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Dale A. Rand

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16. Abstract
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There was no significant difference in accuracy and repeatability of the results obtained by either gauge in the lab. The Troxler 3241-B is being used by SDHPT personnel in the field with good results. The CPN AC-2 gauge has yet to be field tested by SDHPT.

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COMPARATIVE EVALUATION OF THE TROXLER 3241-B AND THE CPN AC-2 ASPHALT CONTENT GAUGES

3-F-6-136

BY

Dale A. Rand

Engineering Assistant

Texas State Department of Highways

and Public Transportation

Materials and Tests Division

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ABSTRACT

A laboratory analysis of a the CPN Corporation's model AC-2 asphalt content gauge was performed to determine if the CPN AC-2 gauge could measure asphalt contents with the same degree of accuracy and repeatability as the Troxler Electronic Laboratories', Inc. model 3241-B asphalt content gauge. Several miscellaneous items of interest were also investigated such as the effects of changing asphalt sources, aggregate mineralogy, and gradation.

SUMMARY

This investigation, though limited in scope, indicates that the CPN AC-2 gauge is capable of producing equivalent results when compared to those from the Troxler 3241-B asphalt content gauge. It was found that both gauges performed well when used to determine the asphalt content of a bituminous mixture. There was no significant difference in the accuracy and repeatability of the results obtained by either gauge.

The two gauges operate fundamentally the same. However, there are differences in the software packages and instrumentation. The software package and instrumentation of each gauge have advantages and disadvantages. Since these characteristics are highly subjective, no definitive statement can be objectively made concerning operational performance.

Another area of evaluation is the "field performance" of each gauge. Currently, the Troxler 3241-B is being used by SDHPT field office personnel with good results. The CPN AC-2 gauge has yet to be field tested by the Department. In the laboratory, the gauges perform equally, but a field evaluation of the CPN AC-2 gauge is needed to conclude the comparative analysis of the two asphalt content gauges.

IMPLEMENTATION STATEMENT

The findings of this research should be implemented by:

1. Obtaining tentative departmental approval to use the CPN AC-2 gauge to determine asphalt contents of a bituminous mixtures by the nuclear method;

2. Purchasing a limited number of CPN AC-2 gauges to be used in the field by District personnel to continue the evaluation of the asphalt content gauge.

TABLE OF CONTENTS

I. SUBJECT

This study analyzed the use of a CPN AC-2 asphalt content gauge and of a Troxler 3241-B asphalt content gauge and compared their accuracy and repeatability in measuring the asphalt content of five different mix designs.

II. PURPOSE

The primary purpose of this analysis was to determine if the CPN AC-2 asphalt content gauge could provide accurate and repeatable results. Another objective was to determine if the CPN AC-2 gauge could provide an equivalent level of extended field service and reliability to that of the Troxler 3241-B asphalt content gauge.

III. FINDINGS AND RECOMMENDATIONS

1) The test results indicate that in a laboratory environment the CPN AC-2 asphalt content gauge can accurately determine the amount of asphalt in a bituminous mixture and can provide the results with a high degree of repeatability.

2) Both asphalt content gauges demonstrated the ability to measure the asphalt content of bituminous mixtures with acceptable levels of accuracy and precision.

3) Both gauges provided acceptable results with neither gauge demonstrating a discernible advantage over the other.

4) The software packages and general operational procedures are the primary differences in the two asphalt contents gauges.

5) The CPN AC-2 gauge has yet to be field tested by the Department. The Department should purchase a limited number of CPN AC-2 gauges to determine how well the gauges will perform in a field environment.

IV. MATERIALS

Five different mix designs were used to evaluate the asphalt content gauges. A listing of each of the mixtures including the respective target asphalt percentages follows:

1) Silicious Aggregate Type "D" with Exxon AC-20 3.0%, 4.0%, 5.0%, and 7.0%.

2) Limestone Aggregate Type "D" with Exxon AC-20 3.0%, 4.0%, 5.0%, and 7.0%.

3) Lightweight Aggregate Type "D" with Texaco AC-5 6.0%, 7.0%, 8.0%, and 12.0%.

4) Limestone Aggregate Type "B" with Texaco AC-10 3.0%, 4.0%, 5.0%, and 7.0%.

5) Limestone Aggregate Type "B" with Shamrock AC-10 4.0% only.

V. EQUIPMENT

1) 1 CPN AC-2 asphalt content gauge

2) 1 Troxler 3241-B asphalt content gauge

3) 1 Hobart mechanical mixer

4) 6 sample pans

5) 1 electronic balance (16,000 gram capacity)

6) 1 electric oven (350 +/- 5 degrees F capacity)

7) Assorted spoons, scoops, mixing bowls, trowels, and/or spatulas

8) Waxed paper

9) 3/4" x 12" x 10" plywood

10) Thermometer with a temperature range of 50F to 500F

11) Straightedge, steel, approximately 18 inches long

VI. TEST PROCEDURE

The test procedure used to evaluate the CPN AC-2 gauge and the Troxler 3241-B gauge closely followed ASTM D-4125-83, "Standard Test Method for Asphalt Content of Bituminous Mixtures by the Nuclear Method" as provided in Appendix D. Some minor variations of the ASTM method were used.

A total of five different mix designs were used to evaluate the two gauges. A comparative analysis was made by changing asphalt types, gradation, aggregate mineralogies, and asphalt contents. An 8,000-gram sample size was initially blended for each given asphalt content. The aggregate was placed in a 280F oven and dried to a constant weight. The asphalt was heated to approximately 280F and blended with the aggregate in a Hobart mechanical mixer. Typically, four different asphalt contents were used for each mix design. Approximately 7,000 grams of mix were placed in each sample pan provided by the manufacturers. The sample was then compacted to consistent density in accordance with ASTM D-4125-83. Two of the four mixtures were used to calibrate the gauges for the mix design. The gauge manufacturers' recommended procedure for a two point calibration was used. Once the calibration was established, the asphalt contents were measured using the procedures recommended by the gauge manufacturers. (A clear explanation of the calibration and test pan preparation procedure is provided in the operating manuals supplied by the gauge manufacturers.) Both gauges used the same size sample pans, which simplified the calibration and testing since only one set of sample pans was needed for each mix design. This eliminated any variable associated with mix uniformity and density used to compare the two gauges. After the set of sample pans was prepared, the individual pans were transferred back and forth between the two gauges for testing. Repeatability was determined by placing a sample pan full of mix in each gauge and running ten consecutive tests. Results from these tests can be found in Table 5. The two asphalt content gauges were set up approximately 30 feet apart to prevent interference by radiation. Initial tests were run at one-minute, four-minute, eight-minute, and sixteen-minute time increments. It was later determined that the four-minute and eight-minute tests would be sufficient since no appreciable difference in repeatability was found due to testing duration. Each mix design required a separate calibration. A total of 17 sample pans of mixture were prepared and tested to determine asphalt content. The results from these tests are provided in Tables 1A through 4 and Figures 1 through 4.

