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DISCUSSION

W. H CAMPEN, *Omaha Testing Laboratories*—The authors have devised a semi-unconfined compression test for evaluating stability in bituminous mixtures The method is rapid, and for that reason is particularly suitable for plant control work.

Without detracting from the accomplishments of the authors, it should be pointed out that determination of stability in itself does not indicate the factors responsible for its magnitude. These factors include the quality of the aggregate, the gradation of the mixtures, and the asphaltic content, as well as the density. Since the stability of mixtures is governed by known factors, it appears simpler to control the factors themselves to insure the desired stability. As a matter of fact, in actual practice the mixture is designed for desired stability in the laboratory, and during plant operations the inspector sees to it that the desired mixture is produced. Occasional stability tests are also made in the laboratory to check the plant control.

AN APPROACH TO MEASURING THE QUALITY OF ASPHALTIC PRODUCTS

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SYNOPSIS

The need for a test or system of tests to measure the quality of asphaltic products is neither recent or new The renewed search for such a test or tests was undertaken in Kansas because of an unmistakable observation that many asphaltic products since approximately 1940 were generally of poorer quality than those produced prior to that time As a result of these conditions it was decided in 1947 to start a project which would bring to light some of the existing characteristics of asphalts used on the State system. It is believed that these findings might provide a method by which future asphalt production can be controlled to give consistently good quality materials.

This series of studies is being conducted in two phases, the first deals with the recovery and analysis of asphalts which have been in service for several years, the second phase examines the current asphalt production before and after it has been subjected to accelerated weathering tests.

There is no attempt here to draw conclusions nor to set up values of these tests, but we believe the data being obtained will make it possible to develop more satisfactory control tests for future asphalt production

The search for a test or system of tests devised to measure the quality of asphaltic products has been under way for at least 30 years and perhaps much longer. Most of the work has not yet produced adequate yardsticks of quality. Some tests have been successful in differentiating certain properties, or at least certain manufacturing processes of asphaltic properties, for example, the Oliensis Spot Test Many of these tests have proved extremely useful and some of them quite satisfactory. No one, nor any group of tests, seemingly, has been capable of consistently controlling production of good asphaltic products insofar as the engineers of Kansas have observed. In fact, it seems that there can be an unnecessarily wide range of quality of asphaltic products furnished within current specifications.

Kansas has no bone to pick with any refiner

nor any group of refiners, for we have had excellent cooperation with all with whom we have had contacts.

The particular need for the development of a test or system of tests to evaluate asphalt arose in our minds because of an unmistakable observation that asphaltic products received since 1940 have been generally of poorer quality than those produced prior to that time. Our bituminous mats require sealing more frequently and our seal coats are less durable than in the earlier periods. No doubt the gearing up of productive capacity during the war had much to do with this. Then too, some of the refinery practices are changing; new equipment is being installed which may provide products of unknown properties and obscure reactions.

Recognition of these factors and existing circumstances, coupled with observations of less durability in asphaltic products caused the State Highway Commission of Kansas to undertake the development of a system directed toward positive determination of quality of asphalts. This program was initiated in 1947 and has developed continuously since that time. We feel that the results which the program is yielding are worthy of attention and that the double-barreled system of attacking this problem may prove useful to other departments Kansas was fortunate enough recently, to have this program and the results reviewed by Mr J. G Welbourne of the Division of Physical Research, Bureau of Public Roads, Washington, D. C. He was favorably impressed with this approach and informed us that the Washington laboratory of the Bureau was using some of the same steps in their approach to this common problem.

We claim no particular credit for any of the individual tests. Most of the tests included in this system were given birth in other minds. We felt that no one or two of them were adequate to describe the quality of the asphaltic materials. Therefore, by careful selection and by a complete study of the problem we developed an overall program of examination of both products in service and original products going into service which we believe will eventually be comprehensive enough to permit the adoption of several new tests for specification requirements. However, before this specification stage is reached we believe that a test road should be constructed embodying asphaltic products of many properties. We believe that such a test road is necessary before final selection of new specification tests is made. This test road is being planned for the 1951 construction season.

