Comparative Testing of Joint Sealers in Sixteen Laboratories

Egons Tons, Research Engineer,
Joint Highway Research Project, Massachusetts Institute of Technology,
Cambridge, Mass.

Bond-ductility, flow, and penetration tests are frequently used to evaluate compounds for joint and crack sealing in pavements. The tests are usually run according to Federal Specification SS-R-406c method 223.11.

It has been observed that laboratories using this procedure do not always arrive at the same results, and therefore some have rejected sealers that pass the test in other laboratories. To find out how different these results could be, 16 laboratories were asked to participate in the evaluation of bond-ductility, flow, and penetration tests for joint sealing compounds.

Three hot-poured type rubber-asphalt sealants were used in this testing program. The material samples, together with special mortar test blocks for the bond-ductility test, were sent to all participants from one centralized source. The Federal Specification SS-R-406c procedure was used, emphasizing certain details in order to have the test better controlled.

In spite of the careful planning and control the test results vary considerably between the participants. This is especially noticeable in the bond-ductility test.

The preliminary conclusions are:

1. The bond-ductility test should be restudied and adjusted to assure a better reproducibility.
2. The flow test is not an accurate test, but gives reasonably comparable results.
3. The penetration test appears to give relatively reproducible results.

●THIS paper is the outcome of a cooperative testing program initiated by the HRB Committee on Fillers and Sealers for Joints and Cracks in Pavements. Sixteen laboratories participated, each testing the same three hot-poured rubber-asphalt sealers of a type used for joints in cement concrete pavement. The author, as part of the work of the Joint Highway Research Project of the Massachusetts Institute of Technology, undertook to assemble and correlate the work of the participants.

Test results of the same sealing material have not always been uniform. In 1951 Robbers and Swanberg (1), using Federal Specification SS-R-406b (May 19, 1947), tested several hundred specimens of one hot-poured rubber-asphalt sealer and found considerable variations in the results. They commented: "It would appear that the testing procedures are still in a pioneering stage and this also applies, at least in part, to the specification requirements." Data obtained by nine cooperating laboratories (Group IV, AASHO, testing in 1950; summarized in (1)) some time ago also show poor agreement in their tests of identical samples. It has been the author's experience that test values on sealing compounds in the laboratory are often noticeably higher or lower than those given by the manufacturer.

OBJECTIVE OF TESTING PROGRAM

The main objective of the testing program was to determine whether different laboratories could get reproducible test results. Identical sealer samples were used, and all laboratories followed Federal Specification SS-S-406c, Method 223.11 with certain additional refinements. This specification dated February 12, 1952, is practically identical with Federal Specification SS-R-406b. For the details, the reader is referred to the specifications; the additional refinements are given in the Appendix.

SAMPLE PROCUREMENT

Three hot-poured rubber-asphalt sealers were used. The samples and the special cement mortar blocks were distributed by one of the participating laboratories.

TESTS SELECTED

The Committee selected three tests from the specification[1] for use in the cooperative program as follows:

1. Penetration test.
2. Flow test.
3. Bond-ductility test.

The penetration indicates the hardness of a material. A sample of a sealer is penetrated for 5 sec by a cone of specified weight, and the depth of sinking is measured. The test is performed at 77 F. The penetration value should not exceed 0.90 cm.

The flow test determines potential softening of a sealer in warm weather. A specimen 4 by 6 cm in area and 0.32 cm thick, is molded on a slightly larger tin panel which is kept for 5 hr at 75 degrees to the horizontal. The test is performed at 140 F. After the test, the change of length of the specimen is measured in cm and expressed as flow. The maximum limit is 0.5 cm.

The bond-ductility test is the most important of the series. It shows how well the sealing material adheres to the test blocks, as well as the ductility of the compound itself. In this test two specially prepared mortar blocks are set 1 in. apart to form a 1- by 2- by 2-in. space, which is filled with the sealer. An extension machine is used to pull the blocks apart slowly at 0 F, simulating the action of road joints in cold weather. If a sealer passes five cycles it is acceptable.

SPECIFIED PROCEDURAL REQUIREMENTS

All participants were asked to run the tests (see Appendix) in duplicate to check their repeatability in the laboratory. Two bond-ductility specimens were to be poured on each testing day. (The specification calls for molding three bond-ductility specimens for one test.) The results were recorded on standard forms, which also included descriptive questions on the test equipment.