In addition to the tests for accuracy and repeatability, tests were run to determine the effects of making changes in the mix design. A miscellaneous mix design of limestone Type "B" aggregate with Shamrock AC-10 asphalt was placed in each of the gauges and the asphalt content was measured using the calibrations of the first four mix designs. The results of this study, found in Appendix B, demonstrate the importance of recalibrating for changes in mix design. Periodic checks of the background counts for each gauge were taken and recorded in Appendix A. Testing the bituminous mixtures was achieved using ASTM test method D-4125-83 as a guideline.

VII. CALCULATIONS

All calculations used to calibrate the two asphalt content gauges were generated from the software packages within the gauges. The two gauges use different nomenclatures for similar terms. The equations used by the gauges to determine asphalt content are as follows:

<u>Troxler 3241-B</u>

Percent Asphalt = A1 + A2/1000*X + A3/10,000,000*X*X

where; X = Counts on sample
A1 = Intercept for linear or coefficient for quadratic
A2 = Slope for linear or coefficient for quadratic
A3 = Coefficient for quadratic

<u>CPN AC-2</u>

Percent Asphalt = ((X-B+(C-S))/A

where; X = Counts on sample
A = Slope
B = Intercept
C = Background, counts at calibration
S = Background, current

The percent asphalt was determined based on a percentage of the total mix: Therefore;

Percent Asphalt = Wt. of asphalt * (100)/Wt. of mix

VIII. TEST RESULTS

The test results clearly indicate that nuclear asphalt content gauges can accurately measure the amount of asphalt in a bituminous mixture. In the majority of the tests, both gauges measured asphalt contents within one tenth of a percentage point of the target asphalt content. This compares very favorably with the conventional methods of solvent extraction. Exceptions to this accuracy occurred when higher asphalt contents were measured. Various factors could have contributed to this error. For investigation purposes, the highest asphalt content for each design was intentionally mixed at an asphalt content above the recommended tolerance of the calibration and outside the calibration curve. The gauge manufacturers recommend that the calibration be made within two percentage points of the target asphalt content. Also, at higher asphalt contents, the sample pan was not completely filled with the required weight of mix. An error in measured asphalt content could result from not completely filling the sample pans.

A series of tests was run to determine the repeatability of the gauges. The results indicate that both gauges are capable of repeating measurements with an acceptable level of accuracy. Several other miscellaneous items were investigated. Periodic checks of the background counts for each gauge were taken and recorded in Appendix A. Also included is a study of the effects of changing asphalt sources, aggregate mineralogy, gradation, etc., without changing calibrations. This study confirms the importance of recalibrating when significant changes in mix design are made. The results of this study are shown in Appendix B. The results of tests from the first four mix designs can be found in Tables 1A through 5 and Figures 1 through 4.

TABLE 1A

SUMMARY OF ASPHALT GAUGE RESULTS

Silicious Aggregate Type "D" with Exxon AC-20

Target Asphalt %	CPN AC-2 %	Troxler 3241-B %
3.0	2.85	2.96
4.0	3.93	4.06
5.0	4.88	4.98
7.0	7.35	7.35

Limestone Aggregate Type "D" with Exxon AC-20

Target Asphalt %	CPN AC-2 %	Troxler 3241-B %
3.0	2.93	3.04
4.0	4.01	4.05
5.0	5.00	5.06
7.0	7.29	7.18

Lightweight Aggregate Type "D" with Texaco AC-5

Target Asphalt %	CPN AC-2 %	Troxler 3241-B %
6.0	5.97	6.07
7.0	7.06	7.02
8.0	8.02	7.99
12.0	14.03	12.61

Limestone Aggregate Type "B" with Texaco AC-10

Target Asphalt %	CPN AC-2 %	Troxler 3241-B %
3.0	3.00	3.03
4.0	3.97	3.96
5.0	5.04	4.95
7.0	7.05	7.11