THE KANSAS SYSTEM

The system of examination is in two separate phases, which will gradually merge into one to perfect the plan.

Phase 1—Phase 1 develops around a careful examination of materials in service, both physically and chemically.

This phase consists of sampling bituminous mixtures in service; thereafter extracting and recovering the bitumen from the aggregates. The bitumen is then subjected to a series of tests which we shall describe later.

We have used no intricate nor unusual tests in this work. We have used only those which are known to everyone and which have a good background.

Fortunately, the records of the Kansas Highway Commission have been complete enough in times past, going back to approximately 1931, that it is possible to know the precise characteristics of the asphaltic material that went into a bituminous mixture at any given point on a project Records have been kept of each mile of mixed material, indicating the car numbers, the source and the test numbers of each car which was used in that particular mile. Thus, it is possible to obtain samples at any given point on a project for extraction and recovery. Further, these samples can be tested under the same series of tests used originally, which will give a rather exact comparison between the original material and the characteristics of the bitumen at the time of sampling. A complete set of conventional specification tests is applied to each recovered sample to be studied in relation to the results of the same tests which were made before the material was placed into service.

Although the other tests have significance, most reliance is being placed on the loss in penetration of the residue from distillation. We also consider the loss in ductility of major importance. The data which we have to date make it necessary to use the ductility of the asphalt before distillation for an indication

of the changes which have taken place in the asphalt after a few years of service. This we believe is indicative of a trend; however, on future tests it is planned to obtain the necessary information so that the ductility of the residue can be considered. We believe this is desirable because any change in the ductility which may occur due to loss of volatiles in the Abson recovery process is minimized in this way.

Greater weight has been given the rate of hardening, the brittleness demonstrated by the penetration loss and ductility loss because we believe they are the best measurements available for determining bituminous durability.

In starting the first phase of study we paid particular attention to SC oils since we were reasonably sure that these oils could be reclaimed, after having been in service for a number of years, with a minimum amount of change in the basic qualities of the oil due to the recovery process. SC oils constitute the major portion of our cold mix construction.

Because of our desire to be currently up-to-date on our products, a large portion of our studies have been limited to bituminous work completed in the past 3 years. By comparing the values indicated in Figure 4, it is apparent that SC oils furnished prior to 1940 were superior to many of those now in service.

In addition to projects constructed with SC road oil, a few samples have been taken from bituminous mats constructed with special soft base MC-4 cutback asphalt. To date this type of asphalt has been used only to a limited extent and is still in the experimental stage in our State.

Some work is being done in an attempt to develop a method by which representative samples of RC and MC cutbacks used as a seal can be recovered after a few years service, so that they, along with asphalt cements may be added to our studies in the near future.

The recovery process which is used for this phase of the work is that set out in ASTM D 762-44T entitled "Hot Extraction of Asphaltic Materials and Recovery of Bitumen."

The blank samples which were used to calibrate the new equipment did not reveal any marked influence of the Abson Test procedure on the properties of the asphaltic material. Further calibration tests have been conducted from time to time and as yet we have found no serious deleterious effect on asphalt cements, slow curing asphalts nor on the medium curing and rapid curing asphaltic products. We are constantly making calibration tests in order to be certain that the recovery process has no effect on the asphaltic materials.

Since it has been necessary for us to establish the minimum size of the recovered asphalt sample at one quart, in order to have sufficient material on which to run a series of routine tests, we have designed an enlarged extracting unit which duplicates the principle of the unit as described in ASTM D 762-44T but with ten times the capacity. A radiant type electric heater has been replaced with an electric thermostatically controlled hot oil bath, which we believe, is a decided improvement over the unit as originally approved.

