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AN EVALUATION OF THE TROXLER 3241-B NUCLEAR ASPHALT GAUGE

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INTRODUCTION:

The Troxler 3241-B Asphalt Content Gauge is intended for rapidly determining the bitumen content of bituminous paving mixtures. A 300 Millicurie Americuium 241: Beryllium source emitts neutrons which are affected by the hydrogen in the mix. The affected neutrons are detected by Helium 3 detectors, counted and computed into a percentage bitumen of the asphalt mix.

The current methods of determining the bitumen content of bituminous paving mixtures requires the use of potentially hazardous chemicals and several hours of testing time. When extracted aggregates are not needed, determination of the bitumen content of a paving mixture by the nuclear method may be easier, quicker and potentially safer.

OBJECTIVE:

The objective of the project is to study the accuracy of the Troxler 3241-B Nuclear Asphalt Content Gauge in measuring the asphalt cement (AC) content of asphalt concrete mixtures produced with different asphalt cements and different aggregates.

EQUIPMENT AND PROCEDURES:

Some of the features listed by the manufacturer of the nuclear gauge are:

1. Meets all requirements of ASTM D4125-83, "Asphalt Content of Bituminous Mixtures by the Nuclear Method."

2. Precision is $\pm$0.050% asphalt for a 4 minute measurement of a 6.0% AC Mixture.

3. Range of sample temperatures is 0^0F to 350^0F.

4. Stores up to 45 different calibrations for different mixes.

5. Contains a temperature compensation program for adjusting data from the sample temperature to the calibration temperature.

6. Calculates and displays AC content.

7. Calibrations on mixes may be transferred to other 3241-B gauges.

To determine AC contents, the gauge must first be calibrated with samples of mixes using the same materials with known but different AC contents. Calibration can be done with only two samples or as many as eight samples. The sample weight for testing is about 7000 grams. Test samples must be of the same weight as the calibration samples to obtain a correct reading.

Sample mix is placed in the sample pan immediately after mixing to avoid cooling. The 7000 grams are placed in the sample pan in three or four layers. Only light tamping is required to level the mix to the top edge of the pan. The pan is placed in the gauge for testing. Calibration samples are tested for 16 minutes and test samples are tested for either 1, 4, 8 or 16 minutes.

STUDY VARIABLES:

The following variables were studied to determine the effects on the calibrations and gauge readings:

1. Asphalt Cements
    a. Asphalt source
    b. Asphalt grade

2. Aggregates
    a. Aggregate sources
    b. Aggregate blend variation

3. Temperature
    a. Test temperature
    b. Exposure to extended high temperature

4. Precision

MATERIALS:

Asphalts

AC-5	Koch Asphalt	(Pine Bend)	AB5-272
AC-10	Koch Asphalt	(Pine Bend)	AB5-273
AC-20	Koch Asphalt	(Pine Bend)	AB5-274
AC-5	Shell Oil	(Wood River)	AB5-267
AC-10	Shell Oil	(Wood River)	AB5-268
AC-20	Shell Oil	(Wood River)	AB5-312

Aggregates

Mix #1	60% 1/2"crushed limestone (Ames Mine)	AAT5-1207
	40% sand (Christensen Pit)	AAT5-1251
Mix #2	100% 3/4" gravel (Soper's Mill)	AAT5-0711
Mix #3	35% 5/8" quartzite (Sioux Falls Quart.)	AAT5-1278
	25% 1/2" quartzite (Sioux Falls Quart.)	AAT5-1279
	40% 1/2" gravel (Doon Pit)	AAT5-1280

TESTING:

Eighteen calibrations and 216 tests were conducted during the winter of 1985-1986, to determine the effects of different asphalt cements, different aggregates and different temperatures, as well as to determine the precision of the gauge.

Asphalt Cement Effects:

The six asphalt cements were mixed with aggregate mix #1 (limestone-sand) and tested. A 16 minute count test was run on each asphalt cement mix with a 4.5% and 6.5% asphalt content (Table 1) and plotted as calibration curves (Figure 1 and 2).