TEST RESULTS

The results are given in Tables 1, 2, and 3. Both average penetration and average flow were obtained from two sets of two specimens each. Data on melting equipment are given in Table 4; on ovens, in Table 5.

Penetration Test Results

The average penetration data of Tables 1, 2, and 3 are summarized in Table 6. Inasmuch as the maximum allowable penetration is 0.90 cm, and the three samples were below this limit, they all passed the test.

There are considerable differences between the findings of the various laboratories. Thus, for Sample O the difference between the highest and the lowest recorded penetrations is 0.15 cm. The differences for the other two samples are not as large. There are no unusual values in the readings, and the mean and median are identical. The

[1]As used in this paper, "the specification" always means Federal Specification SS-R-406c, Method 223.11, unless otherwise designated.

TABLE 1

SUMMARY OF TEST RESULTS FOR SAMPLE N

Lab. No.	Test Day	Melt Temp. (°F)	Melt Time (min)	Aver. Pen. (cm)	Aver. Flow (cm)	Bond-ductility (cycles) Spec. A	Bond-ductility (cycles) Spec. B
1	1	400	51	0.48	0.15	5	5
	2	400	49	0.48	0.10	5	4
2	1	398	43	0.52	0.18	2	2
	2	398	50	0.52	0.19	3	3
3	1	395	50	0.44	0.15	5	3
	2	395	45	0.46	0.10	5	3
4	1	400	34	0.44	0.20	0	0
	2	395	32	0.47	0.20	1	0
5	1	400	50	0.47	0.20	5	3
	2	400	50	0.48	0.20	4	4
6	1	385	55	0.53	0	1	1
	2	400	45	0.52	0.20	5	5
7	1	402	50	0.52	0.20	0	0
	2	400	48	0.51	0.20	0	0
8	1	400	28	0.57	0.15	2	5
	2	400	25	0.57	0.20	1	1
9	1	400	49	0.59	0.08	0	0
	2	400	49	0.56	0.08	0	0
10	1	400	39	0.51	0.18	4	4
	2	400	44	0.55	0.20	1	1
11	1	400	45	0.56	0.20	3	3
	2	400	44	0.55	0.20	3	3
12	1	400	26	0.53	0.10	2	1
	2	400	27	0.53	0.10	0	0
13	1	400	35	0.50	0.15	0	3
	2	400	40	0.51	0.15	0	0
14	1	399	47	0.53	0.10	1	5
	2	400	47	0.52	0.10	3	5
15	1	401	50	0.58	0.10	0	0
	2	401	42	0.55	0.20	0	0
16	1	400	35	0.55	0.10	1	4
	2	400	35	0.55	0.15	1	4
Low		385	25	0.44	0	0	
High		402	55	0.58	0.20	5	
Mean		-	43	0.52	0.15	2.1	
Median		-	-	0.52	0.15	-	

TABLE 2

SUMMARY OF TEST RESULTS FOR SAMPLE O

Lab. No.	Test Day	Melt Temp. (°F)	Melt Time (min)	Aver. Pen. (cm)	Aver. Flow (cm)	Bond-ductility (cycles) Spec. A	Bond-ductility (cycles) Spec. B
1	1	400	51	0.84	0.25	5	5
	2	400	49	0.80	0.20	5	4
2	1	395	42	0.80	0.18	5	5
	2	400	73	0.82	0.12	5	5
3	1	395	45	0.75	0.10	5	5
	2	400	45	0.77	0.10	5	5
4	1	400	30	0.75	0.30	5	5
	2	395	32	0.74	0.30	5	5
5	1	400	49	0.76	0.10	4	3
	2	400	50	0.78	0.10	4	4
6	1	400	40	0.80	0	5	5
	2	386	50	0.81	0.10	5	5
7	1	400	47	0.82	0.20	5	5
	2	400	48	0.82	0.10	5	5
8	1	400	26	0.88	0.20	5	5
	2	400	26	0.89	0.05	3	5
9	1	400	52	0.85	0.08	5	5
	2	400	53	0.87	0.15	5	5
10	1	400	47	0.85	0.13	5	5
	2	400	45	0.83	0.18	5	5
11	1	400	45	0.82	0.20	5	5
	2	400	47	0.82	0.20	5	5
12	1	400	30	0.86	0	5	5
	2	400	30	0.86	0	5	5
13	1	400	50	0.87	0.15	5	5
	2	400	35	0.80	0.20	5	5
14	1	400	48	0.81	0	4	5
	2	400	47	0.80	0	5	5
15	1	401	37	0.79	0.10	3	0
	2	399	45	0.79	0.10	3	0
16	1	400	35	0.87	0.10	5	5
	2	400	35	0.86	0.10	5	4
Low		356	26	0.74	0	0	
High		401	73	0.89	0.30	5	
Mean		-	43	0.82	0.13	4.6	
Median		-	-	0.82	0.10	-	

