and took into account such factors as fading, yellowing, darkening, and dirt accumulation. It was rated on a scale of 0 (complete failure) to 10 (perfect).

The durability was rated by estimating, from examination with the unaided eye, the percentage of line remaining in the wheel tracks. These ratings were made on a scale of 0 (no line remaining) to 10 (no film loss). For the ratings, ASTM designations D 821-47 (abrasion resistance) and D 913-51 (chipping resistance) were used as standards for comparison. Details of the rating scale are shown in Table 1. The percentage of line remaining on the pavement is considered as the percentage of the wheel track area in which the pavement is not exposed. The term "wheel track" is defined as the area of greatest wear caused by the tire and the 9 inches to either side. Therefore, each line has two wheel tracks approximately 18 inches wide as shown in Figure 9.

Table 1

Durability Rating Scale

Scale	Percentage Intact	Description	ASTM Designation
0		perfect condition	10
1			9
2	97%		8
3			7
4	92%		6
5		intermediate failure	5
6	77%		4
7			3
8	60%	requires restriping	2
9			1
10		complete failure	

The night visibility designates the brightness of the materials obtained by utilizing photometric readings taken with a retroreflectance meter placed on each line in the wheel tracks. For paints, the night visibility at each inspection was taken as a percentage of the original average night visibility for each paint color, as measured by the photometer; i.e., the original values of night visibility for all white paints on both concrete and bituminous pavements were averaged and individual paint values obtained at each inspection thereafter were presented as a percentage of the original average. The same procedure was followed for yellow paints. Night visibility values at each inspection for the thermoplastics and preformed tapes were taken as a percentage of the original brightness of each individual material. The night visibility rating (N) was on a scale of 0 (no night visibility reading) to 10 (100% of initial night visibility reading).

$$\text{Rating (R)} = 0.10\,A + 0.40\,D + 0.50\,N,$$

where

R = overall rating,

A = appearance rating,

D = durability rating, and

N = night visibility rating.

RESULTS

The results are presented on the basis of the overall rating as discussed above. Although all test strips have not deteriorated to failure, it is felt that sufficient data are available for the purposes of this evaluation.

Paint

The overall rating for each paint stripe is shown in Table 2 along with the "days to failure", which was based on the length of time required for the overall rating to reach a value of 4.0. Also, graphs plotting the rating of each paint type considered versus that of Virginia's current standard paint (No. 3, white and No. 7, yellow) are shown in the Appendix.

Based on the results obtained from these test applications, there were differences in the quality of paints. Using "days to failure" as a criterion, the white paints on concrete pavements showing the highest rating were Virginia's fast drying white with linseed oil in place of soya oil (#5), and the high durability, two-minute dry paint (#6). For the yellow paint on concrete pavement, Virginia's fast drying yellow (thick #8), and New Jersey's Type IV chlorinated rubber yellow (#12) were the best.

Of the white paints tested on bituminous pavements, Virginia's fast drying paint (thick #4); high durability, two-minute dry paint (#6); and Virginia's fast drying paint with linseed oil in place of soya oil (#5) were superior. Of the yellow paints on bituminous pavements, Virginia's fast drying (thick #8) and New Jersey's Type IV chlorinated rubber (#12) were the best.

Table 2

Overall Rating and Days to Failure for Paints

No.	Class Designation	Overall Rating								Days to Failure		
		Oct. 23, 1979		Nov. 28, 1979		Jan. 16, 1980		May 1, 1980				
		Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.	Average
1	A-702-white	3.6	7.3	2.1	6.5	1.9	4.1	1.0	2.3	28	116	72
2	TM-5368-white	8.6	7.1	4.1	4.5	2.2	3.6	1.8	1.8	56	88	72
3*	TM-9216-white	6.9	5.4	5.1	4.5	3.5	2.9	0.5	1.3	94	74	84
4	TM-9216-white	6.1	6.6	4.3	6.0	3.5	5.0	1.8	1.8	74	147	111
5	284-270-white	7.4	6.4	6.5	5.6	5.3	4.5	2.3	2.3	160	137	149
6	284-272-white	6.9	6.8	4.8	5.5	3.9	4.6	1.0	1.8	108	135	122
7*	TM-9217-yellow	5.7	7.4	3.9	5.7	3.5	5.6	2.9	2.3	50	182	116
8	TM-9217-yellow	7.8	7.4	6.2	5.6	6.0	5.7	4.2	4.2	236	236	236
9	284-271-yellow	7.6	7.6	4.9	5.5	4.6	4.1	1.8	1.8	135	119	127
10	284-273-yellow	7.2	7.2	4.1	4.7	2.9	4.3	0.5	1.3	59	128	94
11	A-701-yellow	8.4	9.2	7.0	6.9	3.9	6.1	2.3	2.3	112	188	150
12	TM-5367-yellow	9.8	9.4	6.4	6.0	5.8	5.4	3.7	4.1	204	236	220
13	284-275-yellow	7.6	5.0	5.6	4.6	3.3	2.4	2.3	1.1	95	69	82
14	284-274-white	6.0	6.7	5.8	5.2	3.1	2.6	2.3	1.3	92	82	87
									Avg.	107	138	

*Virginia's present standard paint.

Averaging the "days to failure" for both pavement types, the white paints having the highest rating were Virginia's fast drying with linseed oil in place of soya oil (#5) and the high durability, two-minute dry (#6). For the yellow paints, Virginia's fast drying (thick #8) and New Jersey's type IV (#12) chlorinated rubber were superior.

Paints applied to the concrete pavement deteriorated faster than those placed on the bituminous surface. With the exception of the yellow paint placed on bituminous pavement, the traffic paint Virginia currently uses (white #3, yellow #7) had relatively low ratings.

Soya Oil vs. Linseed Oil

A comparison of paints using soya oil instead of linseed oil as a vehicle showed that those with soya oil were superior in the overall ratings for white and yellow paints on both concrete and bituminous pavements, with the exception of yellow on bituminous pavement.

Paint Thickness

Placing Virginia's standard paint (#3 white and #7 yellow) at a wet thickness of 15 mils and 26 mils resulted in higher overall ratings for the thicker paints. A 32% increase in the overall rating was found for white paints and a 103% increase for yellow. Also, it is noted that a higher night visibility was maintained throughout the observation period for the thicker paints.

Thermoplastics

Table 3 gives the overall rating for each thermoplastic placed. Those materials placed on bituminous pavement rated higher than those placed on concrete; however, the primary reason for this was the early spalling of those materials placed on the concrete pavement. Because of this excessive spalling of thermoplastics, especially on concrete, it is felt that insufficient results are available to allow any conclusions concerning the overall effectiveness of the thermoplastic materials used.

Table 3

Overall Rating for Thermoplastics

No.	Class Designation	October 23, 1979		November 28, 1979		January 16, 1980	
		Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.
15	9HM31	9.7	9.9	8.6	9.4	3.0	7.2
16	9HM32	9.6	9.9	8.7	9.8	2.7	7.5
17	9HM33	8.8	9.9	8.4	9.6	2.5	6.8
18	9HM30	9.9	9.9	9.8	9.7	3.4	7.8
19	9HM35	4.9	7.9	0.1	6.3	1.5	2.2
20	9HM34	9.9	8.1	5.4	7.7	1.6	5.4

Preformed Tapes

The overall ratings for preformed tapes are shown in Table 4. Most of the tapes considered had high overall ratings without deteriorating to the point of failure (R = 4.0) as of May 1, 1980. The high overall rating is primarily due to the durability rating remaining high since the tapes are relatively intact. The night visibility rating decreased steadily for all tapes except numbers 23, 24, and 27, which increased between the January 16 and May 1, 1980, inspections. Graphs showing the overall rating versus time are shown in the Appendix.

It is reiterated that the night visibility factor is based on the percentage loss of night visibility relative to the initial visibility upon placement. Table 5 gives an example of the average night visibility readings for all materials in each category. Both colors of preformed tapes were much brighter initially than the paints or thermoplastics, with the white tape being twice the value of yellow. Values for the white paint and thermoplastic were about the same when the materials were applied (September 24, 1979). Also, the yellow paint was about half as bright as the white. After approximately two months, all materials had substantailly decreased in night visibility, with the exception of the thermoplastics, which remained about the same. The night visibility values for the tapes are at least triple those for comparable colors in the paint category; however, they show a lower percentage of initial night visibility. Also, the tapes were still brighter after two months than the initial readings for paints and thermoplastics.

Table 4

Overall Rating for Preformed Tapes

Number and Classification	Oct. 23, 1979		Nov. 28, 1979		Jan. 16, 1980		May 1, 1980		Approx. Cost per Foot
	Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.	Conc.	Bitum.	
21-257	9.9	9.2	8.1	7.1	6.7	5.8	4.5	4.0	.37
22-5361	7.3	6.0	5.4	5.7	4.6	4.7	3.8	3.8	.22
23-5731	7.9	8.9	5.6	6.3	5.4	5.3	7.6	7.9	.68
24-5730	8.0	8.2	6.4	6.5	5.7	5.8	6.4	6.2	.68
25-256	9.4	9.1	8.8	7.8	7.8	7.7	5.4	5.4	.37
26-5360	0	0	0	0	0	0	0	0	.22
27-5730	8.2	8.1	6.7	6.0	5.8	5.8	7.6	6.8	.68

Table 5

Average Night Visibility Values

Category	Night Visibility		Percent Initial Night Visibility
	(Sept. 24, 1979)	(Nov. 28, 1979)	
Paint — white	0.17	0.06	35
Paint — yellow	0.08	0.03	38
Thermoplastic — white	0.19	0.19	100
Tape — white	1.02	0.21	21
Tape — yellow	0.52	0.12	23

CONCLUSIONS

1. The method of placing transverse lines across the pavement for the purpose of determining the performance of marking materials has merit. It should be noted that the time required for sufficient deterioration to determine their performance was considerably longer for preformed tapes and thermoplastics than for paints.

2. The white paint exhibiting the highest overall rating was Virginia's fast drying (50 second) paint that has soya oil rather than linseed oil in the alkyd. The best yellow paint was Virginia's fast drying (50 second) paint having a linseed oil vehicle and placed at double thickness.

3. Paints using soya oil in place of linseed oil as a vehicle generally exhibited higher overall ratings.

4. A comparison of paint thicknesses showed higher overall ratings for thicker paints (26 mils wet vs. 15 mils wet).

5. Paints applied to the concrete pavement deteriorated faster than those placed on bituminous pavement.

6. Insufficient results were available to allow conclusions concerning the performance of the thermoplastic materials.

7. Most of the preformed tapes were still intact on both pavement types and exhibited acceptable overall performance. It seems that the performance of each tape is related to its cost.

8. Upon initial installation, there was little difference in night visibility for paints and thermoplastics; however, preformed tapes were 5 to 6 times as bright.

9. After two months, thermoplastics and preformed tapes generally had night visibility ratings 3 to 4 times those for comparable colors in the paint category. Also after two months, the tapes were brighter than were the paints and thermoplastics when they were initially installed.

10. Overall, it is believed that the results were very beneficial in learning about the relative performance of selected paints under a controlled environment and are a major step in ensuring that the state is getting the best product for its expenditures.

RECOMMENDATIONS

It is recommended that the state adopt a performance specification wherein suppliers would be required to submit their traffic paints for on the road evaluation and the product exhibiting the best overall performance, considering general appearance, durability, night visibility, and cost, would be purchased.

It is recommended that the Department change the Road and Bridge Specifications to allow the use of soya oil as well as linseed oil.

Attention should be given to the testing of preformed tapes using on the road performance techniques. It is noted that such an evaluation would take considerably longer than the evaluation of traffic paints; therefore, conditions leading to a rapid deterioration should be considered.

Minimum values for night visibility of traffic markings should be considered.

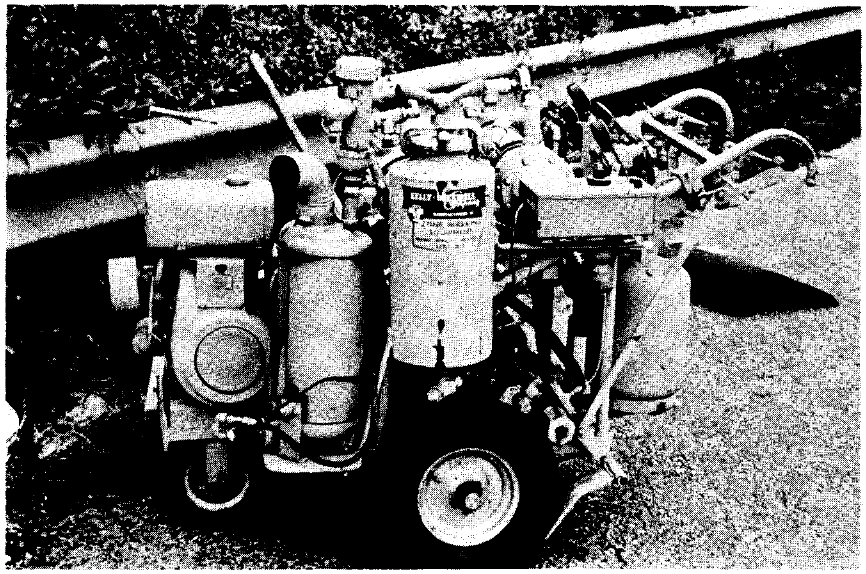


Figure 1. Paint striping machine.

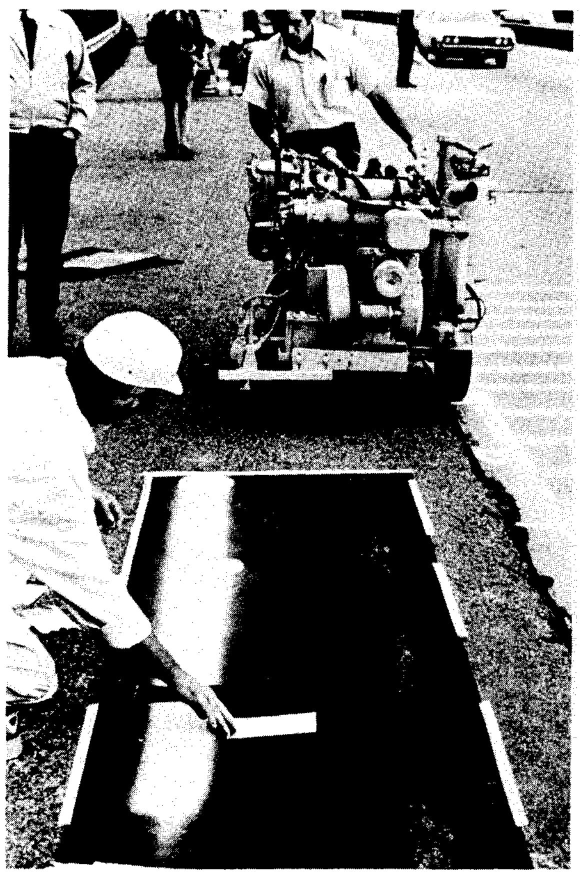


Figure 2. Calibrating for paint thickness.