Limestone Aggregate Type "B" with Shamrock AC-10

Target Asphalt %	CPN AC-2 %	Troxler 3241-B %
4.0	4.36	4.32

SILICIOUS AGGREGATE TY "D" WITH EXXON AC-20

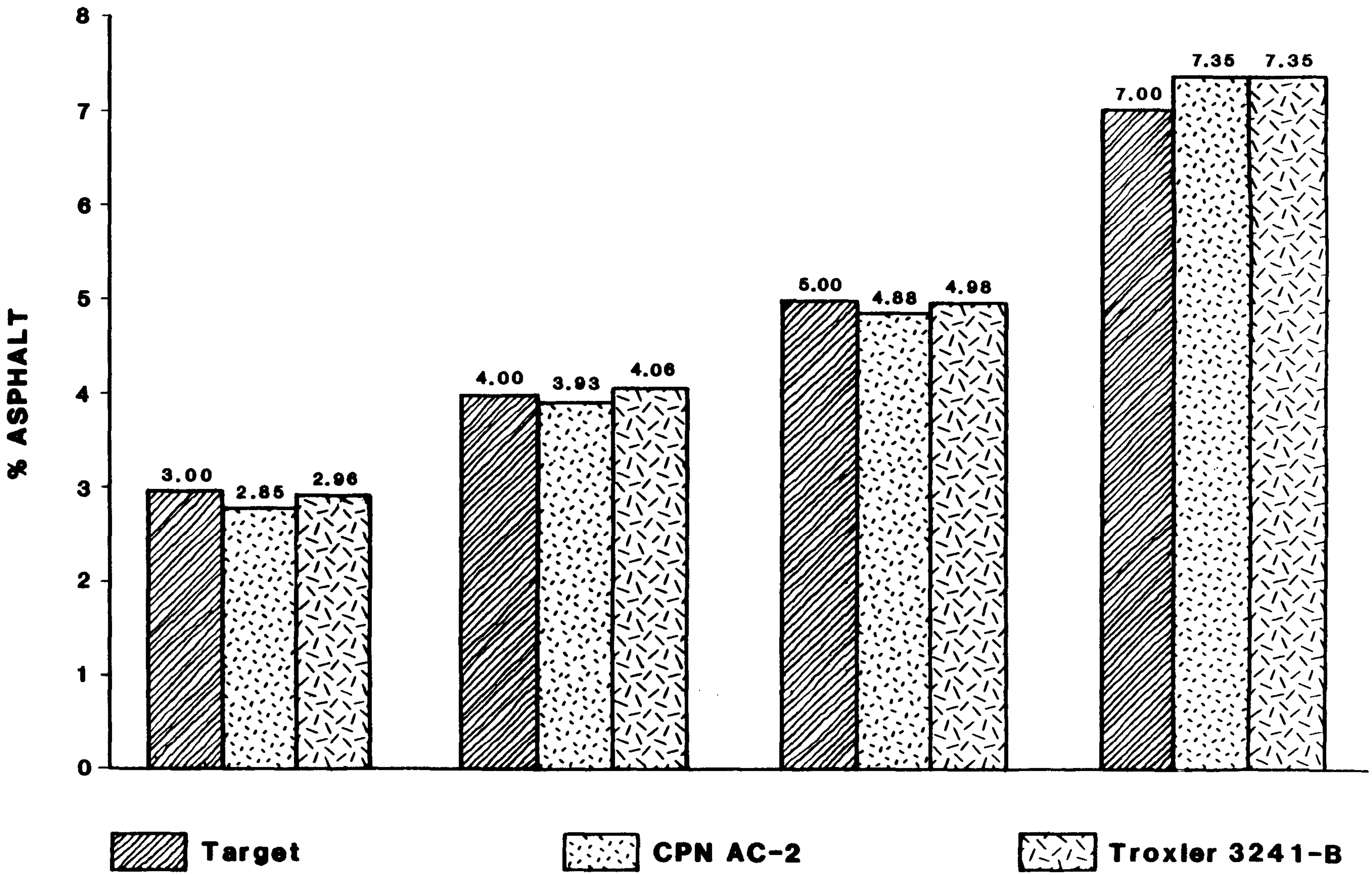

Figure 1

TABLE 1

SILICIOUS AGGREGATE TYPE "D" WITH EXXON AC-20

	Target AC %	T=1 min	T=4 min	T=8 min	T=16 min	Avg	Stand. Dev.
CPN	3.0	2.84	2.83	2.85	2.88	2.85	.0216
Troxler	3.0	2.92	3.01	2.98	2.93	2.96	.0424
CPN	4.0	3.96	3.93	3.93	3.91	3.93	.0206
Troxler	4.0	4.10	3.97	4.10	4.08	4.06	.0624
CPN	5.0	4.88	4.84	4.90	4.91	4.88	.0310
Troxler	5.0	4.81	5.02	5.01	5.07	4.98	.1147
CPN	7.0	7.36	7.29	7.41	7.34	7.35	.0497
Troxler	7.0	7.37	7.23	7.35	7.44	7.35	.0873

Troxler Cal #30	CPN AC-2 Cal #2
Slope*1000 = 5.51	R = 1.0
Intercept = -6.65	A = 1345.74
Temperature=275 F	B = 8559.20
Cal Bkgnd = 1516	C = 9930.32

NOTES: (1) 3% and 5% were used for a two-point calibration.

(2) A weight of 6883.2 grams was used for each sample.