maximum difference between the penetration values obtained on each test day in any one laboratory was 0.07 cm.

The specification does not include reproducibility limits for the cone penetration test of sealing materials. However, as this test is an adaptation of the penetration test for petrolatum (ASTM Designation D 937-49T), the reproducibility limits given in that specification can be used. For penetrations of less than 2.00 cm the maximum allowable deviation from the mean in this test is 0.07 cm. In the tests reported here, all samples exceeded this limit by 0.01 cm. As any penetration between 0 and 0.90 cm is accepted, and the main importance of the test is to give a feeling for the consistency of the sealer, the accuracy of the test seems adequate from a practical standpoint.

A needle penetration test (ASTM Designation D 5) can be used where more exact values are needed. Here the allowable mean deviation changes with the consistency of the material; that is, if the material is soft, a larger deviation is expected. Robbers and Swanberg (1) performed some comparative needle and cone penetration tests, and their results point toward the superiority of the former.

Flow Test Results

The average flow data of Tables 1, 2, and 3 are summarized in Table 7. All specimens passed the flow test, but the results vary considerably from one laboratory to another. Sample O is the most striking example: three laboratories found no flow at all, whereas seven others recorded between 0.20 and 0.30 cm. The test results on the rest of the samples are also uneven. The largest difference between the flow values

TABLE 3

SUMMARY OF TEST RESULTS FOR SAMPLE P

Lab. No.	Test Day	Melt Temp. (°F)	Melt Time (min)	Aver. Pen. (cm)	Aver. Flow (cm)	Bond-ductility (cycles) Spec. A	Spec. B
1	1	400	50	0.56	0.15	5	5
	2	400	48	0.59	0.12	5	5
2	1	400	49	0.62	0.10	5	5
	2	400	44	0.55	0.14	5	5
3	1	400	50	0.53	0.05	1	1
	2	395	50	0.53	0	1	2
4	1	400	30	0.53	0.20	5	5
	2	400	30	0.54	0.25	5	3
5	1	400	50	0.57	0.20	5	5
	2	400	50	0.58	0.10	5	5
6	1	386	50	0.55	0	0	0
	2	400	45	0.55	0	0	5
7	1	402	50	0.58	0.20	5	5
	2	404	50	0.57	0.20	5	5
8	1	400	28	0.64	0.20	5	5
	2	400	28	0.65	0.10	5	5
9	1	400	51	0.63	0	5	5
	2	400	53	0.63	0	2	1
10	1	400	41	0.55	0.10	5	5
	2	400	46	0.55	0.13	5	5
11	1	400	48	0.58	0.20	5	5
	2	400	49	0.58	0.20	5	5
12	1	400	25	0.56	0	5	5
	2	400	25	0.56	0	5	5
13	1	405	50	0.55	0.15	5	5
	2	400	50	0.55	0.20	5	5
14	1	395	50	0.52	0	5	5
	2	400	48	0.54	0	5	5
15	1	401	45	0.56	0.10	0	0
	2	401	38	0.58	0	0	0
16	1	400	35	0.58	0.10	5	5
	2	400	40	0.57	0.10	5	1
Low		386	25	0.52	0	0	
High		405	53	0.65	0.25	5	
Mean		-	44	0.57	0.10	4.0	
Median		-	-	0.57	0.10	-	

obtained on each test day in any one laboratory was 0.20 cm. Consequently, if a sealer has a flow near the allowable limit of 0.50 cm, it may be accepted at one time and rejected at another. There is no set standard of reproducibility for this test.