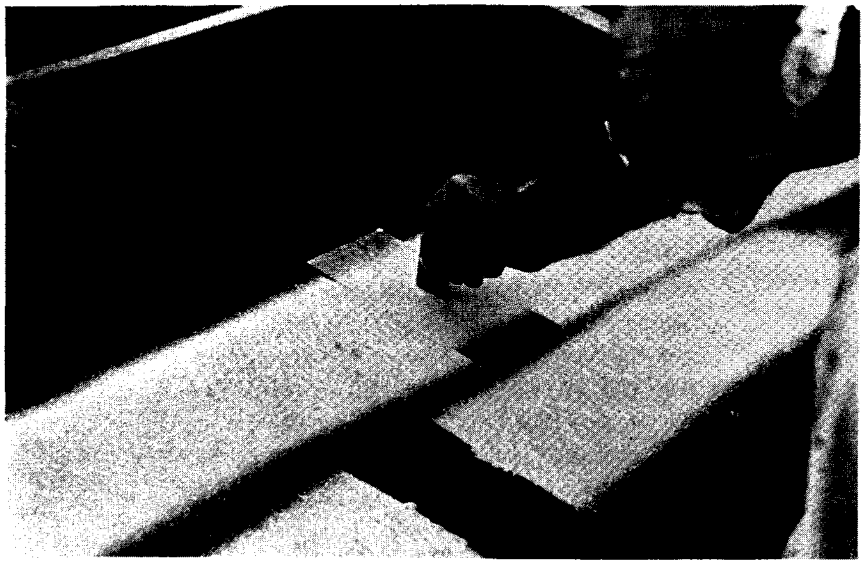


Figure 3. Checking test plate for paint thickness.

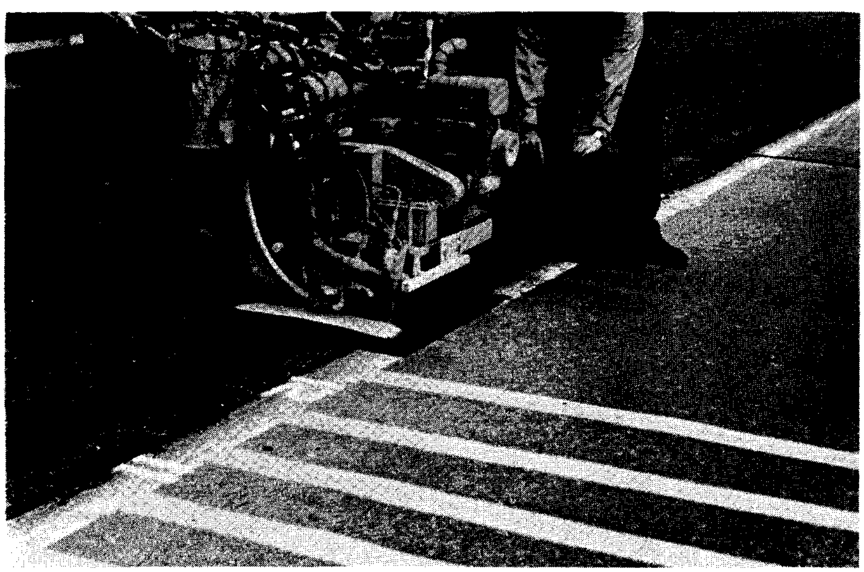


Figure 4. Beginning of test stripe application.

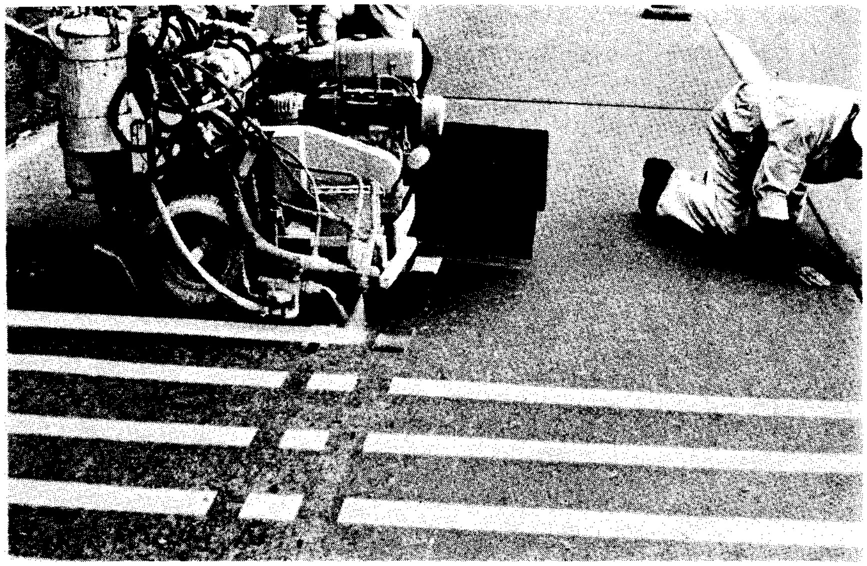


Figure 5. Applying test stripe on pavement and sample plates.

Figure 6. Machine for applying thermoplastic.

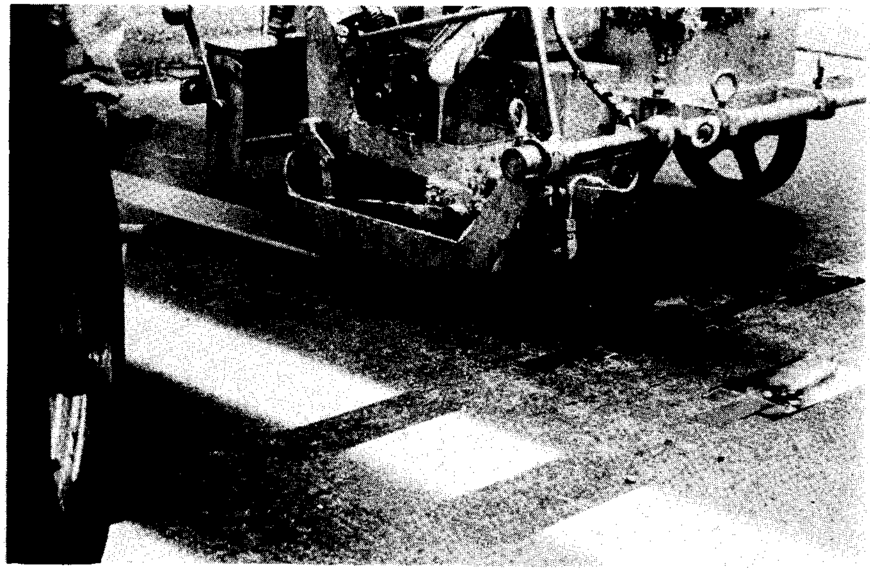


Figure 7. Applying thermoplastic material.

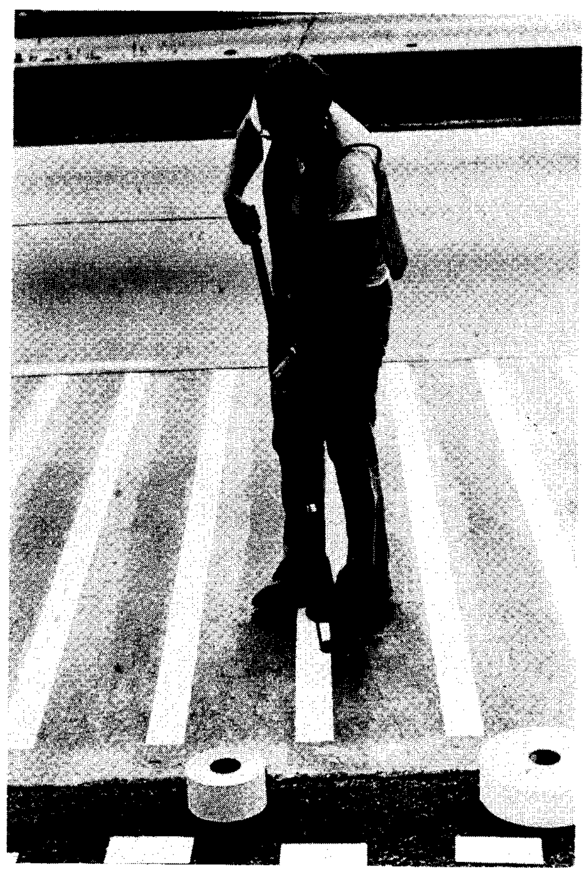


Figure 8. Applying preformed tapes.

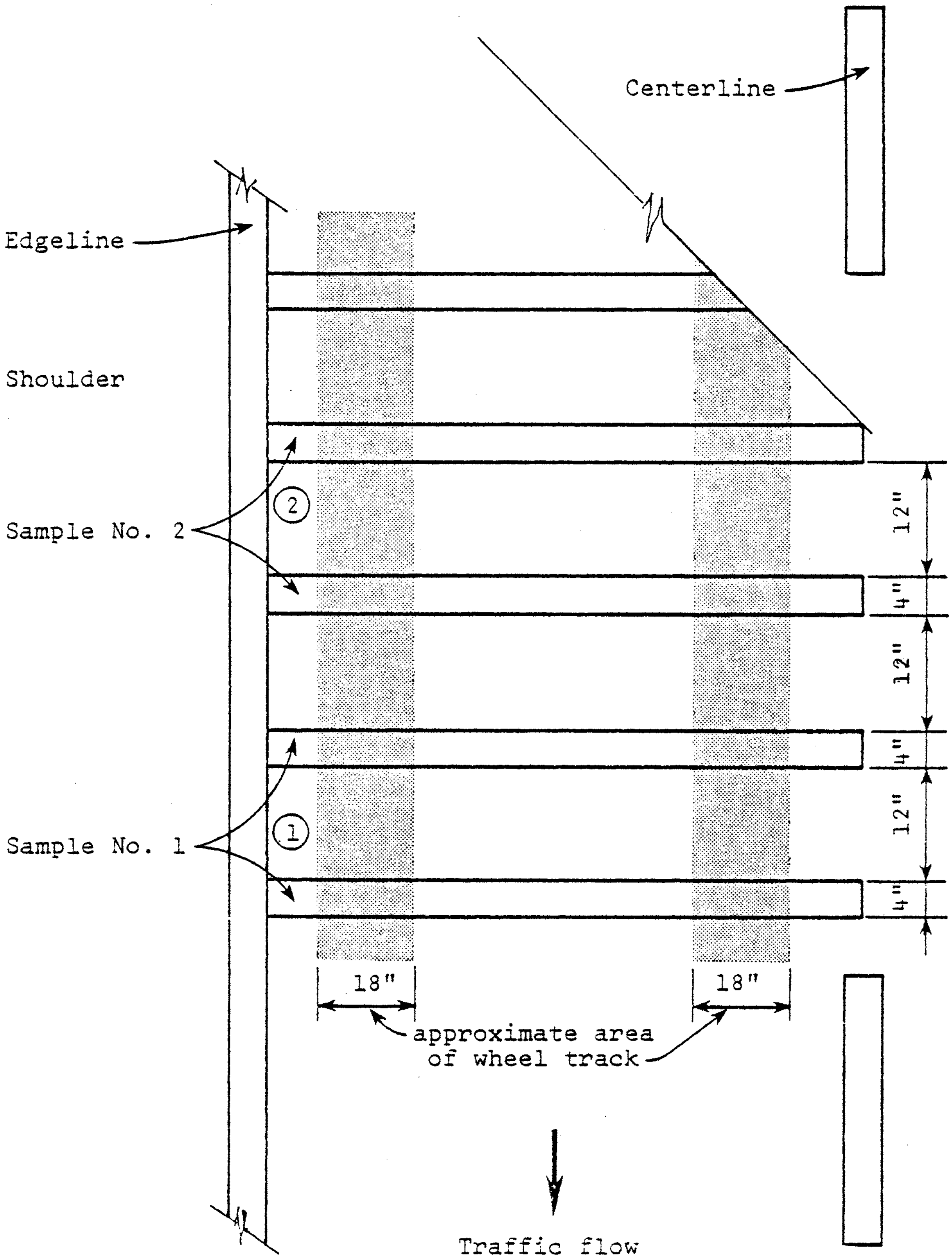


Figure 9. Placement of test materials.

Figure 10. Test section on concrete pavement.

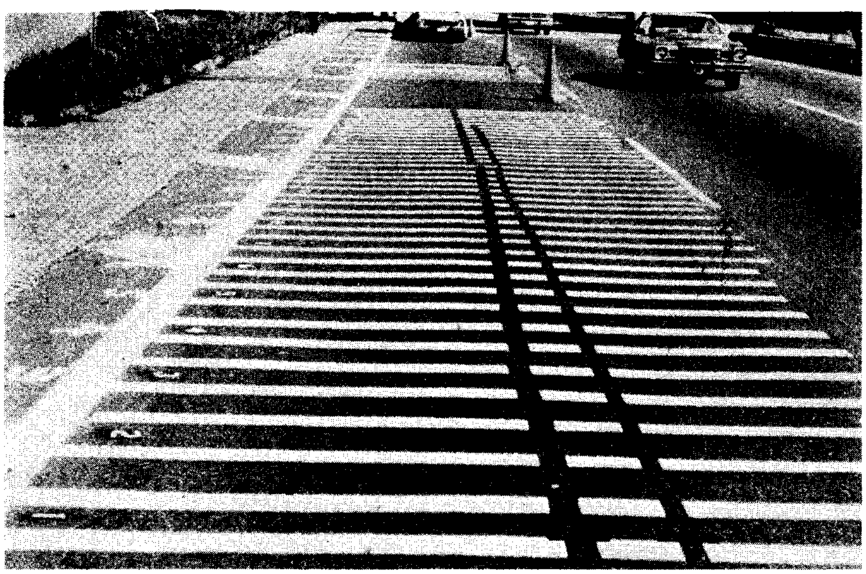


Figure 11. Test section on bituminous pavement.

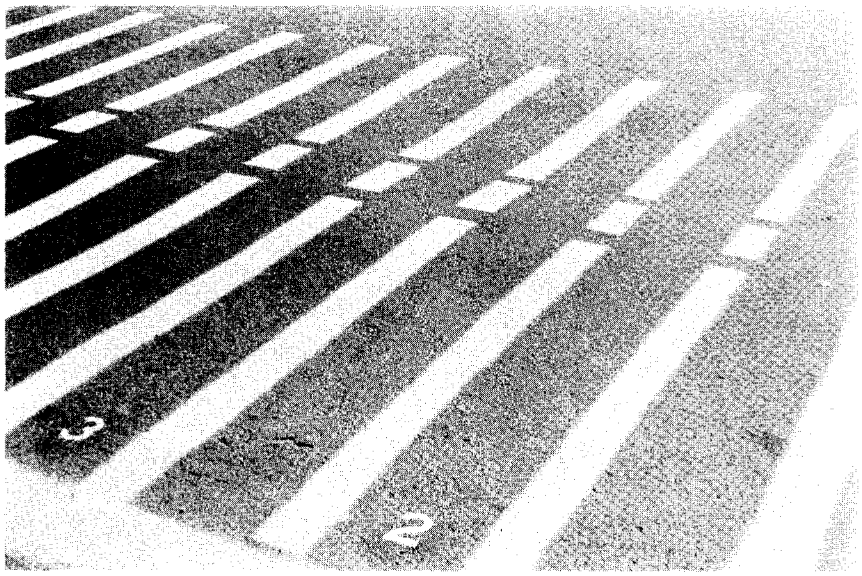


Figure 12. Typical test stripes.