LIMESTONE AGGREATE TY "D" WITH EXXON AC-20

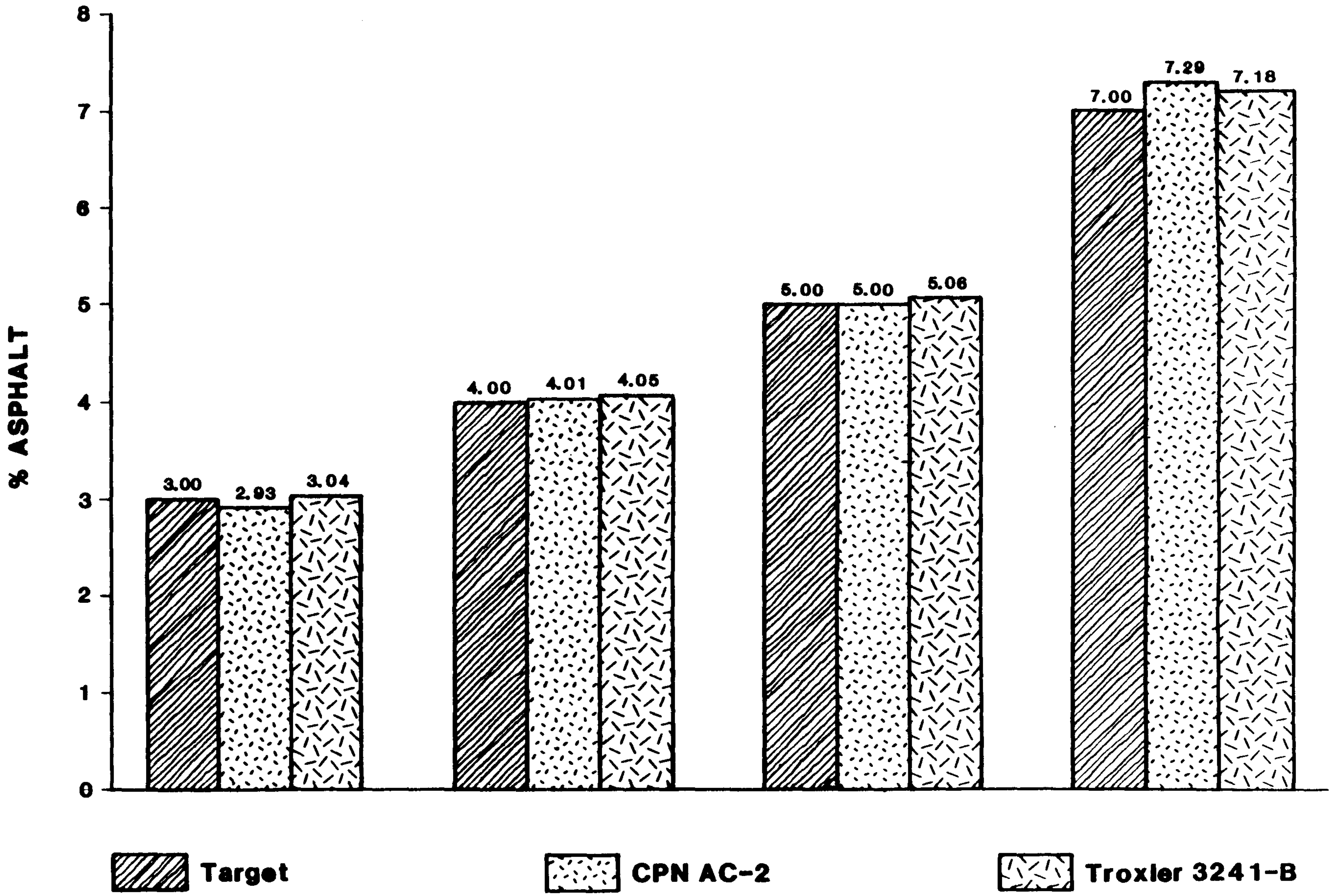

Figure 2

TABLE 2

LIMESTONE AGGREGATE TYPE "D" WITH EXXON AC-20

	Target AC %	T=1 min	T=4 min	T=8 min	T=16 min	Avg	Stand. Dev.
CPN	3.0	2.87	2.90	3.01	2.94	**2.93**	.0606
Troxler	3.0	3.15	3.00	3.01	2.99	**3.04**	.0754
CPN	4.0	4.06	4.04	3.95	3.97	**4.01**	.0532
Troxler	4.0	3.98	4.07	4.11	4.03	**4.05**	.0556
CPN	5.0	5.08	4.91	5.04	4.95	**5.00**	.0785
Troxler	5.0	5.06	5.06	5.05	5.07	**5.06**	.0082
CPN	7.0	7.21	7.30	7.34	7.30	**7.29**	.0550
Troxler	7.0	7.03	7.25	7.29	7.18	**7.19**	.1144

Troxler Cal #31	CPN AC-2 Cal #3
Slope*1000 = 5.04	R = 1.0
Intercept = -5.66	A = 1487.42
Temperature=275 F	B = 7828.55
Cal Bkgnd = 1518	C = 9935.97

NOTES: (1) **3% and 5% asphalt were used for a two-point calibration.**

(2) **A weight of 7048.4 grams was used for each sample.**

(3) **A three-point calibration (3%, 4%, and 5%) was also used on this mix design, but it produced no significant change in the gauge readings.**