The following is a tabulation of the standard tests being run on the recovered asphalt at the present time:

1. Specific gravity (60 F./60 F)
2. Penetration (77 F.) 100 g, 5 sec or same temperature as used on original
3. Ash test and total soluble in CCl_4
4. Oliensis spot test
5. Melting point
6. Ductility (77 F) or same temperature as used on original
7. Viscosity, Saybolt Furol (Same tip and temperature as used on original if possible)
8. Loss 325 F. (5 hrs.)
9. Complete 680 F. distillation
10. Penetration after loss
11. Flash point (Cleveland Open Cup)
12. Percentage of 100-penetration asphalt
13. Volume of residue after distillation
14. Penetration and ductility of distillation residue
15. Float test of distillation residue.

The graphs on Figures 1 to 7 show a comparison of the original and recovered test results on penetration and ductility for each producer of SC-4 asphalt used in Kansas.

Although these results are not conclusive they do indicate widely different performance for products of various refiners.

The bars on the chart showing ductility were arbitrarily extended to 150 cm., since it was assumed that this was the minimum original ductility of all SC-4 asphalts produced. This assumption is based on a limited number of tests available in our files on original ma-

terials, which indicate this to be a conservative estimate.

In addition to recovering and testing asphalt from designated bituminous mat projects at time intervals of two years throughout the show the results of tests for loss in penetration and ductility after two to three years service on several projects which are badly hardened and have very little apparent life left in the asphalt.

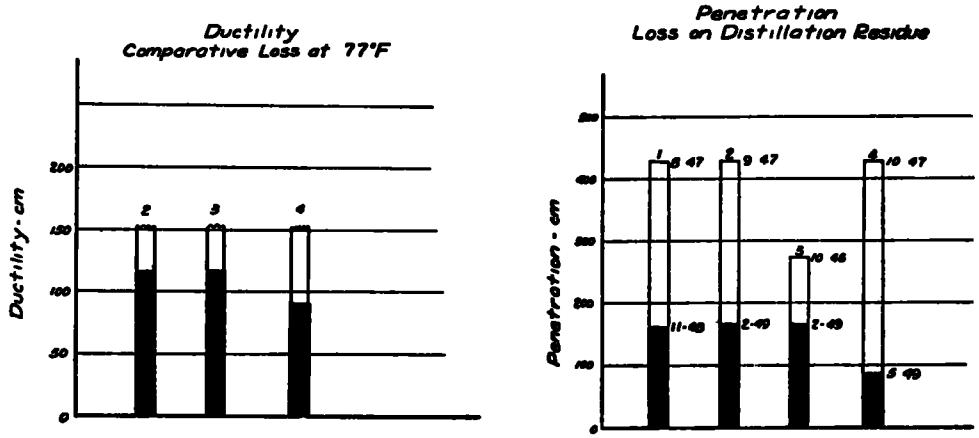

Figure 1. Ductility and Penetration Tests—SC-4 Asphalt—Producer A-(note: Numbers at top of bars indicate projects from which data were obtained—Dates indicate span of service)