Bond-Ductility Test Results

There are various ways of looking at the bond-ductility test results given in Tables 1, 2, and 3. If the criterion is used that a sealer must pass five cycles in three out of four tests, grouping four specimens from the two separate days, the results are as given in Table 8, from which it is concluded that Sample N is inferior and Sample O performed best.

If the total number of specimens passed is contrasted with the total number of failures, the results given in Table 9 are obtained. Here it is found that Sample N's chances of passing have more than doubled, while those of Sample O are lower. Since the statistical sample population in Table 9

TABLE 4

MELTERS USED BY PARTICIPANTS

Lab. No.	Oil Jacket	Melting Pot (in.) Dia.	Ht.	Covered	Bottom Disch.	Type Heat	Agitation Hand	Mech.
1	Yes	4.4	3.1	No	Yes	Elec.		120 rpm
2	Yes	4	5	No	No	Gas	X	
3	Yes	9	5.5	Yes	No	Elec.	X	
4	Yes	4.5	5.5	No	Yes	Gas		60 rpm
5	Yes	4	5.5	No	No	Gas	X	
6	Yes	4	5	No	Yes	Gas		60 rpm
7	Yes	4.5	5.5	No	No	Gas	X	
8	Yes	3.8	5.3	No	No	Elec.	X	
9	Yes	3.5	7	No	No	Elec.		25 rpm
10	Yes	3.5	7	Yes	Yes	Gas		32 rpm
11	Yes	4	6	Yes	Yes	Gas		25 rpm
12	Yes	3.5	7	No	Yes	Elec.		30 rpm
13	Yes	3.6	7.5	No	Yes	Gas		30 rpm
14	Yes	3.5	7.8	No	No	Elec.		20 rpm
15	Yes	4	5.6	Yes	No	Gas	X	
16	Yes	3.5	7.5	Yes	Yes	Elec.		31 rpm

TABLE 5

OVENS USED BY PARTICIPANTS

Lab. No.	Inside dim. (in.) H	W	L	Ventilation Natural Draft	Forced Draft	Type of heating elements
1	12	12	24	x		Nickel-chromium ribbon, bottom
1	19.8	17	14	x		Two 225-w coils
3	19	14	19	x		Electric coils, bottom
4	19.8	17	14	x		Five 165-w elements, bottom
5	9.5	12	10	x		Resistance type
6	11.5	10.5	12	x		Electrical (open coil)
7	12.3	12.3	12.3		x	Two 250-w and one 500-w element
8	14	16	16	x		Electric coils, bottom
9	13	14	13		x	Nickel-chromium
10	13	13	13		x	Electric coils, 2000-w, top
11	17	19	14		x	Nickel-chromium coils
12	9	11	9	x		Electric
13	14	12	12	x		Electric coils
14	12	11	12		x	Electric coils
15	13.3	12	12	x		Chromel wire on mica
16	19.8	17	14		x	Four helical coils, 300-w each

TABLE 6

PENETRATION TEST SUMMARY

Sample	Penetration Range (cm)	Max. Diff. (cm)	Mean (cm)	Median (cm)	Max. Dev. from Mean (cm)
N	0.44-0.58	0.14	0.52	0.52	0.080
O	0.74-0.89	0.15	0.82	0.82	0.080
P	0.52-0.65	0.13	0.57	0.57	0.080

TABLE 7

FLOW TEST SUMMARY

Sample	Flow Value Limits (cm)	Arithmetic Mean (cm)	Median (cm)	Max. Dev. from Mean (cm)
N	0 - 0.20	0.15	0.15	0.15
O	0 - 0.30	0.13	0.10	0.17
P	0 - 0.25	0.10	0.10	0.15

TABLE 8

BOND-DUCTILITY PERFORMANCE OF FOUR-SPECIMEN GROUPS

Sample	Number of Laboratories Passed	Rejected	Probability of Passing
N	1	15	0.063
O	14	2	0.875
P	12	4	0.750

is 64 compared to 16 in Table 8, the results should be closer to reality. Tables 8 and 9 distinguish only between specimens that passed the required five cycles and those that failed sooner. A still better comparison between the results of different laboratories may be obtained if the number of cycles for each of them is totaled, as in Figures 1, 2, and 3. The possible maximum in all columns is 20, if every specimen passed five cycles.