LIGHTWEIGHT AGGREATE TY "D" WITH EXXON AC-5

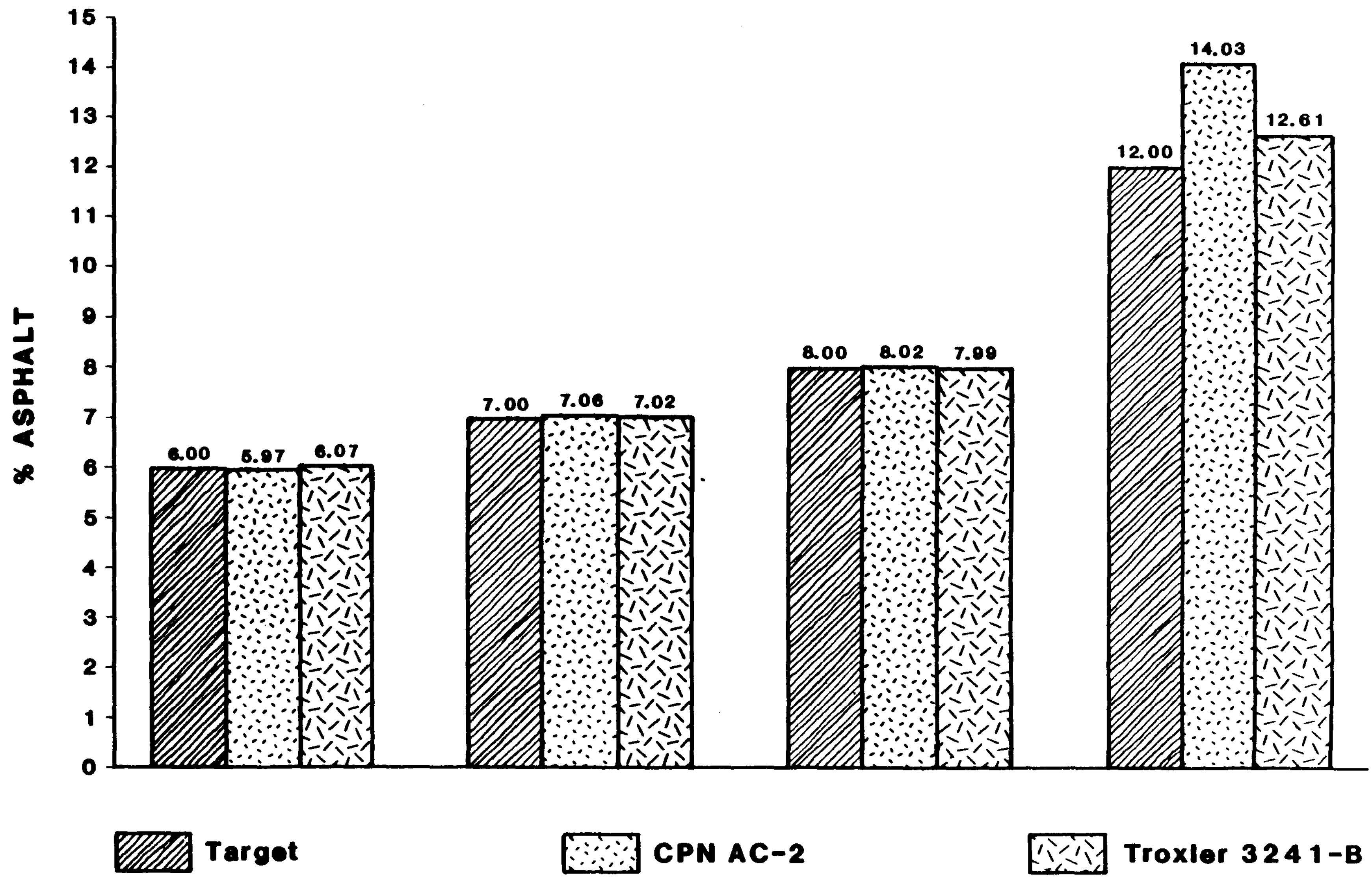

Figure 3

TABLE 3

LIGHTWEIGHT AGGREGATE TYPE "D" WITH TEXACO AC-5

	Target AC %	T = 4 minutes	T = 8 minutes	Average
CPN	6.0	5.99	5.95	5.97
Troxler	6.0	6.03	6.11	6.07
CPN	7.0	7.06	7.06	7.06
Troxler	7.0	7.01	7.03	7.02
CPN	8.0	7.99	8.05	8.02
Troxler	8.0	7.97	8.01	7.99
CPN	12.0	14.15	13.91	14.03
Troxler	12.0	12.64	12.58	12.61

Troxler Cal #33	CPN AC-2 Cal #6
Slope*1000 = 9.13	R = 1.0
Intercept =-10.89	A = 612.85
Temperature =75 F	B = 8895.72
Cal Bkgnd = 1520	C = 10202.4

NOTES: (1) 6% and 8% asphalt were used for a two-point calibration.

(2) A weight of 4397.2 grams was used for each sample.

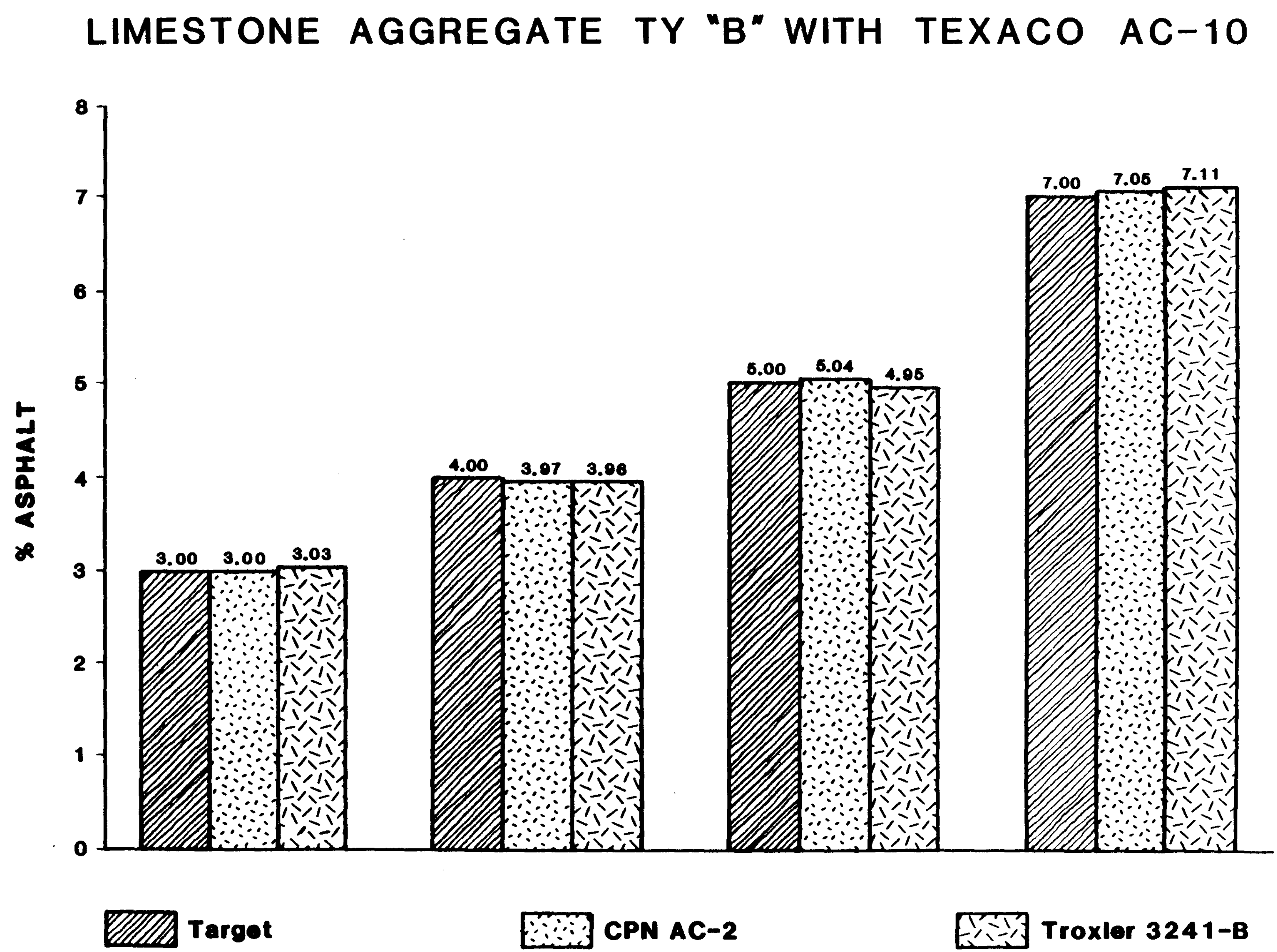
LIMESTONE AGGREGATE TY "B" WITH TEXACO AC-10
% ASPHALT
0
1
2
3
4
5
6
7
8
3.00
3.00
3.03
4.00
3.97
3.96
5.00
5.04
4.95
7.00
7.05
7.11
Target
CPN AC-2
Troxler 3241-B