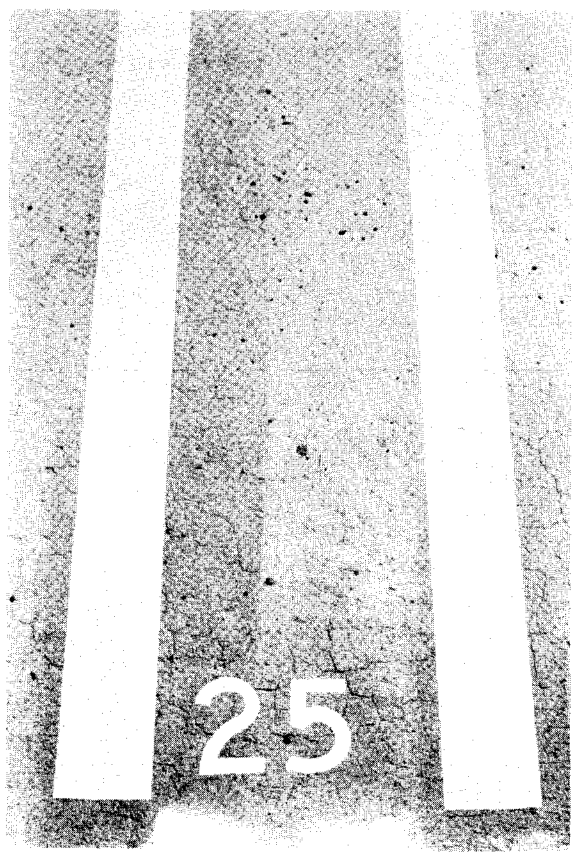


Figure 13. Close-up of test stripe.

990

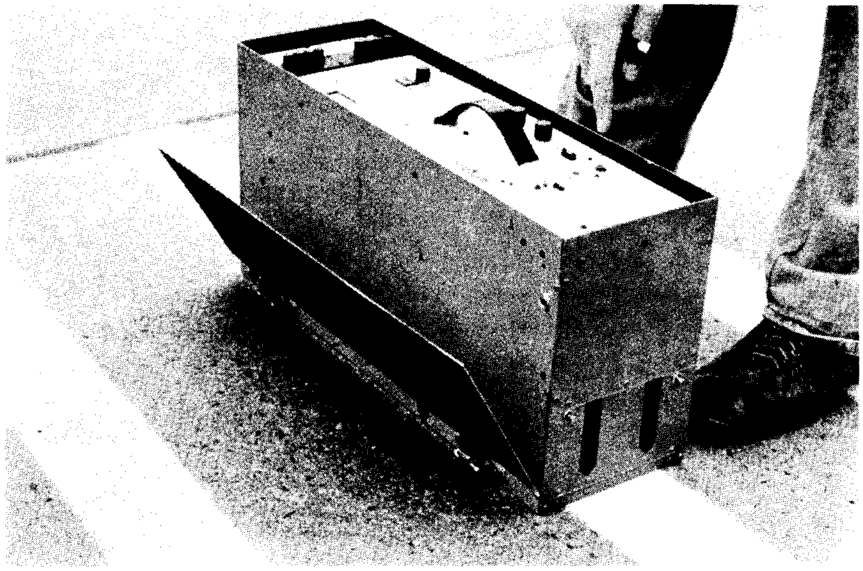
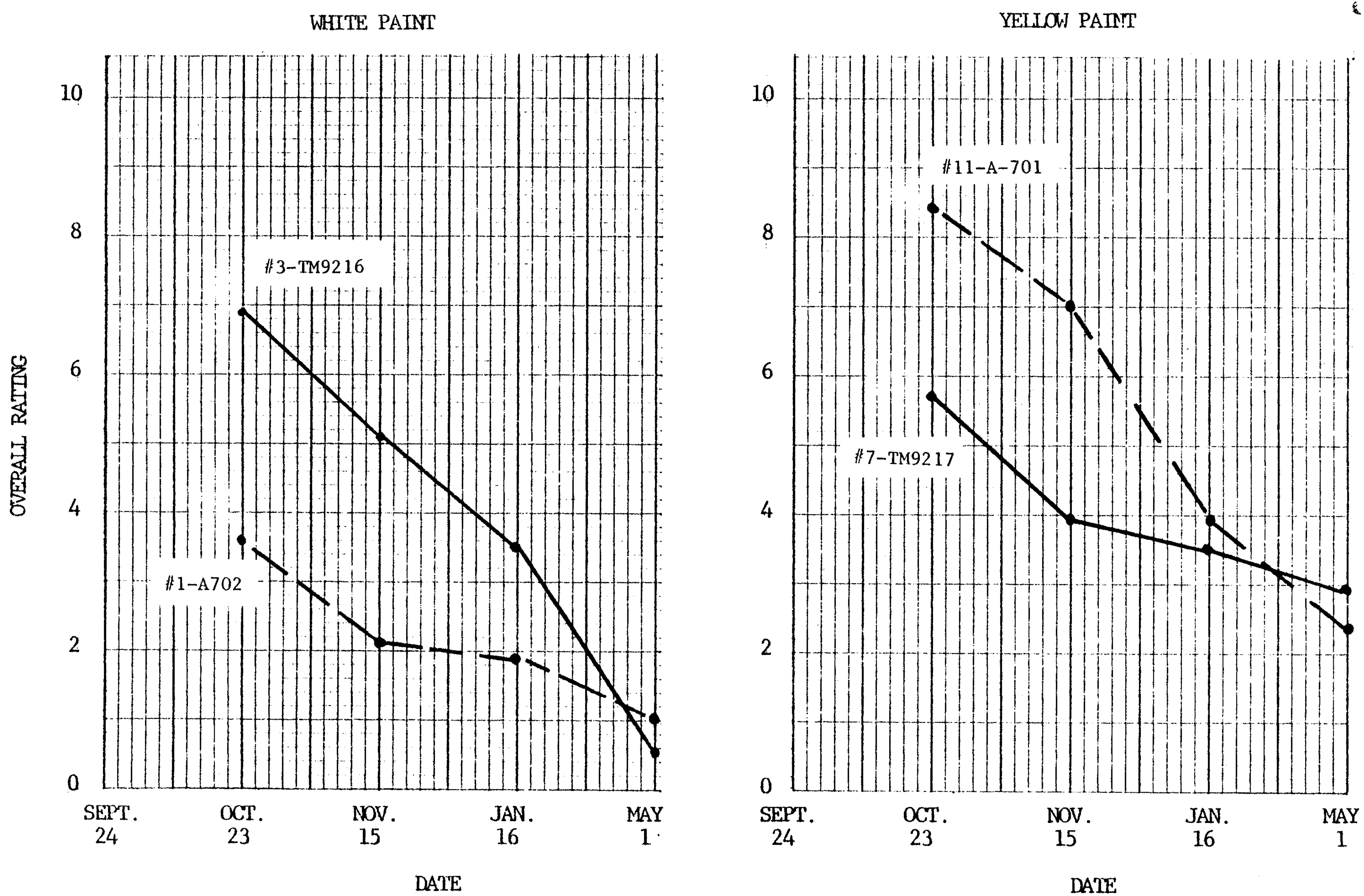


Figure 14. Retroreflectance meter.

APPENDIX

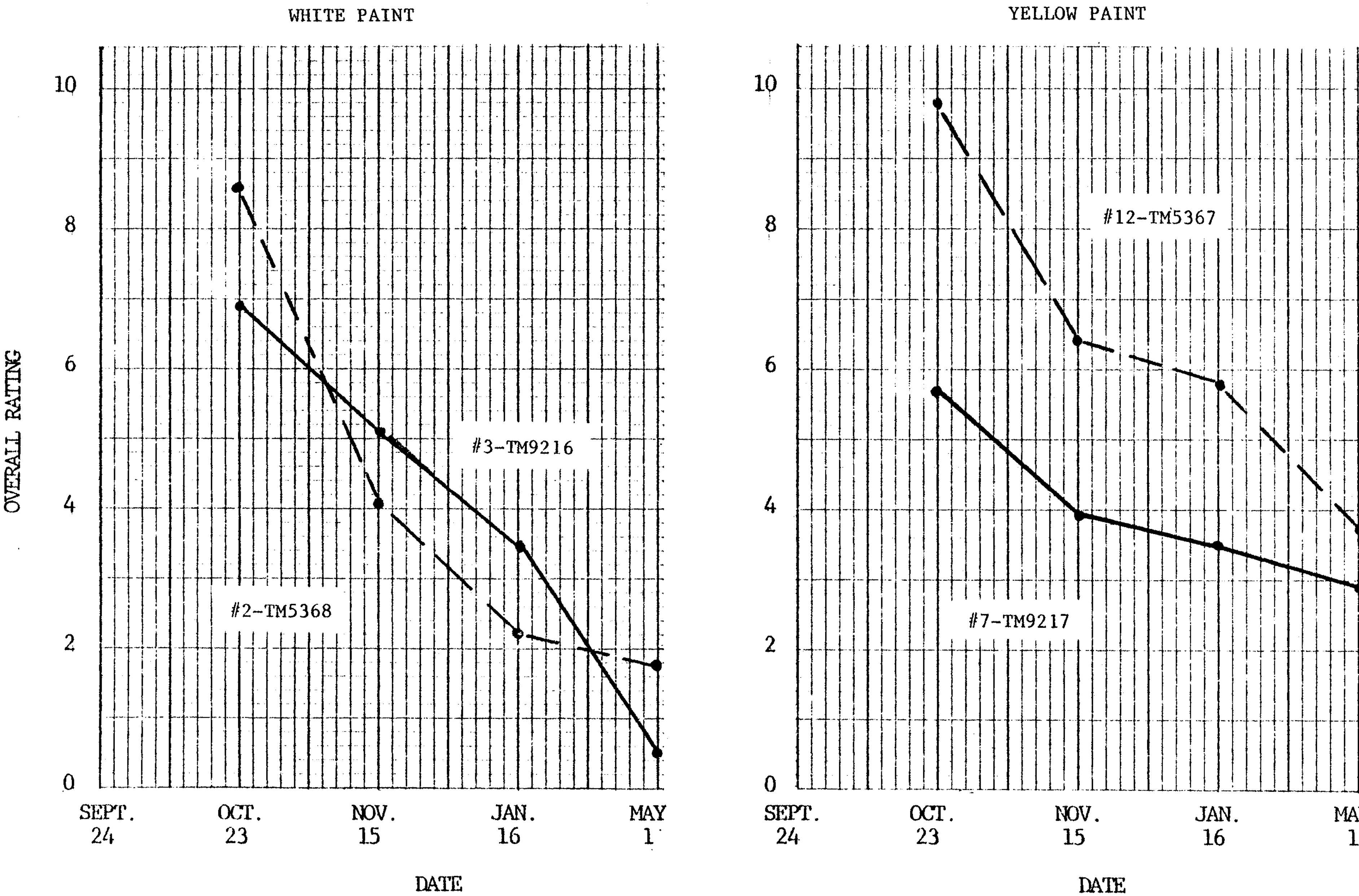
GRAPHS SHOWING OVERALL RATING VS. TIME FOR STRIPING MATERIALS

CONCRETE



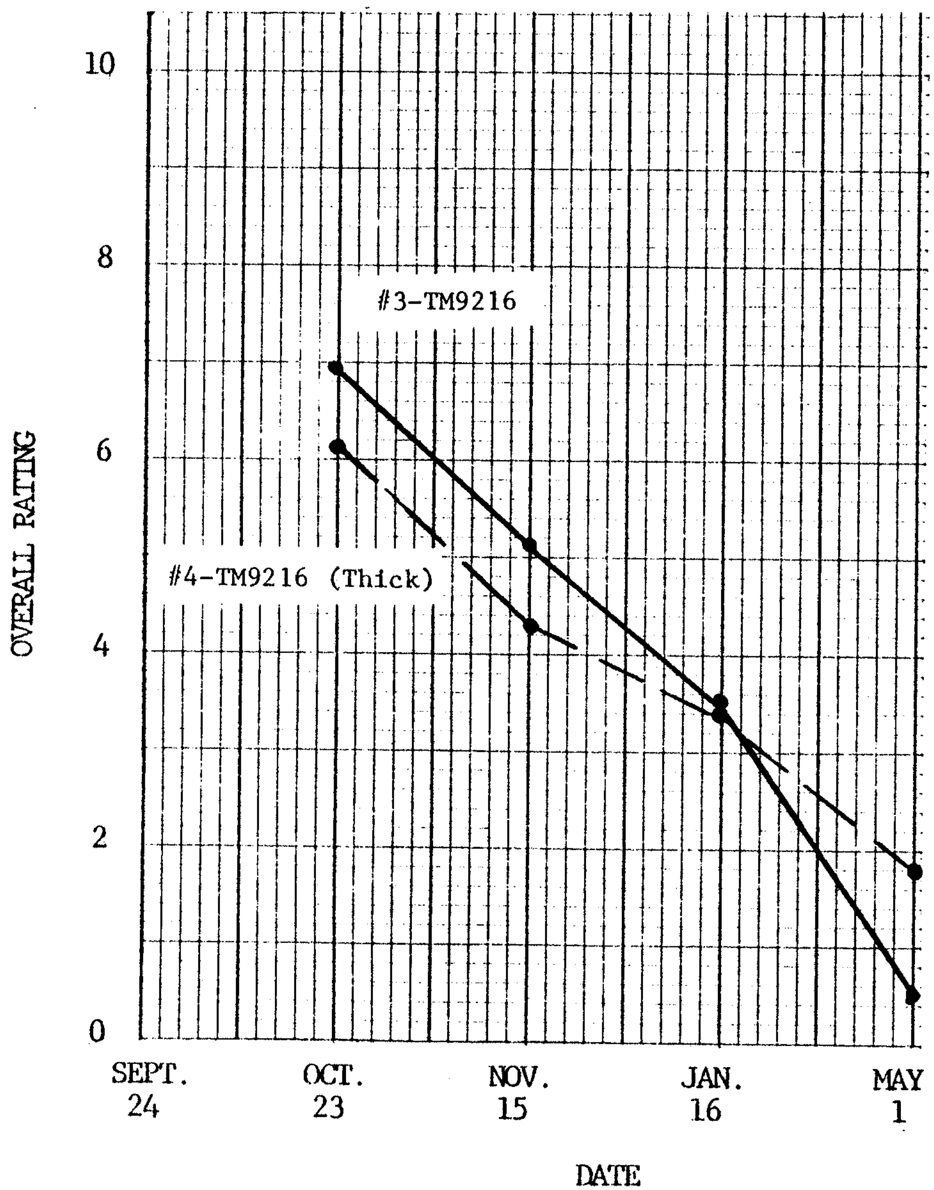
WHITE PAINT
YELLOW PAINT
OVERALL RATING
10
8
6
4
2
0
#3-TM9216
#1-A702
#11-A-701
#7-TM9217
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