Sample N, the least satisfactory of the lot, passed 19 cycles in one laboratory and none in three others. The median value is 10 and the arithmetic mean 8.5 cycles (Fig. 1).

TABLE 9

NUMBER OF SPECIMENS PASSED AND REJECTED IN THE BOND-DUCTILITY TEST

Sample	Passed	Rejected	Probability of Passing
N	11	53	0.172
O	52	12	0.813
P	49	15	0.766

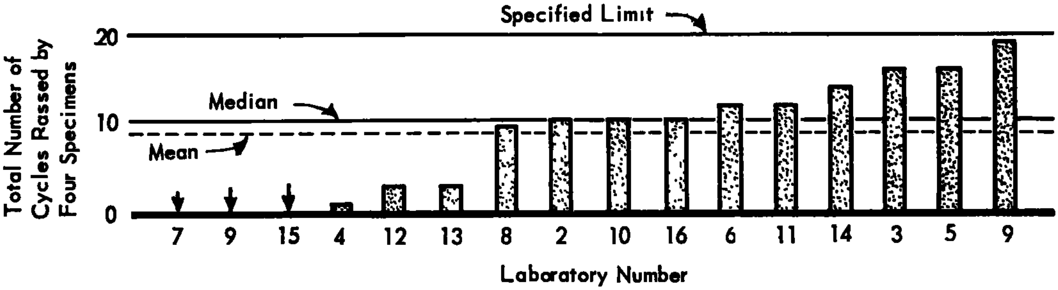

Figure 1. Total number of cycles passed in the bond-ductility test by four specimens of Sample N in each laboratory.

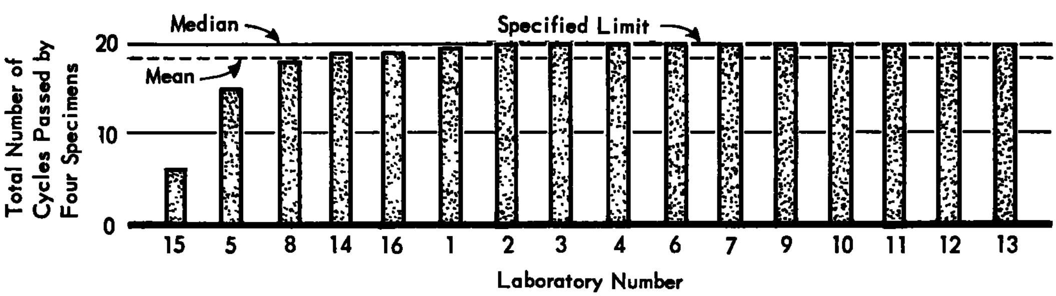

Figure 2. Total number of cycles passed in the bond-ductility test by four specimens of Sample O in each laboratory.

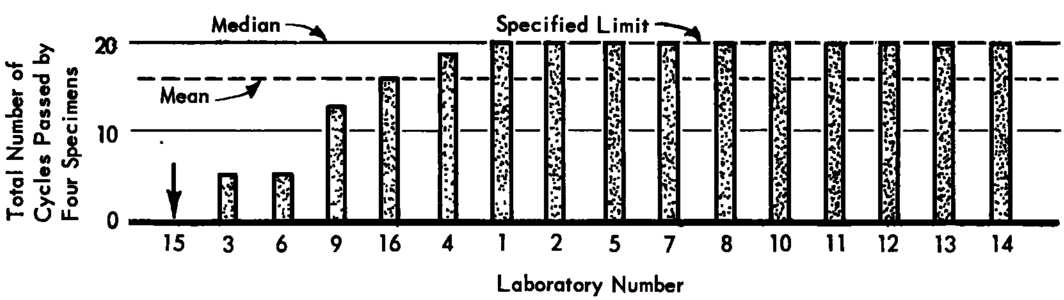

Figure 3. Total number of cycles passed in the bond-ductility test by four specimens of Sample P in each laboratory.

Figure 2 shows the cycle totals for Sample O, which performed better than the others. As the bond-ductility test is not continued until failure in all cases, the right side of the figure is flat. If each specimen had been tested to the end, a distribution pattern similar to Figure 1 probably would result.

Figure 3 shows the cycle comparison for Sample P. Three extreme values are found at the left of the figure, and there is a four-unit difference between the median and the mean. As in Figure 2, the actual range of values cannot be determined because of the five-cycle test limit.