Figure 4

TABLE 4

LIMESTONE AGGREGATE TYPE "B" WITH TEXACO AC-10

	Target AC %	T = 4 minutes	T = 8 minutes	Average
CPN	3.0	2.98	3.02	3.00
Troxler	3.0	3.07	2.99	3.03
CPN	4.0	3.95	3.99	3.97
Troxler	4.0	3.96	3.95	3.96
CPN	5.0	5.03	5.05	5.04
Troxler	5.0	4.94	4.95	4.95
CPN	7.0	7.00	7.10	7.05
Troxler	7.0	7.12	7.10	7.11

Troxler Cal #37	CPN AC-2 Cal #7
Slope*1000 = 5.08	R = 1.0
Intercept =- 6.17	A = 1462.05
Temperature= 75 F	B = 8633.93
Cal Bkgnd = 1518	C = 10145.5

NOTES: (1) 3% and 5% asphalt were used for a two-point calibration.

(2) A weight of 7156.1 grams was used for each sample.

TABLE 5

REPEATABILITY TESTS

Silicious Aggregate Type "D" with 3 % Exxon AC-20

	One-Minute Tests		Eight-Minute Tests	
# of Tests	CPN	Troxler	CPN	Troxler
1	2.84	2.91	2.94	2.92
2	2.87	2.99	2.83	2.87
3	2.91	2.98	2.88	2.88
4	2.86	2.68	2.86	2.89
5	2.86	3.09	2.84	2.88
6	2.86	2.87	2.88	2.89
7	2.82	2.90	2.87	2.88
8	2.95	2.94	2.84	2.89
9	2.80	2.84	2.88	2.89
10	2.84	2.88	2.81	2.92
	====	====	====	====
Average =	2.86	2.91	2.86	2.89
Standard Deviation =	.0431	.1080	.0362	.0166

Limestone Aggregate Type "D" with 4 % Exxon AC-20

	One-Minute Tests		Eight-Minute Tests	
# of Tests	CPN	Troxler	CPN	Troxler
1	3.99	3.93	3.99	3.99
2	3.97	3.97	4.03	3.97
3	3.84	3.79	3.98	3.98
4	4.04	4.06	4.02	3.91
5	4.05	3.84	4.04	3.95
6	3.85	3.99	3.95	3.97
7	3.83	4.07	3.95	3.97
8	3.94	3.92	3.98	3.96
9	3.95	3.82	3.96	3.96
10	3.91	3.88	3.96	3.98
	====	====	====	====
Average =	3.94	3.93	3.97	3.96
Standard Deviation =	.0793	.0966	.0334	.0222

IX. DISCUSSION

The goal of this investigation was to compare objectively the accuracy and repeatability of the Troxler 3241-B and the CPN AC-2 asphalt content gauge. The results show that both gauges perform well in a laboratory environment. The uniformity of the testing environment was an area of concern in the objectivity of this investigation. One variation was in the way the gauges were set up each day. To achieve the required separation of gauges, the CPN AC-2 gauge was moved out of the storage room each day and set up in the lab. It was returned to the storage room at the end of each day. The Troxler 3241-B gauge remained in the closed environment of the storage room throughout the duration of testing. The CPN AC-2 gauge was more susceptible to changes in the environment due to its location. On several occasions, it was noticed that sources of hydrogen (people, water, asphalt samples, etc.) were in close proximity of the CPN AC-2 asphalt content gauge. From the test results, the overall environmental effect appears to be negligible. Another variation is the difference in the temperature compensation features of the two gauges. The CPN AC-2 automatically compensates for temperature differences, whereas the Troxler 3241-B requires the operator to manually input the sample temperature in order to compensate for variations. (The Troxler 3241-C, not evaluated in this study, does have the automatic temperature compensation feature.) After the initial mix design (set of four pans of mix) was calibrated and measured, it was decided to perform all tests at room temperature (approximately 75F). A more objective analysis was attained by testing at room temperature.

Appendix C contains data that emphasizes the importance of recalibrating when significant changes in mix design are made. The data in Appendix C is the result of blending a bituminous mixture (Limestone Type "B" with 4 % Shamrock AC-10 asphalt) and testing it using the four previously established calibrations. Appendix E contains a listing of reference literature used for this study.

Although it is impossible to eliminate all sources of error, this investigation indicates that both the CPN AC-2 gauge and the Troxler 3241-B gauge are capable of accurately determining the asphalt content of a bituminous mixture. Both gauges demonstrate the ability to repeat results with an acceptable degree of precision. When compared on the basis of accuracy and repeatability, the CPN AC-2 gauge and the Troxler 3241-B gauge are both capable of producing acceptable results.

APPENDIX A

BACKGROUND COUNTS

Date		CPN AC-2	Troxler 3241-B
11-28-89		9930	1516
11-29-89		9935	1518
11-30-89		9936	1518
12-05-89		10202	1520
12-08-89		10145	1518
12-11-89		10190	1514
12-12-89		9926	1523
		======	=====
Average	=	10038	1518
Standard Deviation	=	133	2.85

NOTES: The CPN gauge was moved out of the storage room every day and set up out in the lab. It was returned to the storage room at the end of each day. The Troxler gauge remained in the storage room throughout the duration of testing. The CPN gauge was more susceptible to changes in the environment due to its location. On several occasions, it was noticed that sources of hydrogen (people, water, asphalt samples, etc.) were in close proximity of the CPN gauge.