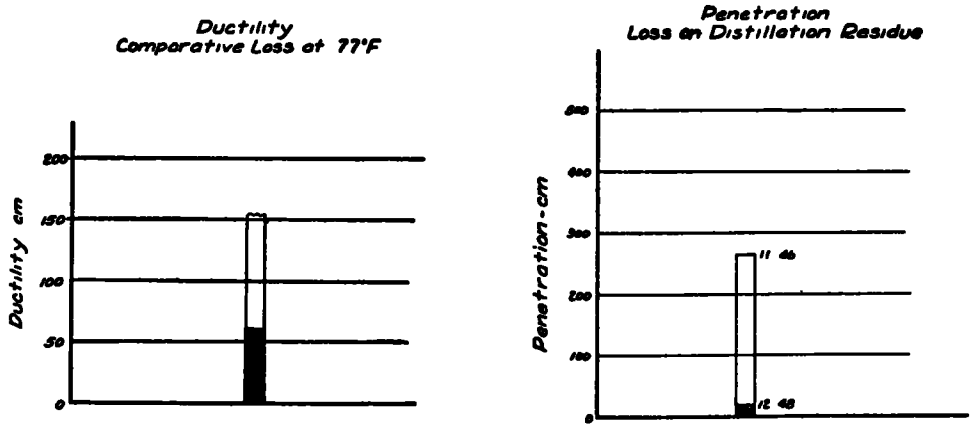

Figure 2. Ductility and Penetration Tests—SC-4 Asphalt—Producer B

serviceable life, we have observed and photographed the general condition of the surface. To date, these observations have borne out the test results.

Particular attention is called to Figure 4 which describes an SC-4 asphalt that has retained a high percentage of its original penetration and ductility after 11 yr. of service. The present condition of those projects is very good. As a comparison, Figures 6 and 7

Phase 2—Phase 2 of this work consists of a series of tests being applied to asphaltic products as they leave the refinery to go into service

These products are weathered by an accelerated test then subjected to an abrasion test to find the rate of hardening and embrittlement. Other tests are conducted to determine the stripping characteristics and the

curing characteristics of various types of asphalt.

These tests are listed as follows:

1. California weatherometer treatment
2. Abrasion test on weathered sample
3. Texas curing index
4. Stripping test.

These tests have been made since 1946. By Mr. F. H. Hveem, Research Engineer, for the California Department of Highways. The Kansas Highway Department became acquainted with this work through his published paper in Volume 15 of the *Proceedings* of the Association of Asphalt Paving Technologists. His approach seemed to be adaptable to our need for a method of accelerating the weather-