Figure 4 compounds the data from Figures 1, 2 and 3. It shows which laboratories tend to be high and which low. Laboratory 15[a] is the only obvious extreme, although the range between the results of the others is considerable: the lowest passed 33 cycles and the highest 58.

The consistency of the results obtained from the same specimen within the same laboratory is generally defined as "repeatability." This, too, seems poor. In a number of cases one specimen of a lot passed five cycles whereas another of the same sample passed only one (see Table 1, Laboratories 6, 8, and 14; and Table 3, Laboratories 6, 9, and 16). Lesser variations occur more often. The specification sets no limits for reproducibility and repeatability.

The differences in the tests of Sample N are striking: the average of the three lowest laboratories is zero, and that of the three highest is 17 cycles. For the best of the three samples (Fig. 2) the difference is much smaller (the comparable values are 13 and 20), which indicates that the reproducibility of the test improves with the quality of the sealer. The five-cycle limit for each specimen explains this difference. However, the worst sample gives the best indication of the actual variations in the test results. As these were scattered over almost the entire possible range, it is safe to conclude

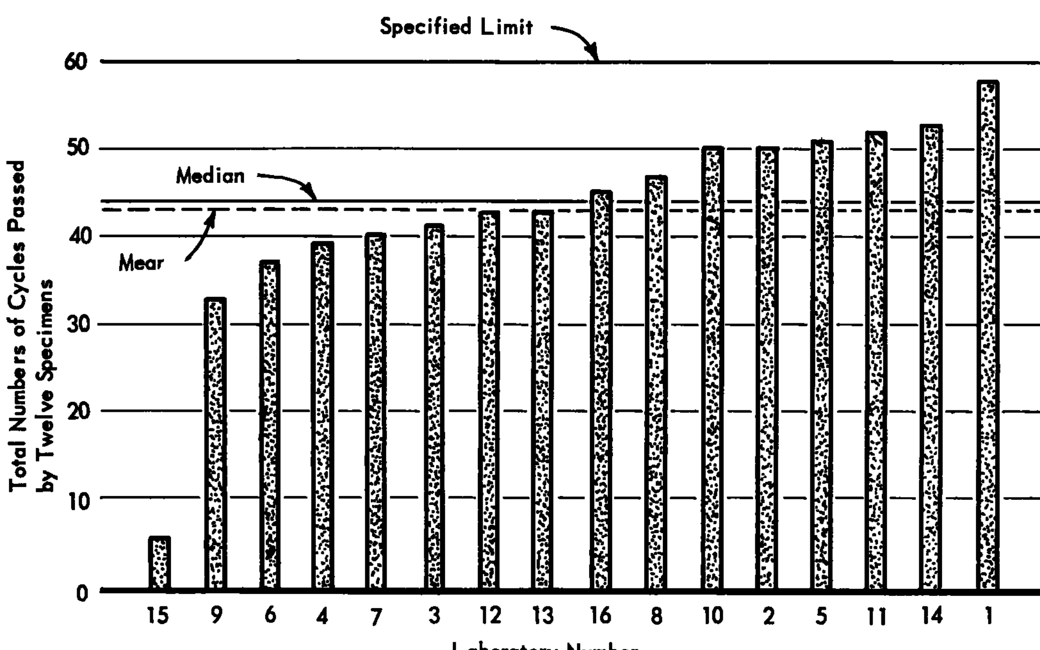

Figure 4. Total number of cycles passed in the bond-ductility test by twelve specimens of Samples N, O, and P in each laboratory.

[a]The summary of the test results was sent to all participants before this paper was written. Laboratory 15 commented that the bond failures which they found occurred mostly in the mortar, not in the sealer. Their specimens had been stored at 0 F for eight weeks before testing.

that the bond-ductility test has a very poor theoretical reproducibility.

TABLE 10

TYPE OF VENTILATION AND FLOW CORRELATION

Type of Oven Ventilation	Mean Deviation Sample N	Sample O	Sample P
Natural draft	0.041	0.072	0.068
Forced draft	0.048	0.057	0.069

COMMENTS ON TESTING PROCEDURES AND EQUIPMENT

There was no known procedural deviation from the Federal Specification. The additional limits on heating time and temperature (see Appendix) were exceeded slightly by several participants. One was low on melting time and another on melting temperature. It is not known how this has affected the test results. No trend was observed in the data, and the deviators were left in the comparison.