APPENDIX B

SUMMARY OF SAMPLE PAN WEIGHTS

Silicious Aggregate Type "D" with Exxon AC-20

	Blank Sample	3% Target	4% Target	5% Target	7% Target
Tare Weight	593.8	592.2	598.3	593.8	601.8
Total Weight	7477.0	7475.4	7481.5	7477.0	7485.0
Net Weight	6883.2	6883.2	6883.2	6883.2	6883.2

Limestone Aggregate Type "D" with Exxon AC-20

	Blank Sample	3% Target	4% Target	5% Target	7% Target
Tare Weight	591.6	591.6	598.3	594.1	601.4
Total Weight	7640.0	7640.0	7646.7	7642.5	7649.8
Net Weight	7048.4	7048.4	7048.4	7048.4	7048.4

Lightweight Aggregate Type "D" with Texaco AC-5

	Blank Sample	3% Target	4% Target	5% Target	7% Target
Tare Weight	593.8	593.8	591.9	591.2	601.6
Total Weight	4991.0	4991.0	4989.1	4988.4	4998.8
Net Weight	4397.2	4397.2	4397.2	4397.2	4397.2

Limestone Aggregate Type "B" with Texaco AC-10

	Blank Sample	3% Target	4% Target	5% Target	7% Target
Tare Weight	598.3	593.9	591.6	594.0	592.3
Total Weight	7754.4	7750.0	7747.7	7750.1	7748.3
Net Weight	7156.1	7156.1	7156.1	7156.1	7156.1

APPENDIX C

MISCELLANEOUS RESULTS USING SHAMROCK ASPHALT

Calibration #		Description	4 % Target Asphalt * % Asphalt
CPN	# 2	Silicious Ty "D" w/Exxon AC-20	4.61
Troxler	#30	Silicious Ty "D" w/Exxon AC-20	4.60
CPN	# 3	Limestone Ty "D" w/Exxon AC-20	4.67
Troxler	#31	Limestone Ty "D" w/Exxon AC-20	4.67
CPN	# 6	Lightweight Ty "D" w/Texaco AC-5	10.05
Troxler	#33	Lightweight Ty "D" w/Texaco AC-5	8.10
CPN	# 7	Limestone Ty "B" w/Texaco AC-10	** 4.36
Troxler	#37	Limestone Ty "B" w/Texaco AC-10	** 4.32

* The "% asphalt" obtained is the result of using a mix of Limestone Type "B" aggregate with Shamrock AC-10. A 4 % asphalt design was mixed and then measured using each of the previous eight calibrations (four for the CPN and four for the Troxler). The intent of this investigation is to show that a change in asphalt, aggregate, gradation, etc. requires that a new calibration be performed as specified in the operations manuals provided by the gauge manufacturers.

** The only variable associated with these results is the change in source of asphalt.

APPENDIX D

Standard Test Method for Asphalt Content of Bituminous Mixtures by the Nuclear Method[1]

This standard is issued under the fixed designation D 4125; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This method covers the quantitative determination of the asphalt content of bituminous mixtures by examining a sample with a device that utilizes neutron thermalization techniques.

1.2 The values stated in inch-pound units are to be regarded as the standard. The metric equivalents of inch-pound units may be approximate.

2. Referenced Documents

2.1 *ASTM Standards:*

D 75 Practice for Sampling Aggregates[2]

D 979 Methods of Sampling Bituminous Paving Mixtures[2]

D 1461 Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures[2]

3. Significance and Use

3.1 This method can be used for rapidly determining the asphalt content of bituminous paving mixtures. Testing can be completed in a matter of minutes so that appropriate adjustments, if necessary, can be made in the asphalt-metering system with a limited amount of mix production. The procedure is useful in the determination of asphalt content only, as it does not provide extracted aggregate for gradation analysis.

3.2 Unless the test sample is completely free of moisture, such percentage must be determined as outlined in 7.3 and a correction made to compensate for the moisture.

4. Apparatus

4.1 While exact details of construction for the apparatus may vary, the system shall consist of the following items:

4.1.1 *Neutron Source*—An encapsulated and sealed radioactive source such as americium-beryllium.

4.1.2 *Detectors*—Any type of thermal neutron detector, such as helium-3 or boron trifluoride.

4.1.3 *Read-Out Instrument*, such as a scaler or a direct-reading digital device calibrated in percent asphalt.

4.1.4 *Reference Standard*, provided for the purpose of checking equipment operation, background count, and to establish conditions for a reproducible count rate.

4.2 *Precision of Apparatus*:

4.2.1 Precision of the apparatus at 6 % (by weight) asphalt content shall be no greater than ±0.075 % asphalt for a 12-min count and no greater than ±0.15 % asphalt for a 3-min count.

4.2.2 The precision of the apparatus is determined from the slope of the calibration curve and the statistical standard deviation of the count rate. Precision is calculated as follows:

$$P = \sigma / S \tag{1}$$

where:

P = apparatus precision, in % asphalt,

σ = standard deviation, in counts per automatically timed period, and

S = slope, in counts per % asphalt.

The standard deviation is calculated from 20 individual automatically timed readings taken at the asphalt content of the mix being tested within ±½ % of the mix design.

4.2.3 The range of control mix should be between 2 and 14 % asphalt by weight.

4.3 *Other Apparatus*:

4.3.1 *Balance*, capable of weighing to 22 lb (10 kg), readable to 0.002 lb (1 g).

4.3.2 *Oven*, capable of heating to 350 ± 5°F (177 ± 3°C).

4.3.3 *Straightedge*, steel, approximately 18 in. (450 mm) in length.

4.3.4 *Plywood*, ¾ in. (20 mm) or heavier, or ⅜-in. (10-mm) or heavier metal plate having an area slightly larger than the sample pans.

4.3.5 Assorted spoons and mixing bowls.

5. Precautions

5.1 The equipment shall be so constructed as to be licensable in accordance with applicable health and safety regulations.

5.2 Equipment operators should wear an approved form of radiation dosimetry (for example, film badges) capable of monitoring the occupational radiation exposure.

5.3 Since this output of equipment measures the total amount of hydrogen in the sample, it is sensitive to changes in moisture content. It must be remembered that both asphalt and water contain hydrogen.

5.4 Keep any other source of neutron radiation at least 25 ft (8 m) from the equipment. Do not place the equipment where large amounts of hydrogenous material may be moved during the calibration or testing procedures (for example, water or plastic materials).

6. Sampling

6.1 Obtain random samples of aggregates in accordance with Method D 75.

6.2 Obtain random samples of the freshly produced bituminous paving mixture in accordance with Method D 979.

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[1] This method is under the jurisdiction of ASTM Committee D-4 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.25 on Analysis of Bituminous Mixtures.

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[2] *Annual Book of ASTM Standards*, Vol 04.03.