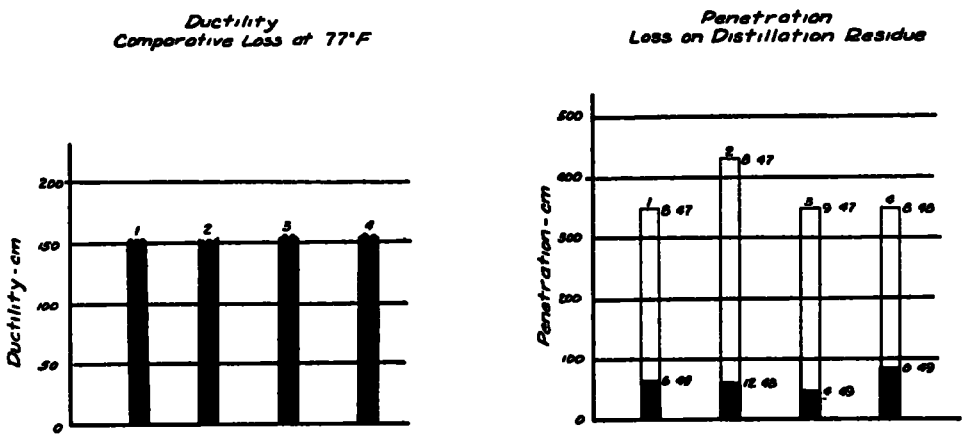

Figure 3. Ductility and Penetration Tests—SC-4 Asphalt—Producer C

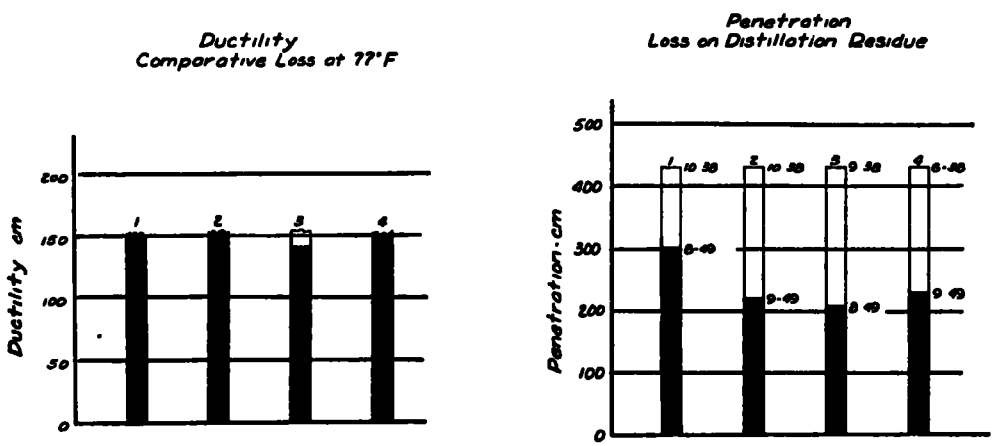

Figure 4. Ductility and Penetration Tests—SC-4 Asphalt—Producer D

Spring 1950 we will be in a position to obtain field samples for extraction and recovery. We can thus get a direct correlation between the service performance and the accelerated tests.

Three of these tests, (1) accelerated weathering, (2) abrasion tests on weathered samples, (3) cohesion tests on weathered samples, were patterned after work which is being done by ing of asphaltic products, coupled with a further series of tests to evaluate the effect of this weathering. The abrasion tests on the weathered samples appeared to be a positive method of determining the rate and degree of hardening of asphaltic products which had been spread in thin films by mixing with standard Ottawa sand

The cohesion test, as originated by Mr. Hveem, produces results which are more obscure in their meaning We are attempting to modify this test by using higher compactive effort and different temperatures in order to produce more significant results

The Texas curing index was originated in the laboratory of the Texas Highway Commission for the original purpose of regulating the consistency of pre-mix patching material mixed with an RC-2 cutback. However, a study of this method revealed its adaptability to other bituminous products since it quantitatively measured the amount of volatiles as related to the consistency of the residue. Thus, it seemed to be the best conception of the actual rate of curing of asphaltic products that had yet been described For this reason, it was decided to incorporate this series of tests into the program for the purpose of studying the amount and type of diluents used in preparing both MC and RC asphaltic products. The results which have been obtained to date show definitely that within the present specifications there is an excessive range of curing behavior.

The stripping test which has been conducted is similar to that which has been used by several other investigators. It consists of thoroughly coating a standard aggregate with various bituminous products, placing the mixed material in a container filled with water