One laboratory stored its bond-ductility specimens for eight weeks at 0 F before testing. (The same laboratory complained about bond failures in mortar, not between sealer and block surface.) The specification does not limit cold-room storage time. The influence of this upon the results is not known, but it might be a loophole in the test procedure.

The test equipment varied widely. Tables 4 and 5 summarize the melting kettles and heating ovens used. It was nearly impossible to make a quantitative analysis of how the equipment affected the results. The ovens with forced draft ventilation were compared with those of natural draft in Table 10, from which no definite conclusions can be drawn. The table was calculated by dividing each sample into two groups—those that were put into natural and those that were put into forced draft ovens.

In a similar statistical comparison on melting kettles, the penetration test showed a slightly better reproducibility with samples coming from the mechanically agitated melters.

LABORATORY TESTS AND FIELD CONDITIONS

There are two prime considerations for laboratory tests of this type as follows:

1. The test procedure should be simple to follow, thorough in detail, and give reproducible results.
2. The test procedure should either simulate field conditions or have a good correlation with them.

It is questionable whether all the present tests for sealers fulfill these requirements. For example, in the present bond-ducility test, one set of conditions simulates a wide variety of joints (2) and other factors (2, 3, 4, 5), especially climate. Simple observations and calculations by the author indicate that the test is mild compared to the strains and bond conditions under which many sealers are expected to operate.

A theoretical and practical analysis should therefore be made of the performance that is required of a sealer. Different types of joints, various climates, and other factors, should be taken into consideration. With this information, the undependable tests could be re-designed to give better and more practical results.

CONCLUSIONS AND RECOMMENDATIONS

The main conclusions based on the results of testing three hot-poured rubber-asphalt sealers are as follows:

1. The reproducibility of the cone penetration test is not good, but it is probably adequate for practical purposes.
2. The results of the flow test vary widely. The test is not accurate.
3. The bond-ductility test shows poor actual repeatability and reproducibility in the case of lower-quality sealers.
4. The apparent reproducibility of the bond-ductility test increases with the improvement in the bond-ductility qualities of the sealer. This is due to discontinuing the testing after five cycles.

In view of the differences in the joint sealer test results described in this paper, the following recommendations based on testing and a limited literature study might be of interest:

1. The present test procedures should be studied thoroughly, all possible loopholes eliminated, and vague statements made more specific.
2. The reproducibility of the bond-ductility and the flow tests should be improved.
3. A change from cone penetration to the regular needle penetration for hot-poured rubber-asphalt sealers would increase the test reproducibility and would be familiar to more people in the sealing and related fields.

Added to the foregoing recommendations are the following opinions of the author:

1. The first in line for redesign is not the test procedure (to increase reproducibility) but the specification requirements.
2. The bond-ductility test should be re-examined in the light of the great variety of field requirements. A similar suggestion can be made for the flow test.

ACKNOWLEDGMENTS

Sincere appreciation is expressed to C. C. Rhodes, Chairman of Project Committee D-3, for his efforts in coordinating and organizing the work before and throughout the testing period. Thanks are due to the Massachusetts Department of Public Works, sponsors of the Joint Highway Research Project at M.I.T., which was one of the participating laboratories and under whose auspices this paper was prepared.

On the M.I.T. staff, Professors A. J. Bone and Vincent J. Roggeveen contributed their constructive criticism and helpful suggestions, and Richard E. Bunyan and Robert V. Wood assisted in the calculations and the preparation of the manuscript.