CONCRETE

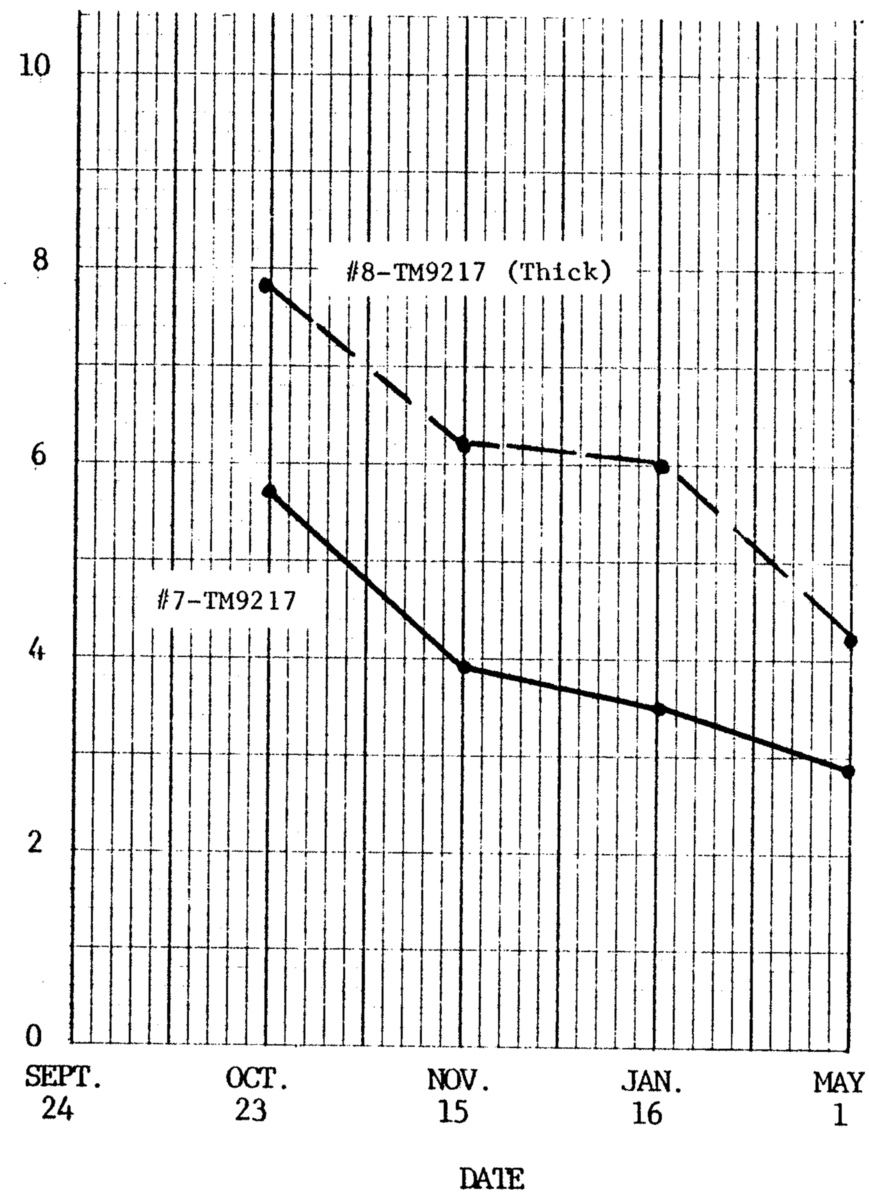

WHITE PAINT
YELLOW PAINT
OVERALL RATING
10
8
6
4
2
0
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE
#2-TM5368
#3-TM9216
#12-TM5367
#7-TM9217