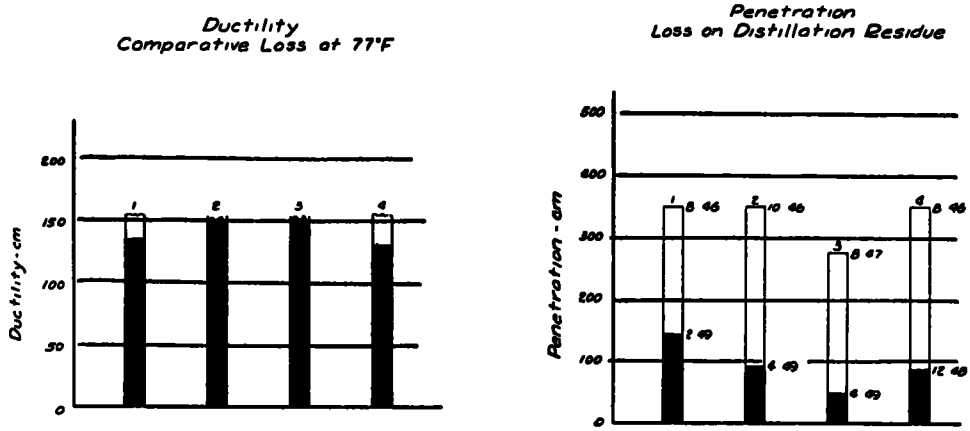

Figure 5. Ductility and Penetration Tests—SC-4 Asphalt—Producer E

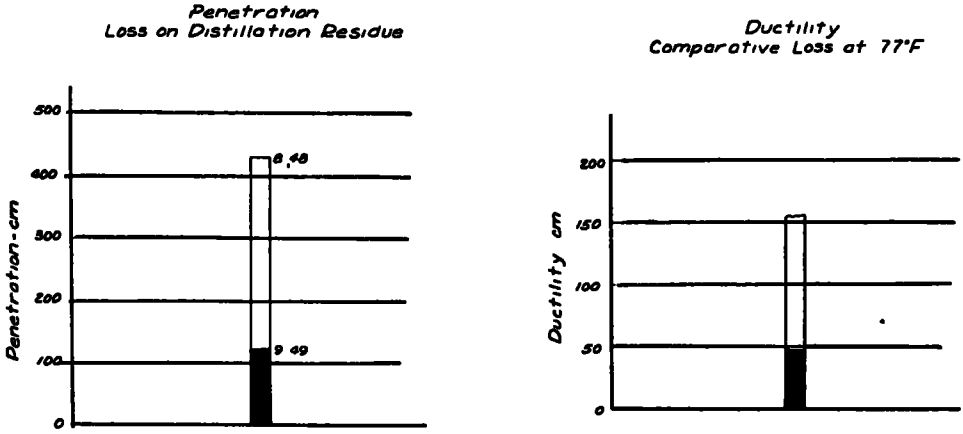

Figure 6. Ductility and Penetration Tests—SC-4 Asphalt—Producer F

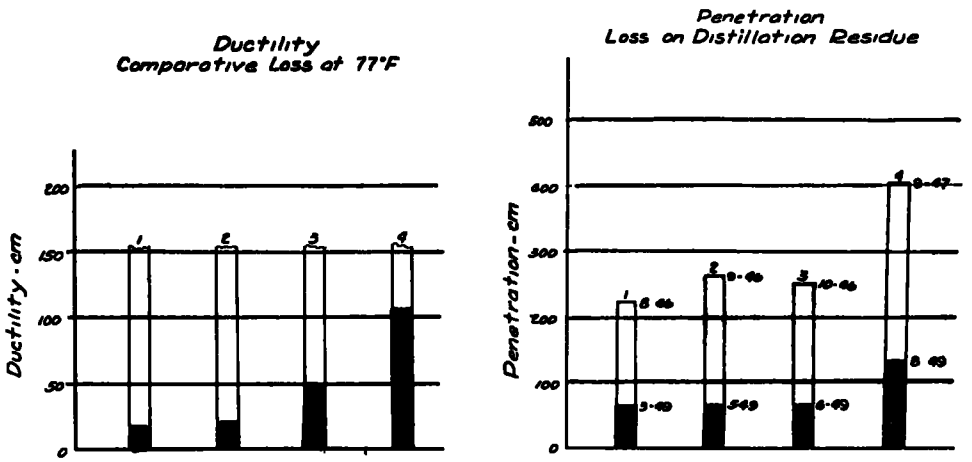

Figure 7. Ductility and Penetration Tests—SC-4 Asphalt—Producer G

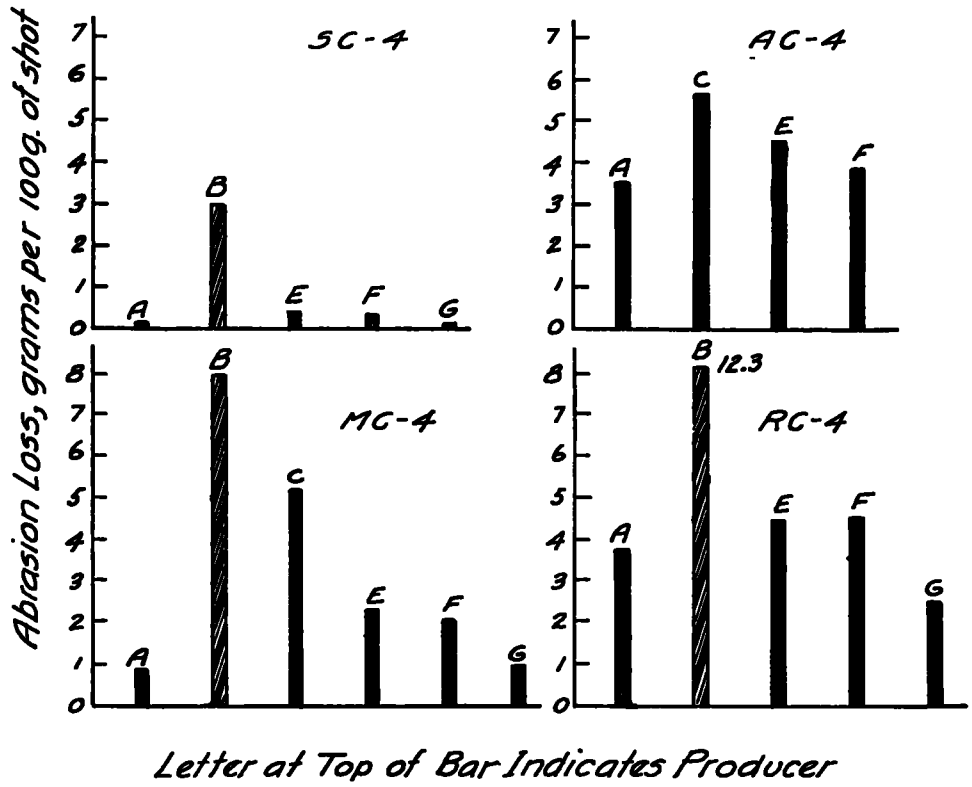

Figure 8. Abrasion Tests—Comparative Losses of Four different Types of Asphalt Produced by different Refineries—Average of 1947 and 1948 Production (Letter at top of bar indicates producer

and vigorously agitating this combination for 30 min. The evaluation of this test is made by then examining the mixture and determining the amount of asphalt which has been stripped from the aggregates. Originally, this evaluation was accomplished visually. The unreliability of this method was soon evident. To overcome this, a photo-electric device was constructed which enabled us to measure the amount of reflected light on the sample before agitation and again after agitation. This method of measurement has been found to be very precise. The values shown are the difference in the micro-amp readings between the original reading and the reading after agitation. Naturally, a stripped sample will leave aggregate exposed and thus give a higher reflected light reading than when it was uniformly coated with asphalt.

To supplement these tests we are presently setting up equipment similar to that of the Bureau of Public Roads, to conduct immersion and compression tests on mixtures We believe that this method has advantages over the water agitation method However, both methods will continue to be used.

We have also obtained many data, but no significant values, on a measure of temperature susceptibility. In view of the fact that we have been unable to find a significance in this test, it has been discarded.

In order to compare some of the data we have obtained to date, we have prepared a series of graphs which make a pronounced picture of some of the changes that are taking place in our asphalts which are probably due to two things; weathering and normal processing during the time of construction.