REFERENCES

1. Robbers, J. C., and Swanberg, J. H., "Resealing Joints and Cracks in Concrete Pavements with Hot-Poured Rubber-Asphalt. HRB Bull. 63 (1952).
2. Anderson, A. A., "Current Practice Questionnaire—Jointing, Fillers, Sealers, and Equipment." HRB Bull. 138, p. 11 (1956).
3. "Filling and Sealing of Joints and Cracks in Concrete Pavements." HRB Bull. 78 (1953).
4. Sternberg, F. E., and Creamer, W.M., "Cleaning and Resealing of Concrete Pavement Joints by Contract." HRB Bull. 138, p. 1 (1956).
5. "Joint Spacing in Concrete Pavements: 10-Year Reports on Six Experimental Projects." HRB Research Report 17-B (1956).
6. Allen, C. W., and Childs, L. D., "Report on Pavement Research Project in Ohio." HRB Bull. 116, p. 57 (1955).
7. "ASTM Standards," Part 5. ASTM (1952).
8. "Standards on Bituminous Materials for Highway Construction, Waterproofing and Roofing." ASTM (Dec. 1955).
9. Spencer, W. T., Allen, H., and Smith, P.C., "Report on Pavement Research Project in Indiana." HRB Bull. 116, p. 1 (1955).
10. Tons, E., and Roggeveen, V.J., "Laboratory Testing of Materials for Sealing Cracks in Bituminous Concrete Pavements." Highway Research Abstr., 25:8,19 (1955).

Appendix

INSTRUCTIONS TO PARTICIPATING LABORATORIES, COMPARATIVE TESTING OF JOINT SEALERS

Subject

Highway Research Board Committee D-3 Joint Sealer Cooperative Program.

Testing Method

Method 223.11 of Federal Specification SS-R-406c will be used for this testing. It is the proposal of Committee D-3 that the following details be strictly adhered to by participating laboratories.

Details of Testing

1. Laboratory Melter.—For these tests, each laboratory will use its own melter. The melter must, however, be of the double-boiler type and means provided for adequate, continuous stirring of the sample as it is heated to pouring consistency. Wherever possible, a melter with a bottom discharge opening is preferred for this testing.
2. Pouring Temperature.—Specimens for the flow, penetration, and bond tests should be poured after the well-blended sealer melt reaches 400±5 F.
3. Oil Bath Temperature.—The oil bath temperature should be maintained at 440±5 F during the entire sample preparation.
4. Sample Preparation.—(a) 600 grams of sample should be taken for each pour, as outlined in the Federal method. (b) As outlined in the Federal method, 200 grams of sealer should be added to the hot melter (oil bath 440±5 F). The remaining 400 grams should be added in 50-gram increments.
5. Pouring Test Specimens.—When the sealer melt reaches the pouring temperature (400±5 F), duplicate specimens for the flow, penetration, and bond tests will be poured in that order. For bottom discharge melters, 2-ounce ointment tin will be poured initially and discarded. The test specimens will then be poured as outlined above.
6. Melting Time.—The rate of heating should be so controlled that the pouring temperature is reached in 40 min. ±10 min. from the addition of the first 200 grams of sealer to the melter. (The bath temperature should be 440 F when the first 200 grams of material is added and should be controlled at 440 F.) The sealer will be kept in the pot at least 30 min, regardless of when the pouring temperature is reached.
7. Method of Test.—The flow, penetration, and bond tests will be run in accordance with the Federal methods described in 223.11. The oven and melter used for the tests should be fully described on the data sheet. The blocks supplied have been surface ground. They should, however, be redried and surface brushed before being used.
8. Number of Tests.—Each participating laboratory will pour each of the three selected sealers on two different days and the tests will be run in duplicate. (Two bond test specimens will be run as per the Federal specification, rather than four. If four specimens were poured, 600 grams of material would not be sufficient.)
9. Reporting of Results.—All Data should be reported on the enclosed reporting form.

Report Form

	Temp.	Time	Penetration	Flow	Bond
Sample N, Day 1	x	x	xx avg	xx avg	xx
Day 2	x	x	xx avg	xx avg	xx
Sample O, Day 1	x	x	xx avg	xx avg	xx
Day 2	x	x	xx avg	xx avg	xx
Sample P, Day 1	x	x	xx avg	xx avg	xx
Day 2	x	x	xx avg	xx avg	xx

Notes: —Each x under "time" represents the time in minutes it takes to bring the sample up to the pouring temperature from the time the first 200 g of material are placed in the melter.
Each x under "Temp." represents the actual temperature of material at time of pouring test specimens.
Each x under "Flow" denotes the greatest flow point on the panel, not an average of both sides of the panel.
Each x under "Penetration" denotes an average of at least 3 penetrations on each tin.
Each x under "Bond" represents a specimen running 5 cycles. In the event of bond failure, the last previous cycle in which it passed should be so noted.

HRB:OR-211