CONCRETE

WHITE PAINT

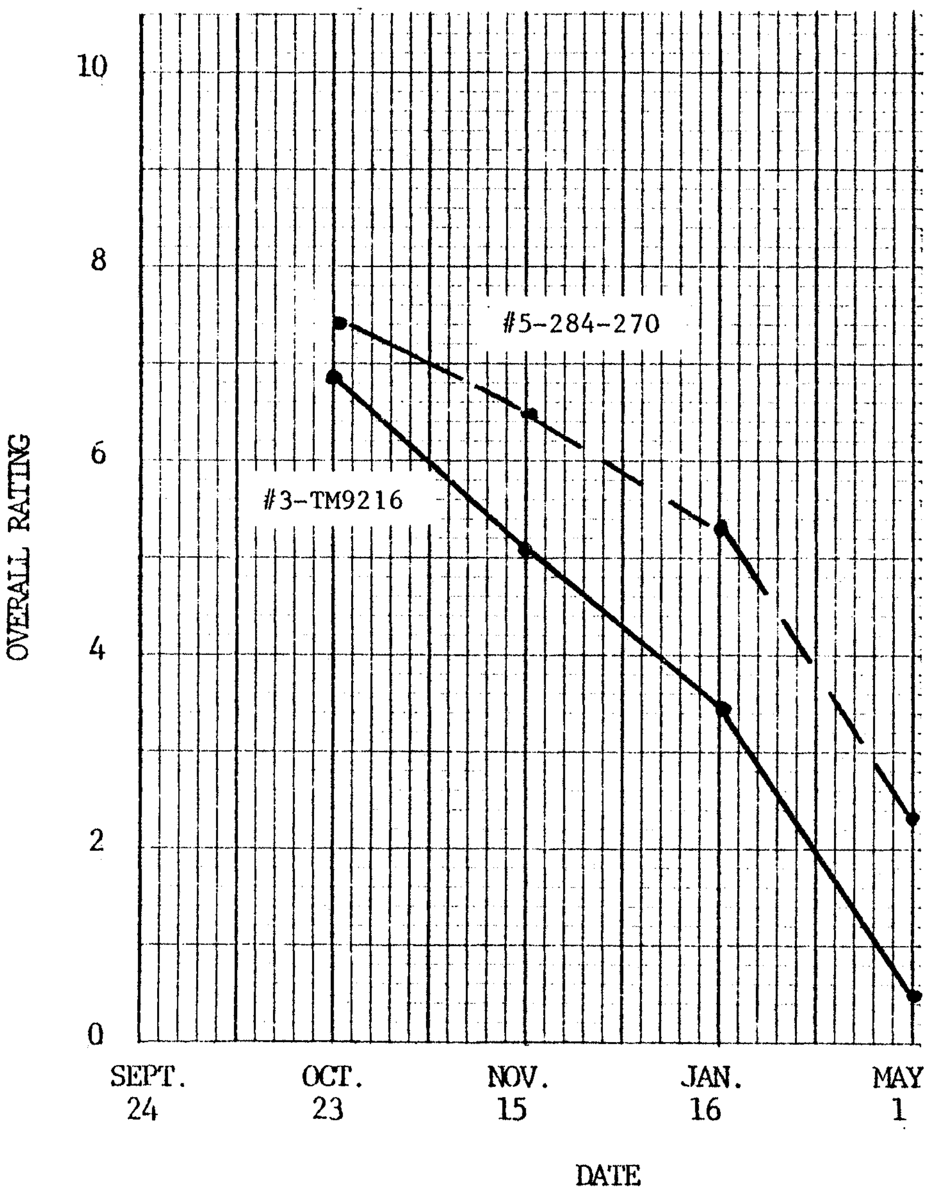


YELLOW PAINT

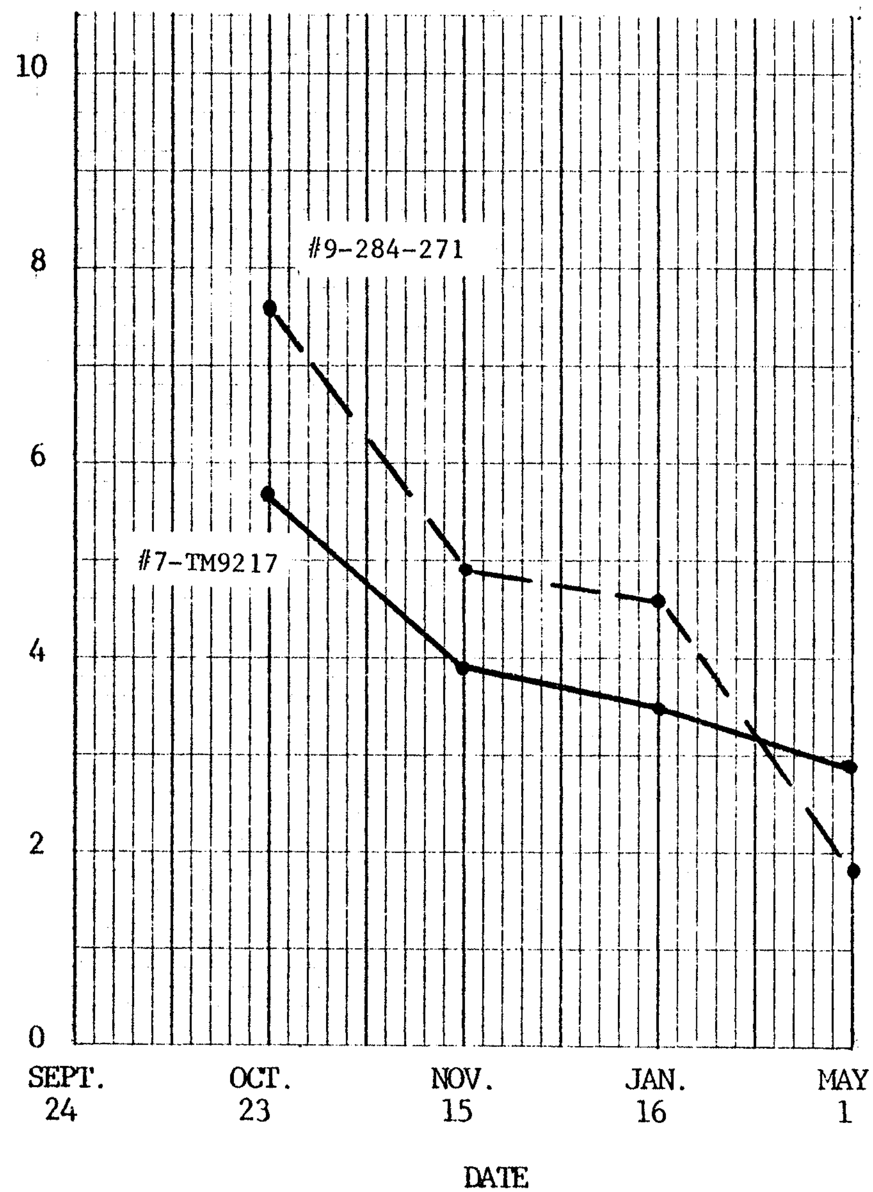


CONCRETE

WHITE PAINT



YELLOW PAINT



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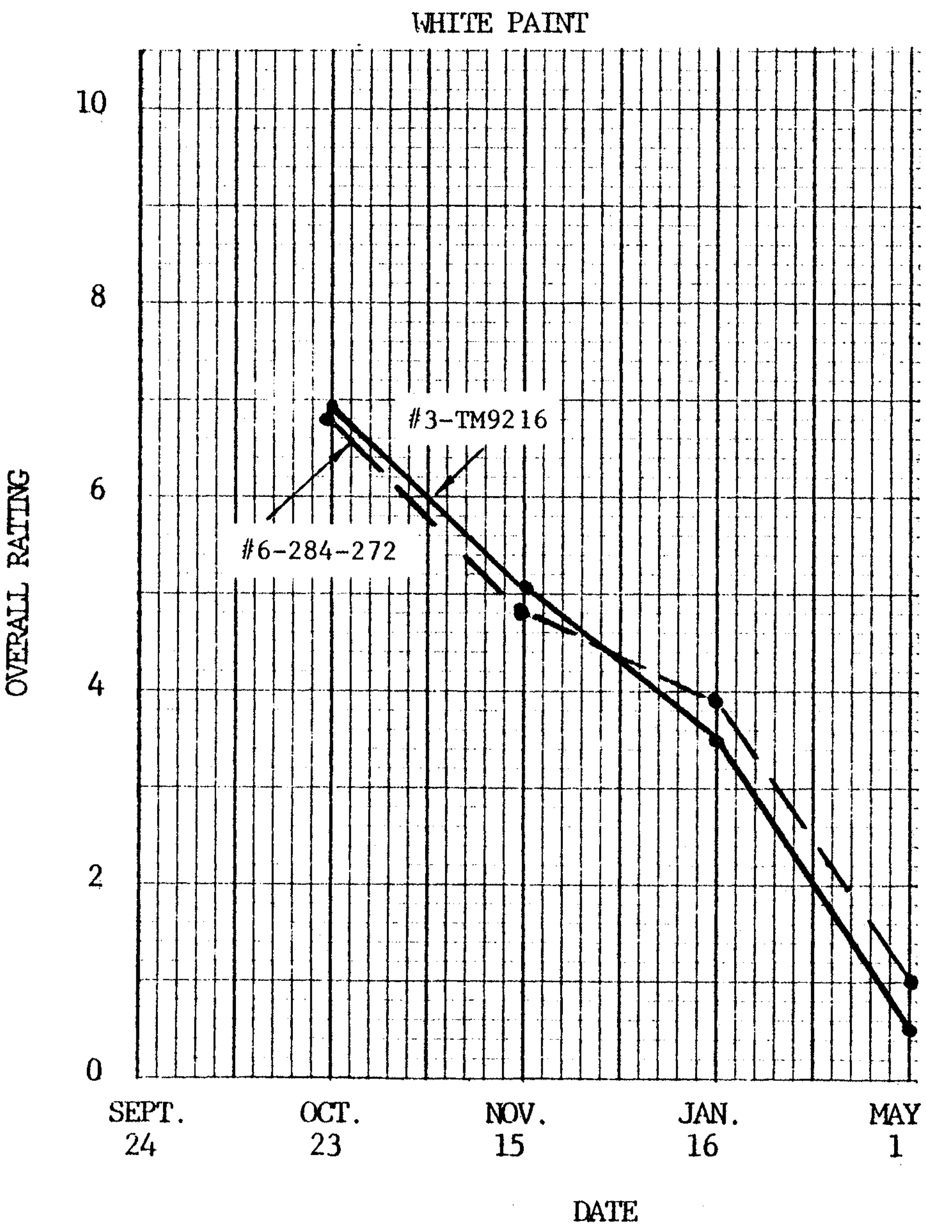
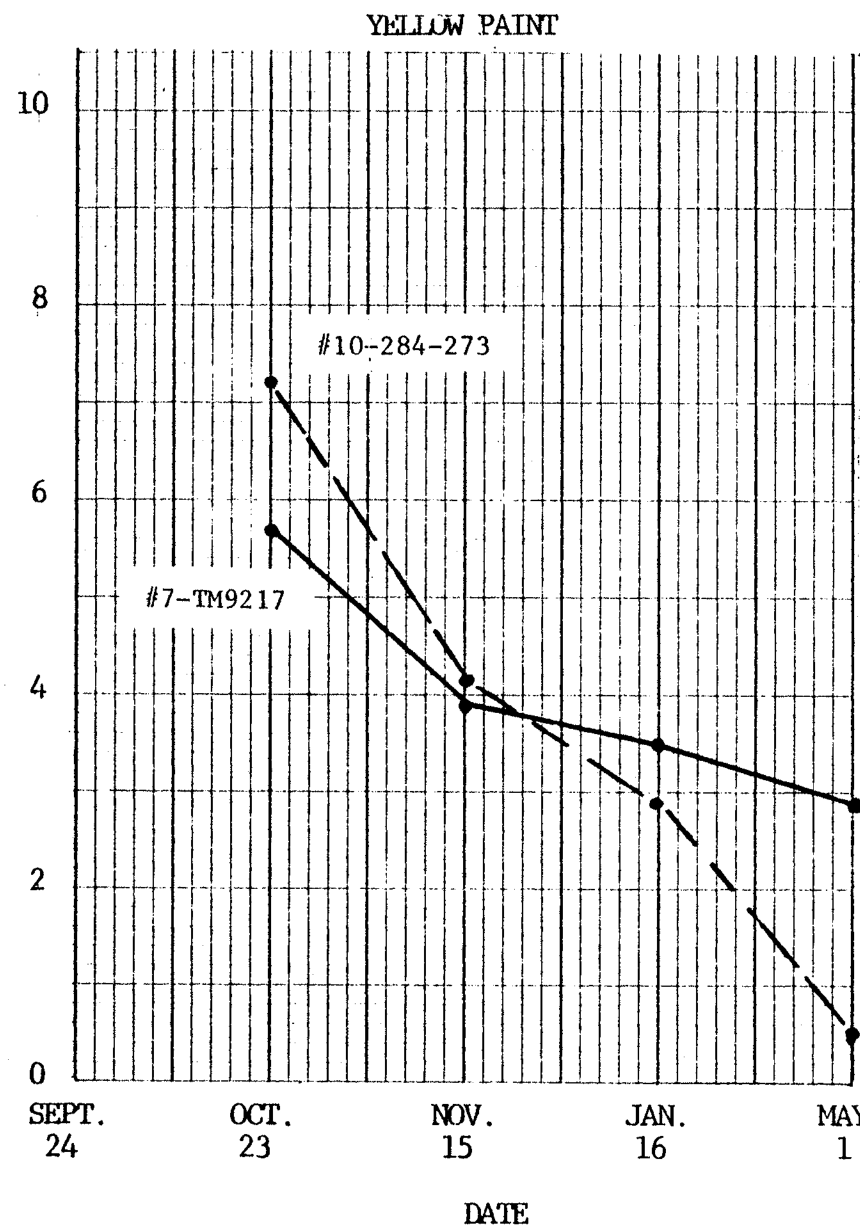
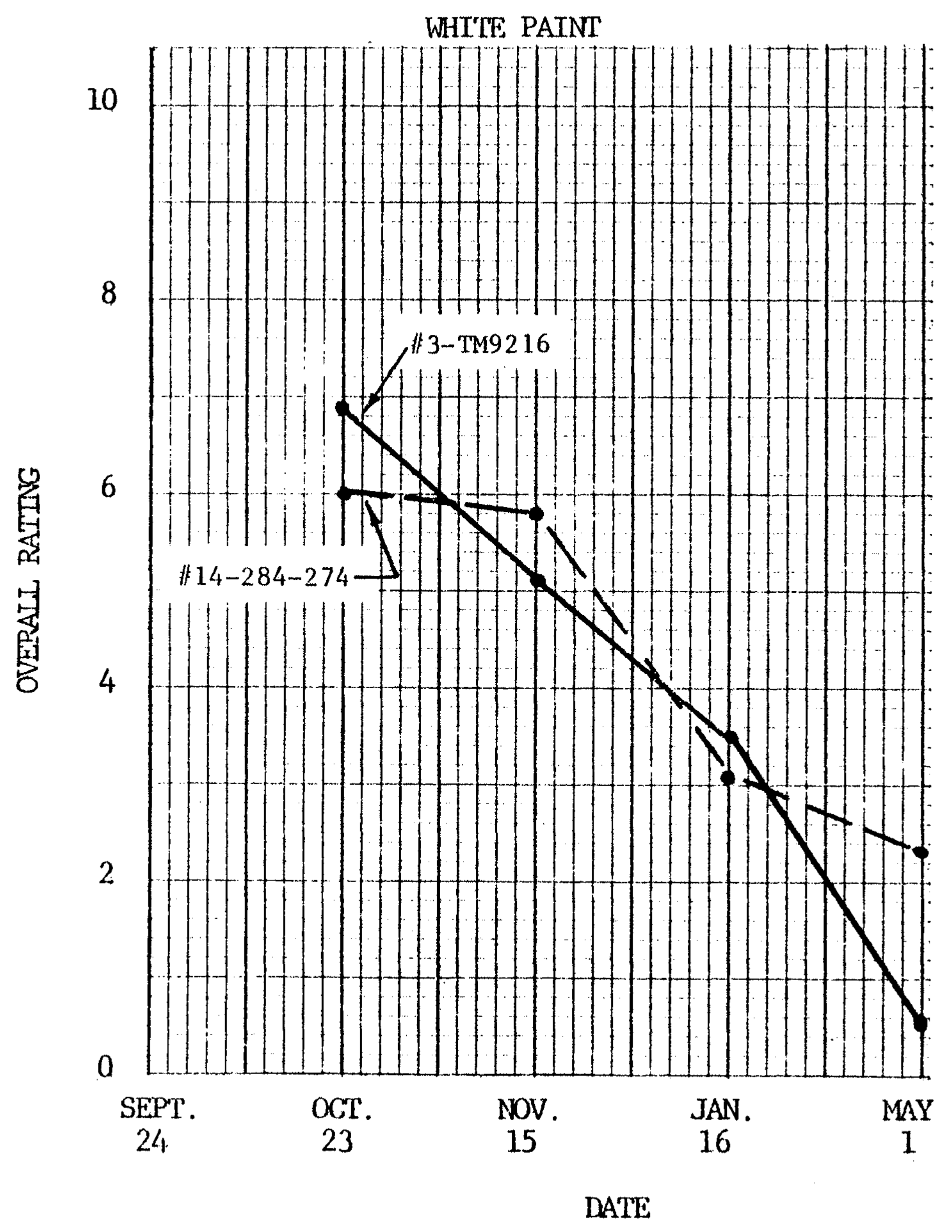
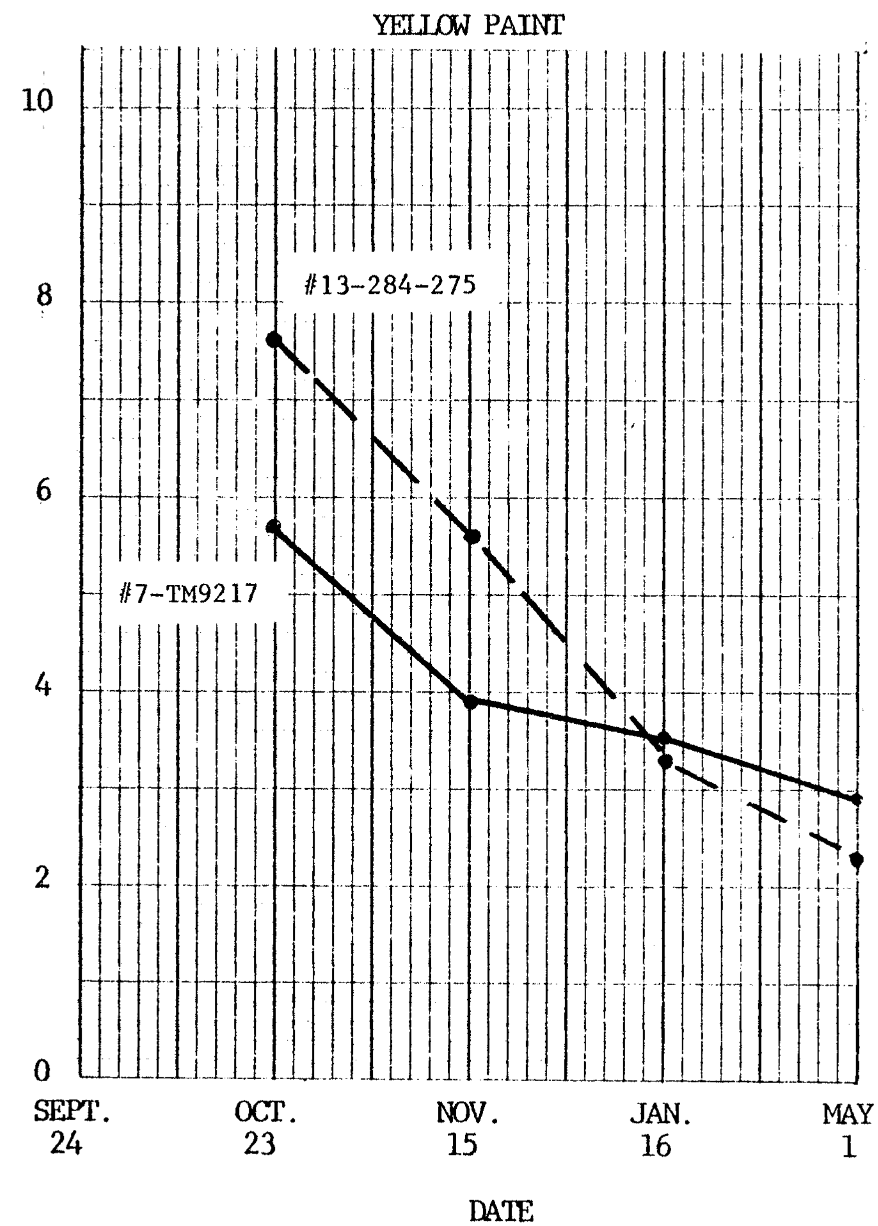

WHITE PAINT
OVERALL RATING
10
8
6
4
2
0
#3-TM9216
#6-284-272
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE


YELLOW PAINT
10
8
6
4
2
0
#10-284-273
#7-TM9217
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

CONCRETE



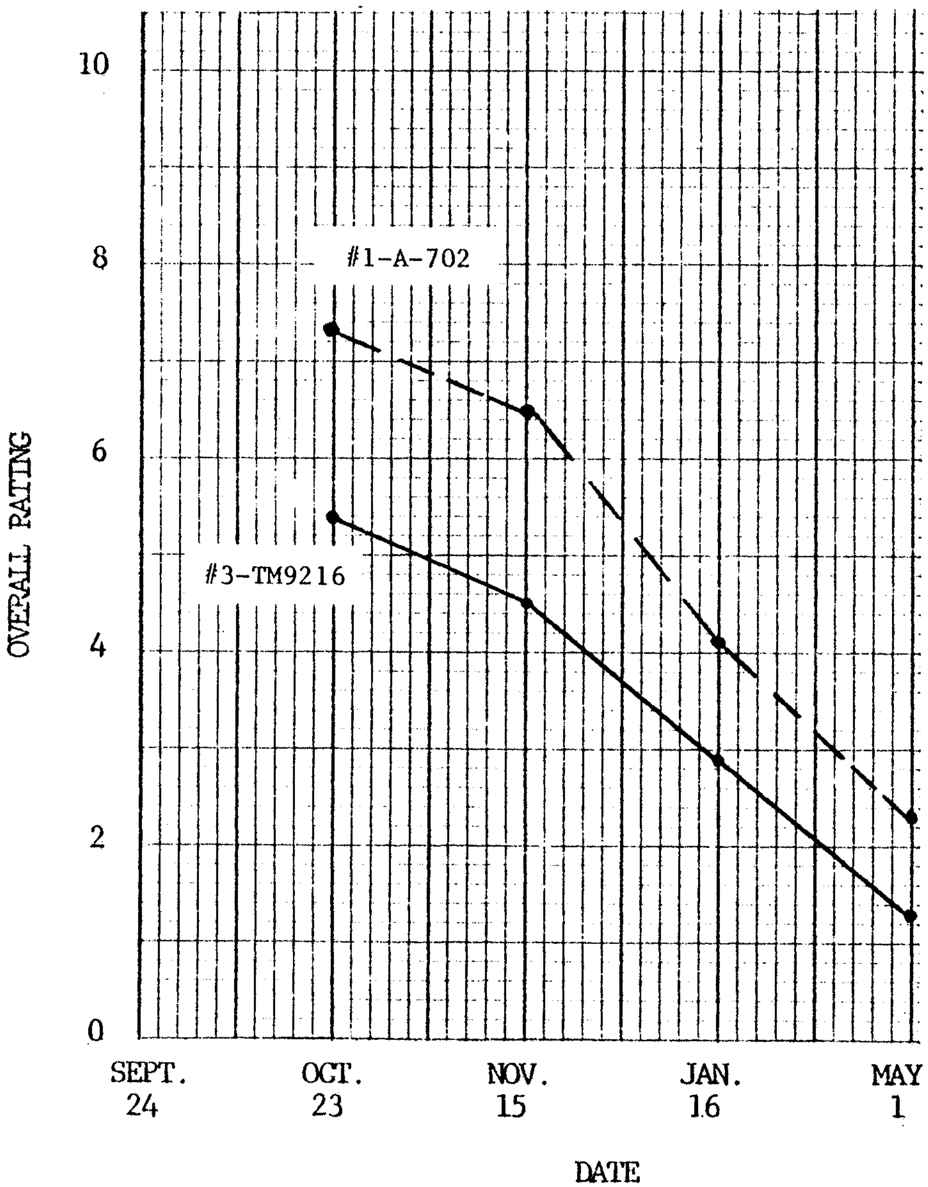
WHITE PAINT
OVERALL RATING
10
8
6
4
2
0
#3-TM9216
#14-284-274
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE



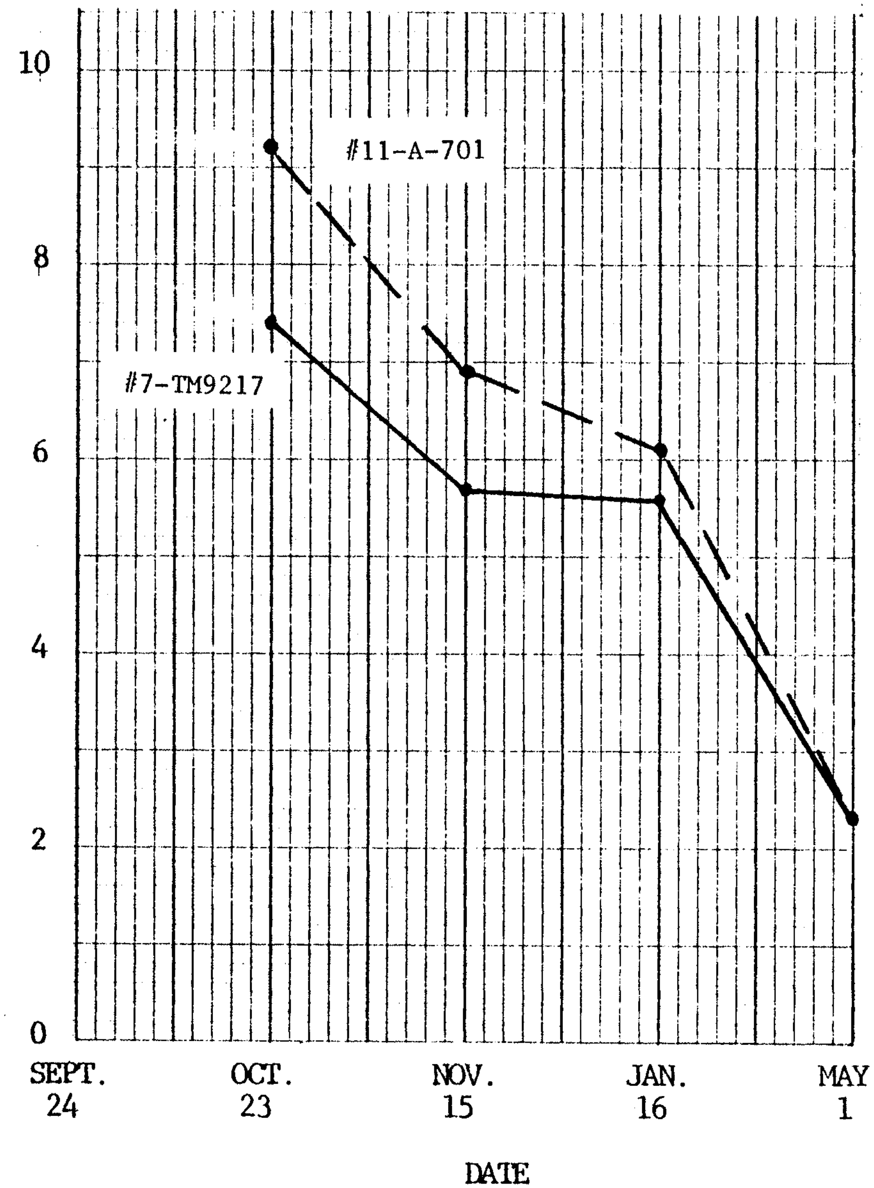
YELLOW PAINT
10
8
6
4
2
0
#13-284-275
#7-TM9217
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