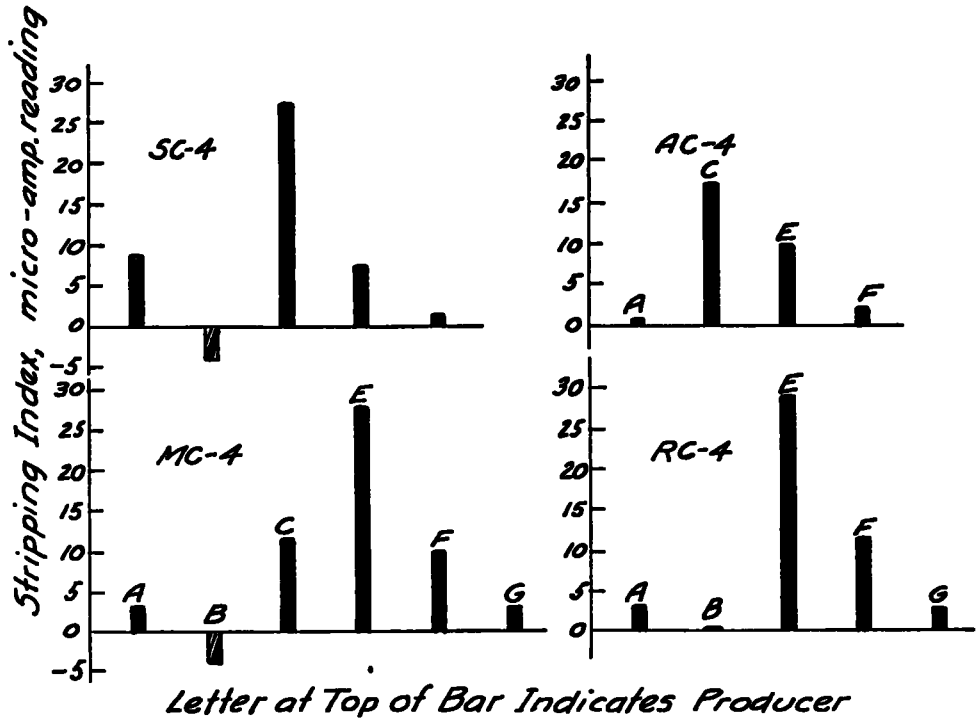

Figure 9. Stripping Index Tests—Comparative Stripping Values for Four Different Types of Asphalt Produced by Different Refineries—Average of 1947 and 1948 Production

In Figure 8 we have shown an average of abrasion losses of a number of samples taken from the product of six different producers in Kansas during the 1947 and 1948 construction seasons.

Since Figures 1 to 7 represented only SC-4 oils and for the most part asphalts produced in about the same period as those represented

on Figure 8, we think it particularly worthy of note that producer B has an extremely high abrasion loss and at the same time his service record is low as shown on Figure 2 Also it is noticeable that the abrasion losses on SC-4 asphalts from all producers are less than those recorded on any of the other three oil types tested.

Often times we have materials which do not show very well on a number of tests but still display some very desirable qualities. Such is the case with producer B as shown on Figure 9. In this case we have negative stripping as compared to a considerable amount of stripping in the case of producer A who had a better than average showing on the penetration and ductility losses shown on Figure 1.

In our studies as outlined under phase 2 we are endeavoring to determine some means of measuring and controlling those qualities necessary in asphalt to give it the ability to maintain its original ductile qualities over a long period of service. Beginning this year we have started accumulating information to show just how much of the losses in ductility and penetration as shown in Figures 1 to 7 may be due to overheating or excessive manipulation at the time of construction. This is being done by analyzing a number of different samples taken at different stages of construction. The first sample is taken before the asphalt enters the heater, then it is resampled after heating and a third sample is taken of the asphalt after it has been mixed with the aggregate. This third sample is taken so as to make a definite check on any changes which may be developed in the asphalt due to the recovery process.

We feel that this two-way approach to the problem of measuring the quality of asphaltic products provides us with a program which will eventually lead to the establishment of a test or series of tests suitable for specification purposes which will enable us to predict the life expectancy of our asphaltic mixtures. We expect to continue this study as long as it bears fruitful results. At the present time, we are keeping the results of the tests of each refiners products strictly confidential between our laboratory and the refiner's technicians. They have given us their cooperation by correcting obvious faults in their materials. At such time as the refineries in our given area have improved the qualities of their materials to a satisfactory point, we shall, no doubt, be able to present a final report showing the progress that was made with this program

There has been no attempt to draw conclusions nor to set up values of these various tests. There has been no attempt to establish criteria for the values which would be required for high quality asphalts. We have tried to indicate our aims and to demonstrate these aims by showing the comprehensive plan with which we are attacking this problem. Although the program may appear to be intricate and to some extent complicated, we feel that it will produce the end to which we are striving. We shall eventually eliminate all but a few of these tests to be conducted on materials produced for bituminous construction in our area.