7. Preparation of Test Sample

7.1 The sample portion to be tested should provide at least 13.25 lb (6 kg) per test unit.

7.2 The test sample should be placed in the sample holder by the same method used for the preparation of the calibration samples.

7.3 The test sample must be checked for moisture content in accordance with the provisions of Method D 1461. If any moisture is present, the percentage determined must be subtracted from the apparent asphalt percentage as indicated by the nuclear method. Alternatively, the sample may be dried to a constant mass in an oven at 230 ± 9°F (110 ± 5°C), thereby nullifying the need for a moisture correction.

8. Calibration

8.1 The method is sensitive to the type of aggregate, percentage and source of asphalt, and to the mix gradation. Accordingly, a calibration curve must be developed for each mix type. The curve can be established with three points, one of which is at zero asphalt content. The zero point is most easily measured on a hot bin sample of the aggregate, although stockpile samples (dried to constant weight) may be used (Note 1). A new calibration curve must be developed whenever there is a change in the source of asphalt or aggregate, or a significant change in aggregate gradation. The zero point should be checked at least once daily or whenever there is reason to suspect fluctuation in aggregate moisture content. The recommended procedure for developing the calibration curve is as follows:

NOTE 1—This method may not be applicable to dryer drum plants due to the difficulty of obtaining heated aggregate samples.

8.1.1 Sample the hot bins of the plant in accordance with 6.1 and blend the aggregates in the proper proportions (Note 1). (Enough aggregate should be obtained for three samples. Approximately 44 lb (20 kg) total will be required.)

8.1.2 Fill the sample pan to overflowing with the dry aggregate. Lift the pan above a flat surface and drop it several times to ensure that it is compacted. Using the straightedge, carefully level the top of the aggregate sample until it is even with the top edges of the sample pan. Weigh and record the dry aggregate sample weight.

8.1.3 Test the hot blended aggregate to establish the zero percent asphalt content point as described in 9.3. This zero asphalt point is used to determine changes in moisture content on a day-to-day basis.

8.1.4 Mix two samples with an asphalt sample drawn from the plant tank that are at approximately +1 % and −1 % of the design asphalt content.

8.1.5 Select samples of the two mixtures of the same weight as used for the dry aggregate calibration sample. Divide each into approximately equal portions. Place the first portion in the sample pan and, using a trowel or spatula, spade 20 to 30 times around the perimeter to minimize voids between the sample and edges of the pan. Place the second portion in the sample pan and repeat the spading procedure. Level the asphalt mixture that is above the top of the sample pan, using a straightedge or trowel. Use the metal plate or plywood to compact the asphalt mixture until it is even with the top edges of the sample pan.

8.1.6 Alternatively, place the sample pans containing the asphalt mixture in the instrument and determine the gage counts for the samples, using the procedure described in 8.1.3 for the dry aggregate.

8.1.7 Prepare a calibration curve by plotting the two asphalt sample readings versus asphalt content on a piece of linear graph paper, choosing convenient scale factors for counts and asphalt content. Connect the two points with a straight line. The line may be extended to cover a wider range of asphalt contents.

8.1.8 Repeat the calibration procedure for each mix that is expected to be run that day.

8.1.9 The procedure should require approximately 1 h to develop a full set of calibration curves, and routine control testing may commence immediately once the calibration curves are established.

9. Standardization of Apparatus

9.1 All nuclear testing devices are subject to long-term aging of the radioactive source, detectors, and other electronic systems, which may change the relationship between count rate and asphalt content. To offset this aging, all instruments are calibrated as a ratio of the measurement count rate to a count rate made on a reference standard. The reference count rate should be in the same order of magnitude or higher than the range of measurement count rates over the useful asphalt content range of the equipment.

9.2 Standardization of equipment on a reference standard is required at the start of each day's use and a permanent record of this data must be retained.

9.3 Turn on the equipment and allow for stabilization of the equipment in accordance with the manufacturer's recommendations.

9.4 Take at least four repetitive readings on the reference standard timed at the normal measurement period and obtain the mean. If available on the instrument, one measurement at a period of four times the normal period is acceptable instead of the four individual measurements. This constitutes one standardization check.

NOTE 2—Some manufacturers may build reference standards into their equipment. When this equipment is used, follow the manufacturer's procedures for the standardization.

9.5 If the value obtained above is within the limits set by Eq 2, the equipment is considered to be in satisfactory condition and may be used. If the value obtained is outside the limits set by Eq 2, another standardization check should be made. If the second standardization check is within the limits, the equipment may be used. If the second standardization also fails the test, the equipment should be checked in accordance with the manufacturer's recommendations.

$$N_s = N_o \pm 1.96 \sqrt{N_o/PC} \quad (2)$$

where:

N_s = value of current standardization check on the reference standard,

N_o = average of the past four values of N_s taken for prior usage, and

PC = amount of prescale applied to the detector counts prior to display. The manufacturer will supply this value. If no prescale is built into the equipment, the value is 1.

9.6 The value of N_s will be used to determine the count ratios for the current day's use of the equipment. If, for any reason, measured asphalt contents become suspect during the day's use, another standardization check should be performed.

NOTE 3—If the instrument is to be used either continuously or intermittently during the day, it is generally best to leave it in the "power on" condition during the day to prevent having to repeat the standardization check. This will provide more stable and consistent results.

10. Procedure

10.1 Follow the manufacturer's instructions for operation of the equipment and the sequence of operation.

11. Report

11.1 The report shall include the following:

11.1.1 Make, model, and serial number of the equipment,

11.1.2 Name of operator,

11.1.3 Identification of asphalt and aggregate materials,

11.1.4 Type of mix and specified asphalt content,

11.1.5 Calibration data and daily checks,

11.1.6 Count rate for each sample and the converted asphalt content, and

11.1.7 Weight of sample, method of sampling, and method of compaction.

12. Precision

12.1 The precision of this method is under investigation.

APPENDIX E

REFERENCES

1. ASTM test method D-4125-83.
2. Troxler 3241-B Asphalt Content Gauge Instruction Manual.
3. CPN AC-2 Asphalt Content Gauge Operation Manual.