BITUMINOUS

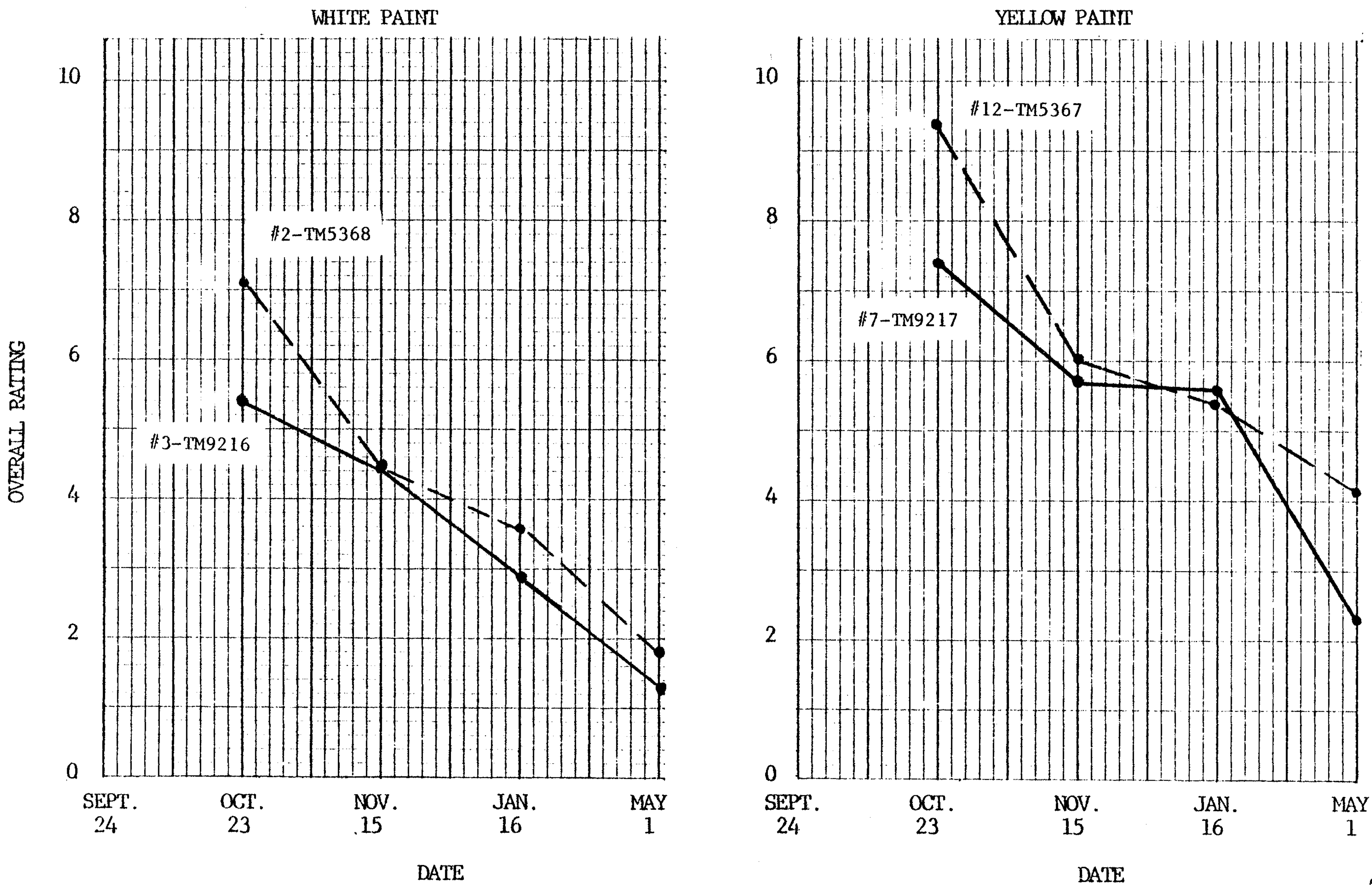
WHITE PAINT



YELLOW PAINT

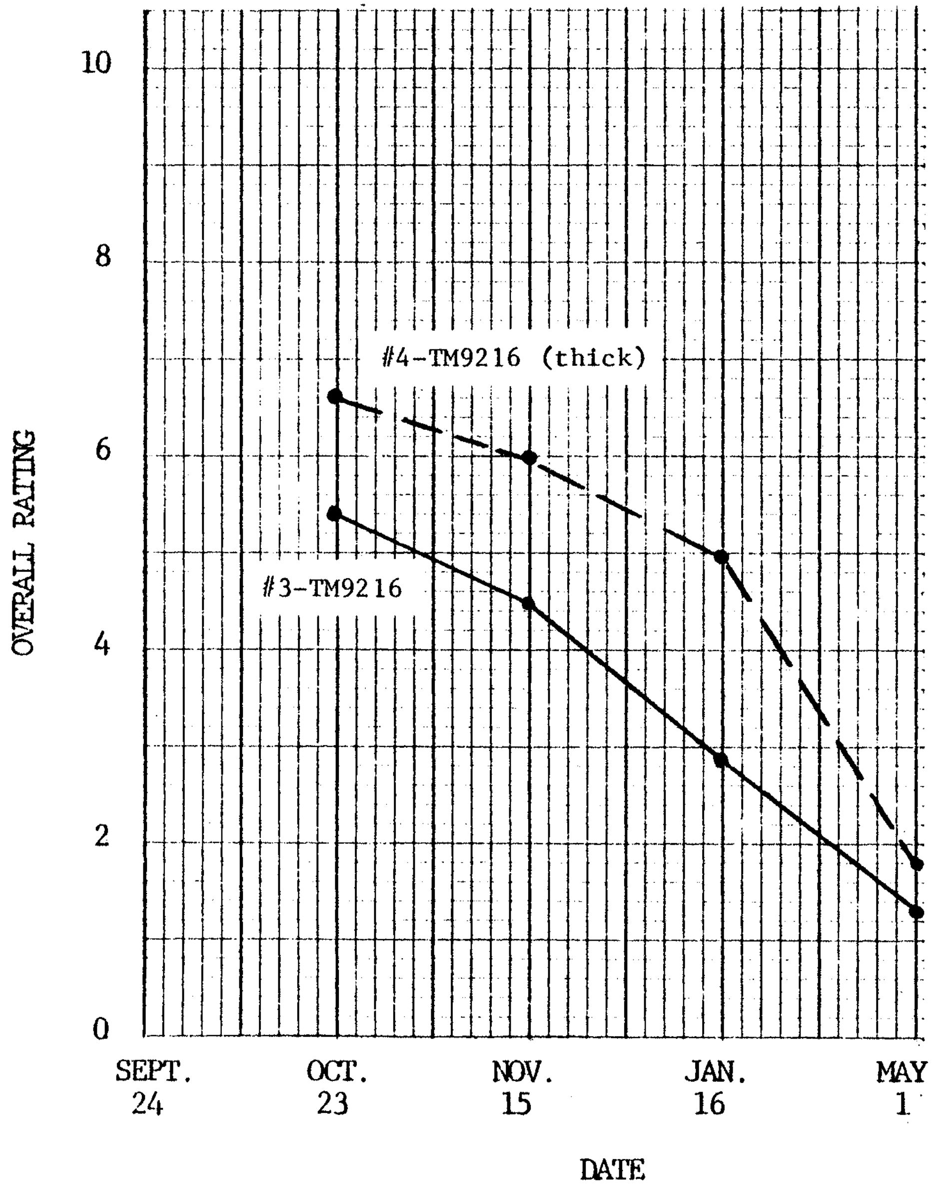


BITUMINOUS

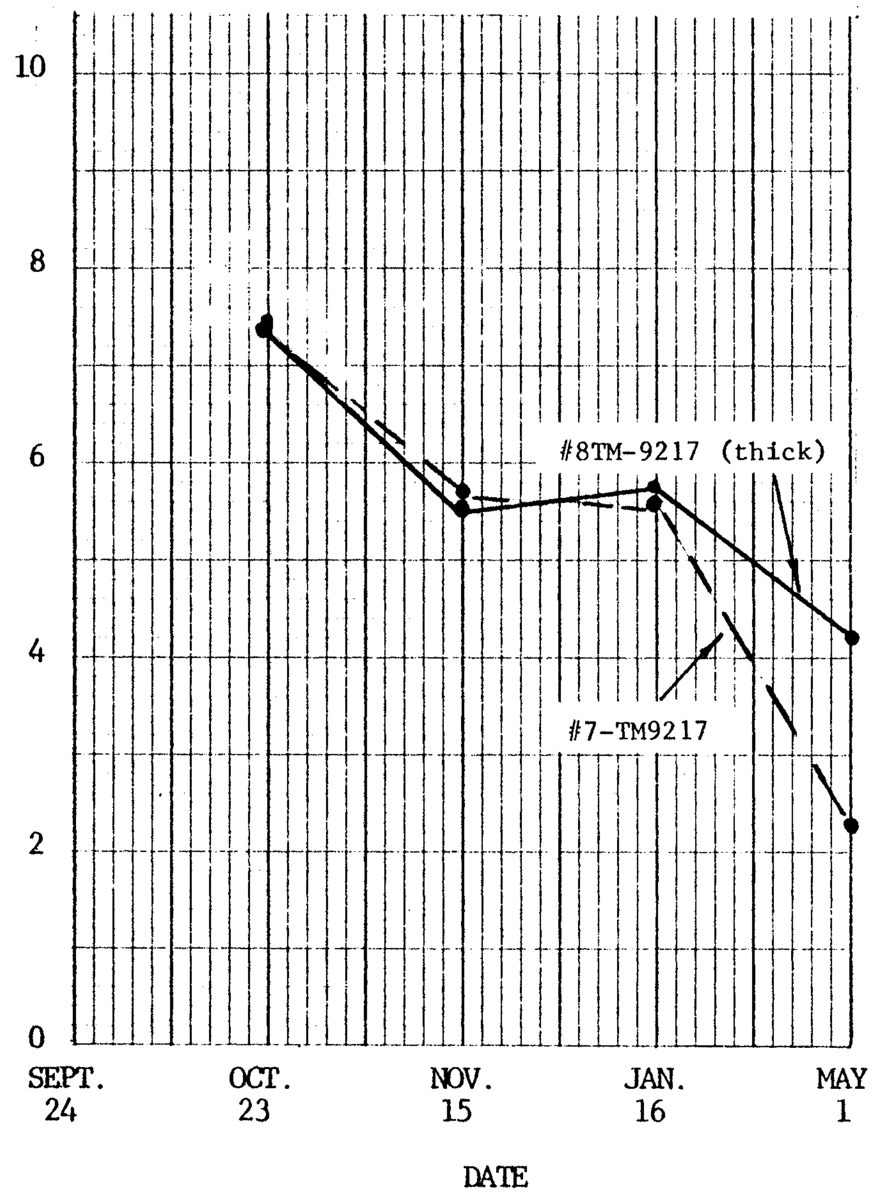

WHITE PAINT
YELLOW PAINT
OVERALL RATING
10
8
6
4
2
0
#2-TM5368
#3-TM9216
#12-TM5367
#7-TM9217
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

BITUMINOUS

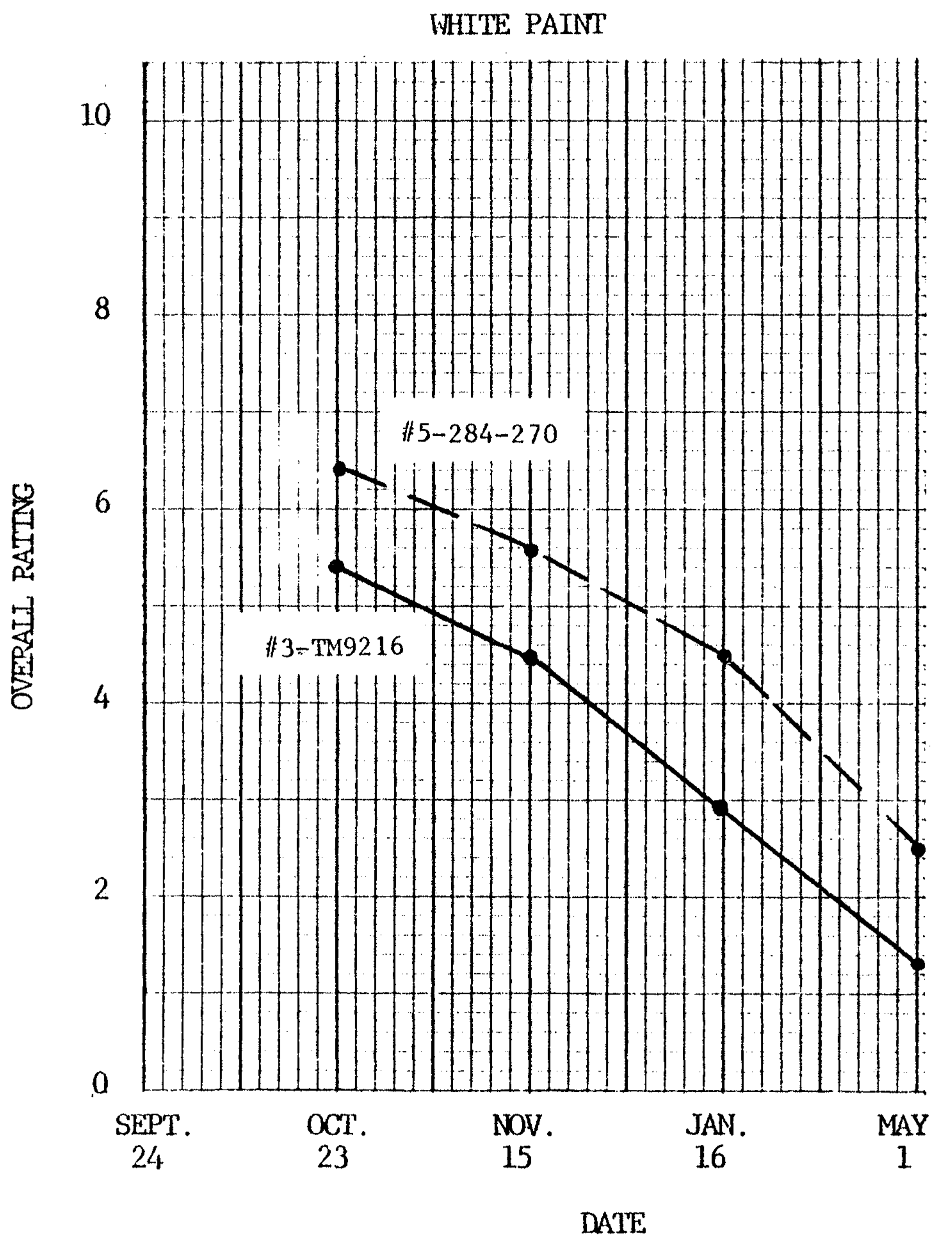
WHITE PAINT



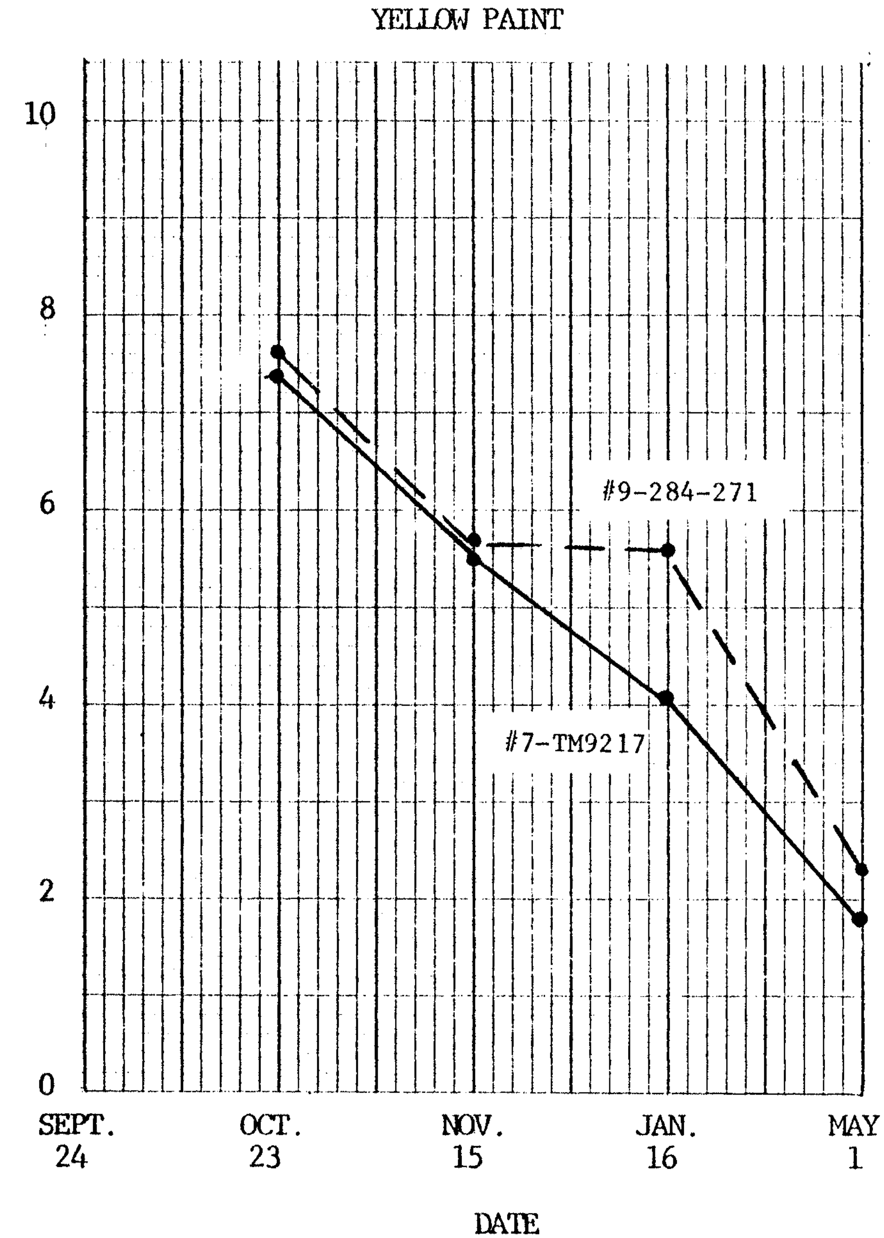
YELLOW PAINT



BITUMINOUS

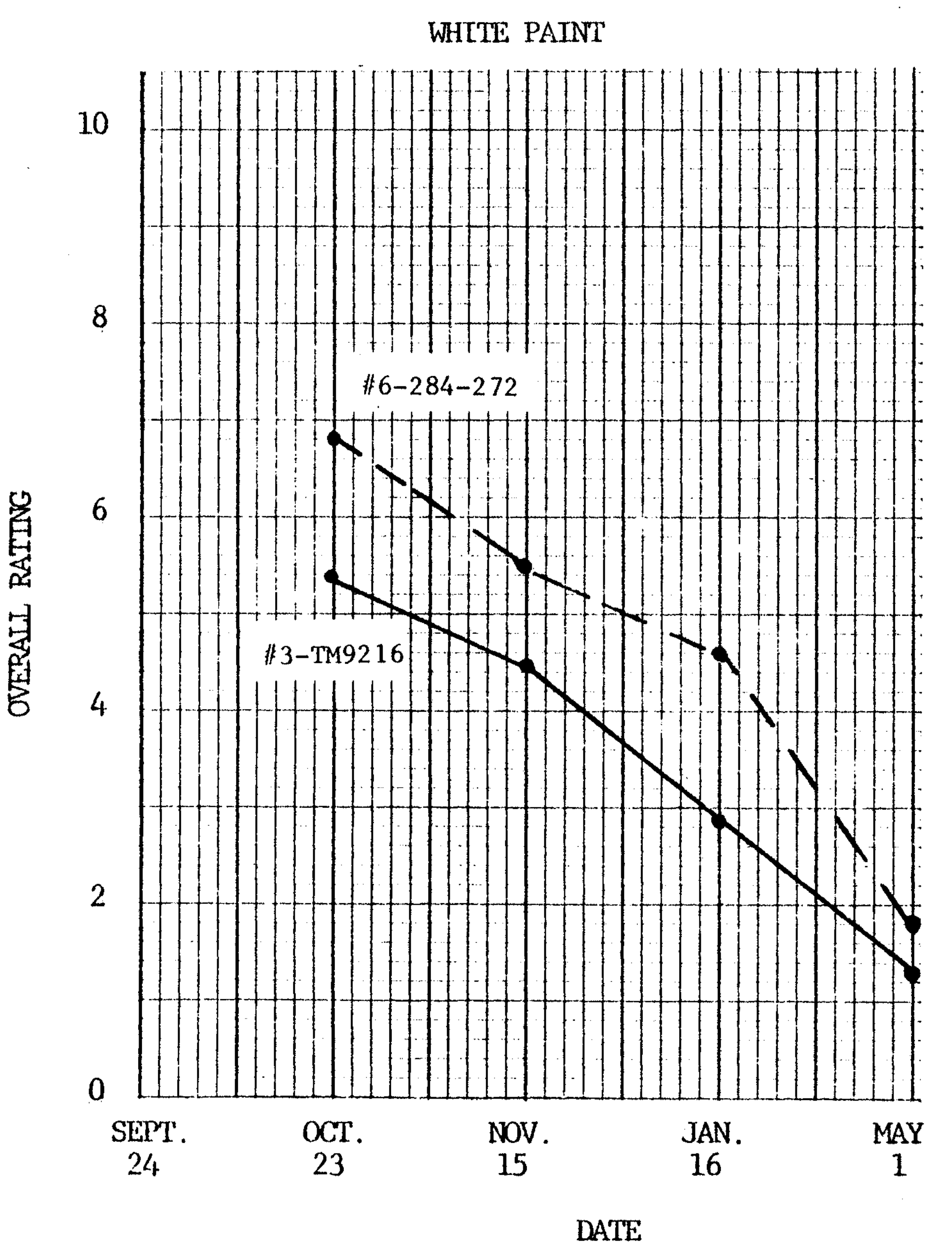


WHITE PAINT
OVERALL RATING
10
8
6
4
2
0
#5-284-270
#3-TM9216
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

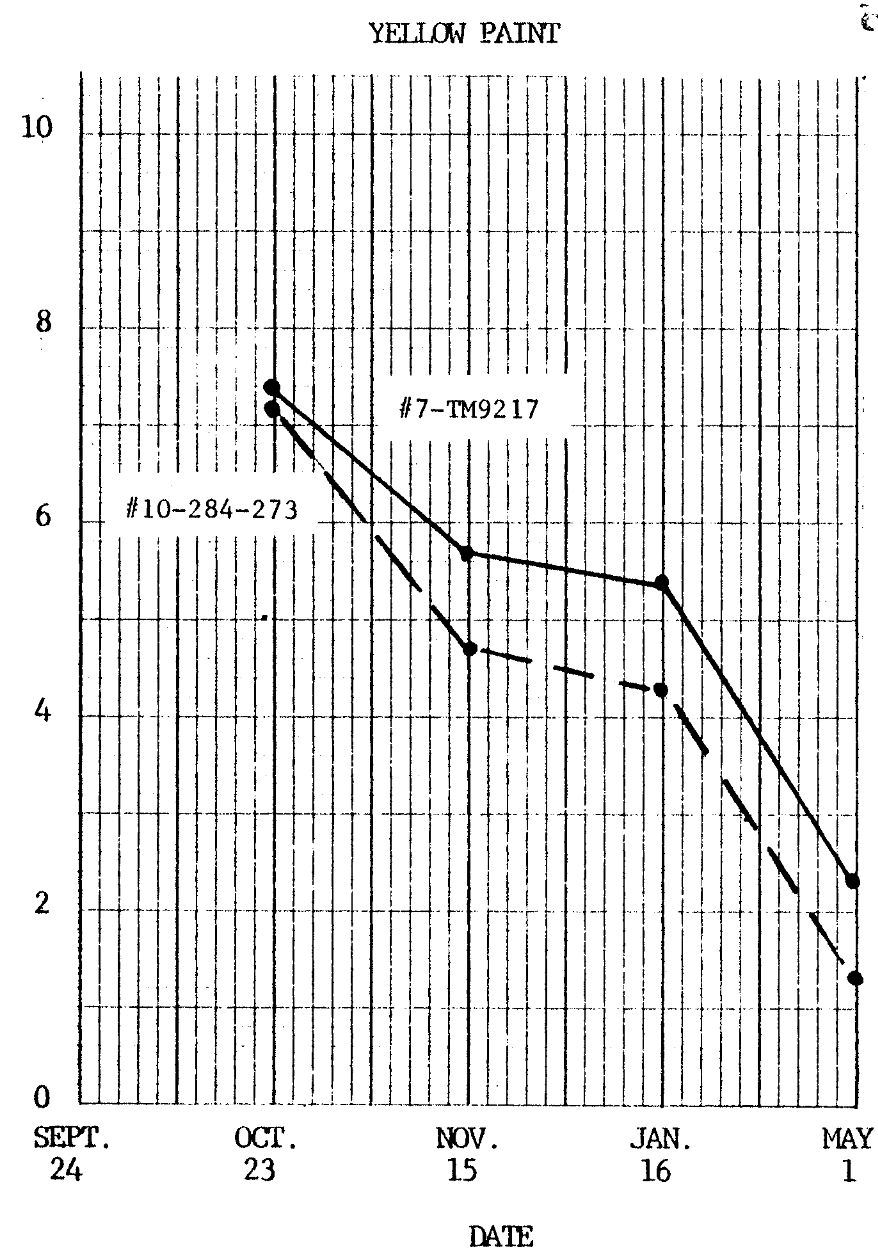


YELLOW PAINT
10
8
6
4
2
0
#9-284-271
#7-TM9217
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

BITUMINOUS

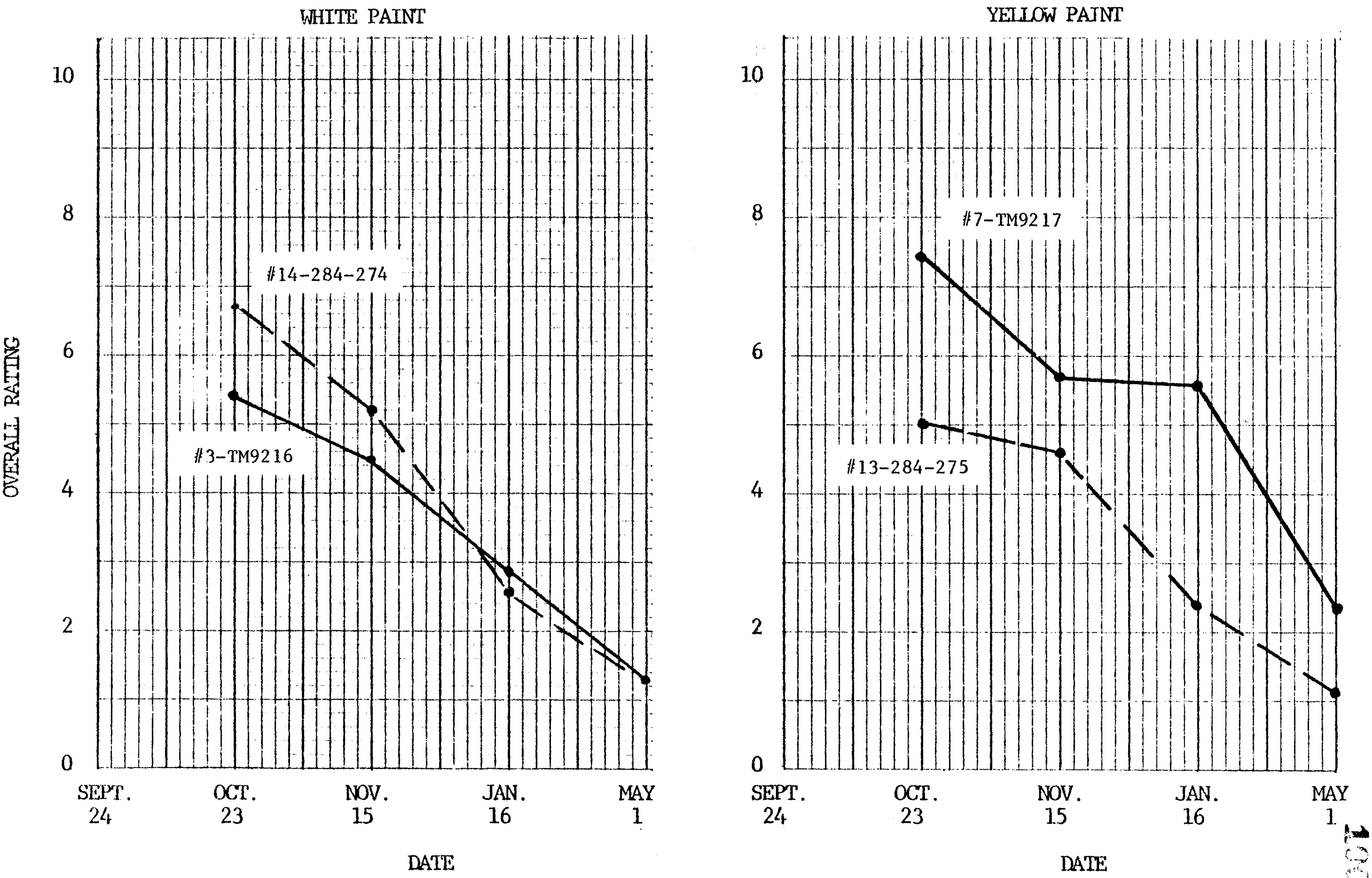


WHITE PAINT
OVERALL RATING
10
8
6
4
2
0
#6-284-272
#3-TM9216
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE



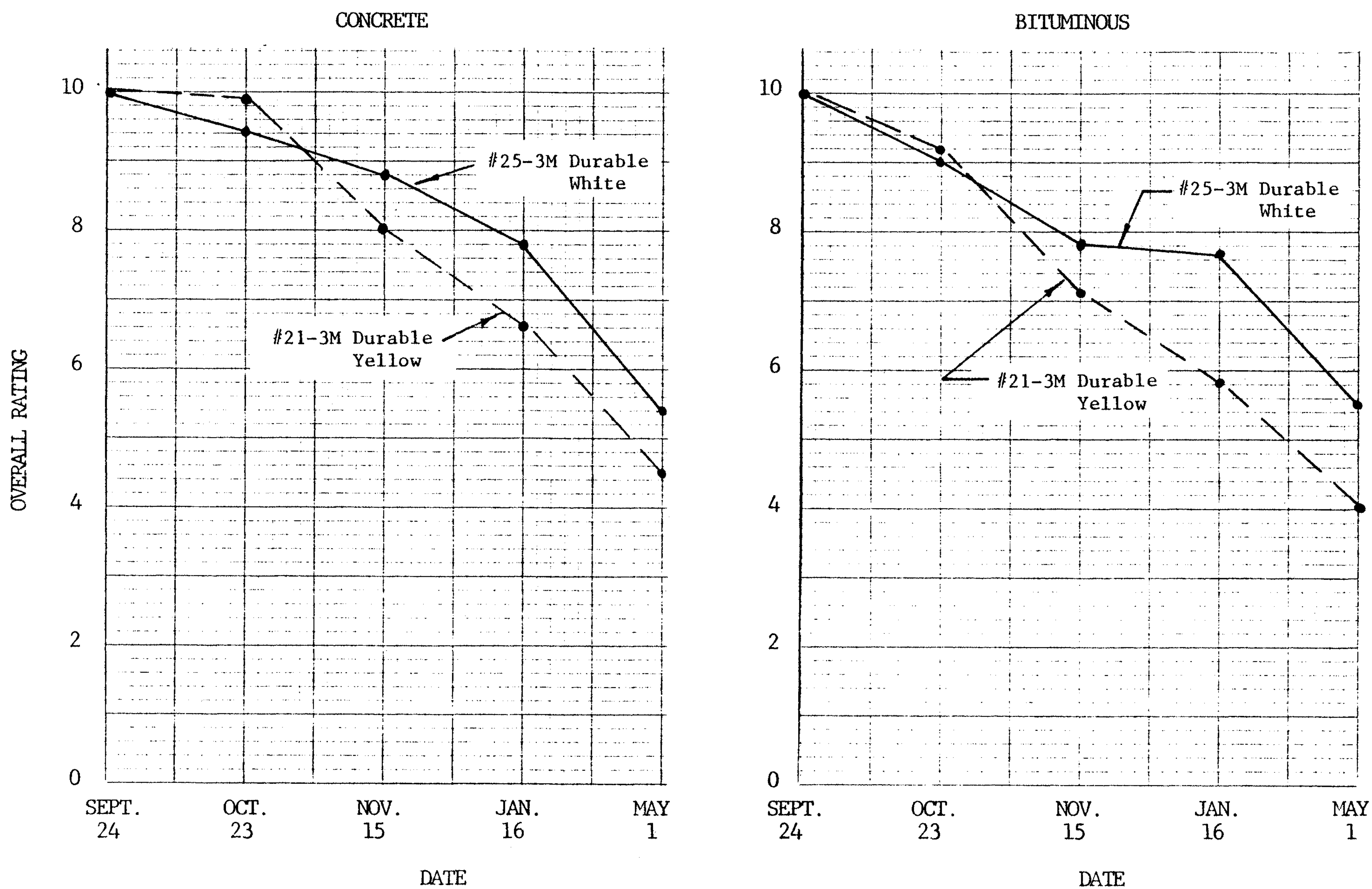
YELLOW PAINT
10
8
6
4
2
0
#7-TM9217
#10-284-273
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

BITUMINOUS

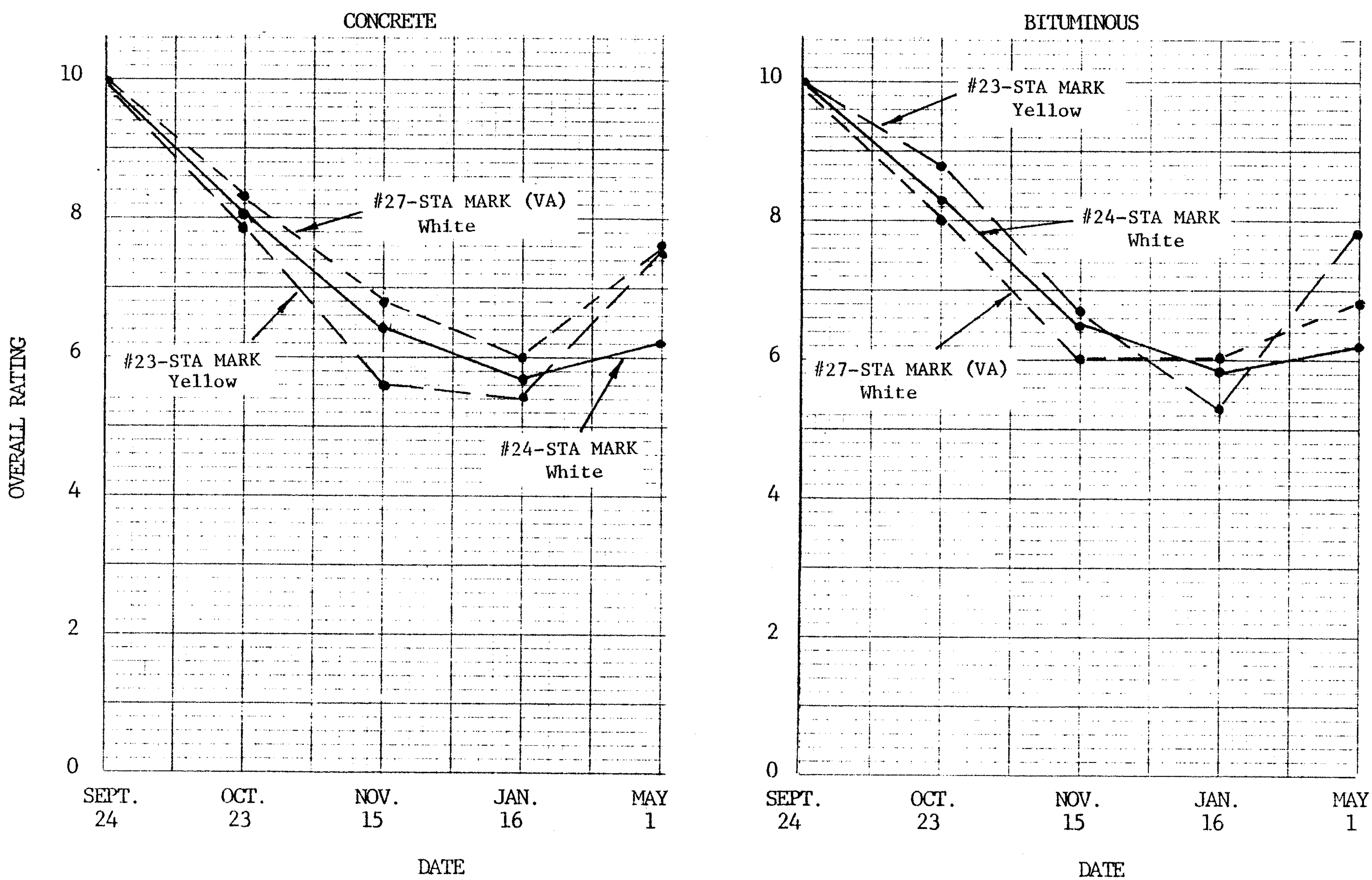


WHITE PAINT
YELLOW PAINT
OVERALL RATING
10
8
6
4
2
0
#14-284-274
#3-TM9216
#7-TM9217
#13-284-275
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

TAPE

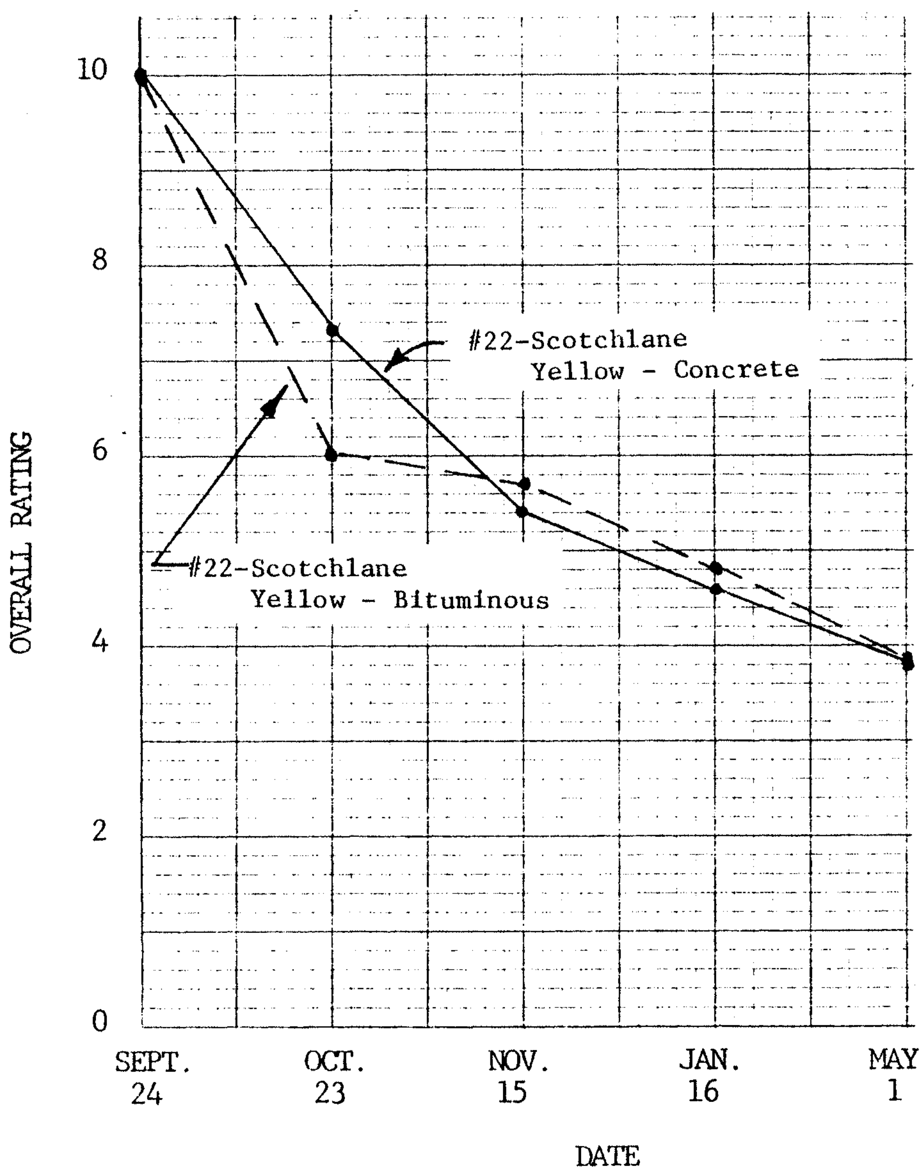

CONCRETE
BITUMINOUS
OVERALL RATING
10
8
6
4
2
0
#25-3M Durable White
#21-3M Durable Yellow
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE

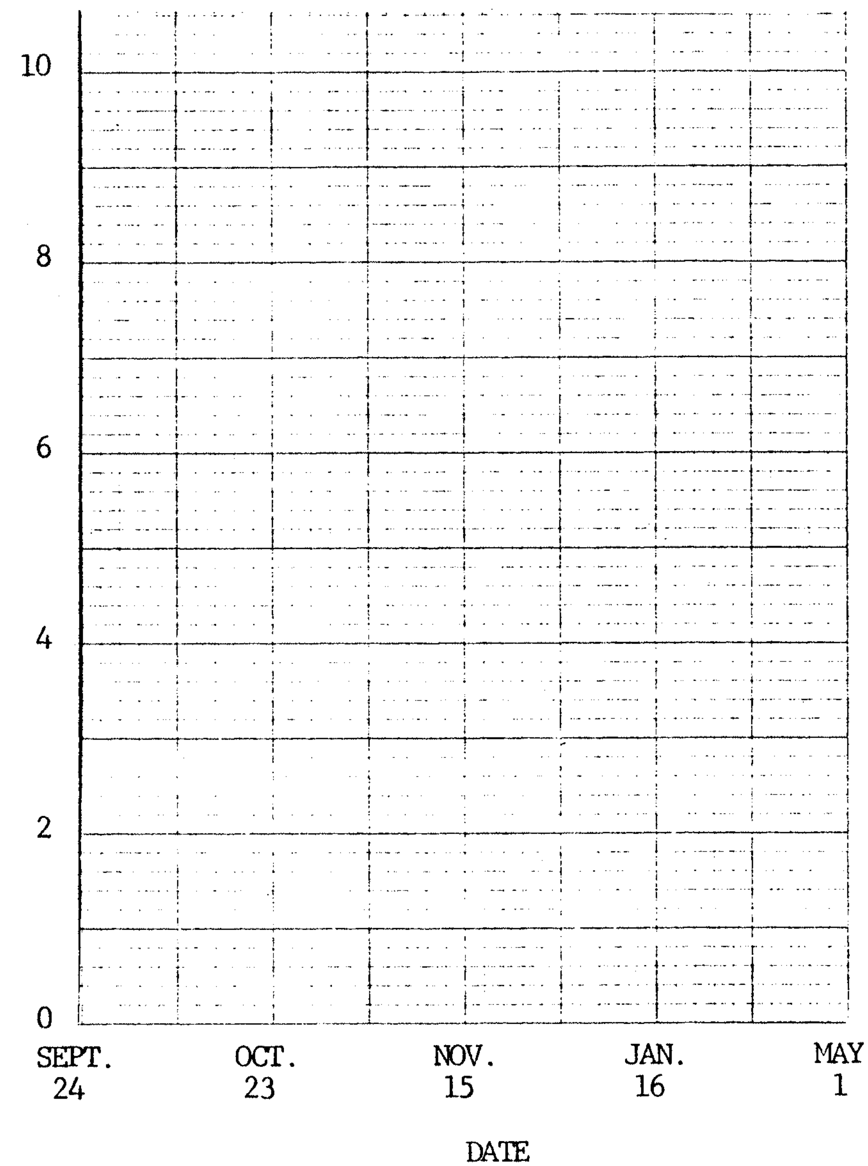
TAPE



CONCRETE
BITUMINOUS
OVERALL RATING
10
8
6
4
2
0
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE
#27-STA MARK (VA) White
#23-STA MARK Yellow
#24-STA MARK White

TAPE


CONCRETE
#22-Scotchlane Yellow - Concrete
#22-Scotchlane Yellow - Bituminous
OVERALL RATING
10
8
6
4
2
0
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE


10
8
6
4
2
0
SEPT. 24
OCT. 23
NOV. 15
JAN. 16
MAY 1
DATE