TABLE 1
AC Grade and Source Effect on Gauge Reading
Gauge Counts

	KOCH		SHELL	
	4.5% AC	6.5% AC	4.5 AC	6.5% AC
AC-5	2245	2738	2222	2704
AC-10	2236	2684	2228	2671
AC-20	2221	2683	2210	2678

A difference of 10 counts on the nuclear gauge is equal to a difference of about 0.04% AC content. Using the Koch AC-10 as the calibration curve for the other gauge counts, the count of 2210 for the shell AC-20 would register as 4.40% asphalt cement (0.10% low) and the count of 2738 for the Koch AC-5 would register as 6.72% asphalt cement (0.22% high).

Aggregate Effects:

The three aggregate mixes were combined with Koch AC-10 at 4.5% and 6.5% AC content. A 16 minute count was run on each mix and plotted as a calibration curve (Figure 3). Using the quartzite/gravel mix as the calibration curve for the other gauge counts, the lower count of the gravel mix would register as 4.65% asphalt cement (0.15% high) and the upper count of the limestone/sand mix would register as 6.24% asphalt cement (0.26% low).

The 60%/40% limestone-sand combination was varied from a 70%/30% blend to a 50%/50% blend at 5.4 percent AC content. The average AC content readings were 5.37% for a 50%/50% blend, 5.36% for a 60%/40% blend, and 5.34% for a 70%/30% blend. Variations in the aggregate blends do not appear to cause much change in the gauge readings.

Temperature Effects:

The gravel aggregate mix was calibrated at 250^{0}F, 190^{0}F, and 75^{0}F to determine the temperature effect on the gauge count. Figure 4 is a plot of 16 minute count calibrations run at 4.5% and 6.5% AC content of Koch AC-10. Temperature differences of the test sample do produce different counts for the same AC content. The gauge contains a temperature compensation program to adjust the gauge reading at the test temperature to the proper reading at the calibration temperature.

Samples of the Koch, Shell and Amoco AC-10 and the 60/40 limestone-sand at 5.4% AC content were heated for an extended period to study the effect. After initial content testing the samples were heated for 4 hours at 235^{0}F. The samples were again tested, allowed to cool and then heated for 8 hours at 275^{0}F. Final testing was conducted at the 275^{0}F temperature and then at room temperature. Table 2 is the results of that testing. The extended heating of the samples did cause a 0.07 to 0.09 percent lower AC content reading on the gauge. The decrease was observed only after 8 hours of heating at 275^{0}F.

TABLE 2
Temperature Effects on AC Reading
Change in Asphalt Content From Initial Reading (%)

		After 4 Hours @ 235^{0}F.	After Additional 8 hours @ 275^{0}F	After heating test at 75^{0}F
Koch	1	-0.02	-0.09	-0.09
	2	+0.02	-0.08	-0.10
	3	-0.03	-0.04	-0.05
	4	-0.02	-0.07	-0.11
	5	-0.06	-0.12	-0.07
Shell	1	+0.04	0	-0.08
	2	-0.01	-0.13	-0.05
	3	-0.05	-0.09	-0.09
	4	+0.08	-0.08	-0.15
	5	-0.03	-0.05	-0.14
Amoco	1	-0.03	-0.01	-0.12
	2	-0.02	-0.14	-0.07
	3	+0.04	+0.05	-0.11
	4	+0.01	-0.08	-0.06
	5	+0.03	-0.08	-0.12
Avg.		0.00	-0.07	-0.09

Precision:

Twelve test samples of 60%/40% limestone-sand with 5.4% Koch AC-10 were tested with a 4 minute count at the same temperature. The precision was ± 0.049% asphalt content. ASTM D4125-83 requires the gauge precision, "...at 6% (by weight) asphalt content shall be no greater than ± 0.075% asphalt for a 12 minute count and no greater than ± 0.15% asphalt for a 3 minute count.," based on 20 individual readings.

DISCUSSION AND SUMMARY:

The 18 calibration curves performed during the study are in Table 3. The intercepts of the lines are different, but the slopes appear to vary only slightly. When the intercepts are ignored and the calibration curves with the largest and smallest slope are plotted through 5.5% asphalt cement content, the close relationship of the curves can be seen (Figure 5) (curve #2 and #17 were omitted because of the low calibration temperature.) The difference of the two curves at 6.5% and 4.5% asphalt cement content is only 0.10% asphalt cement content. If the spread of these calibration curves covers the various combination of materials and mixes in Iowa, then a one point calibration system could be established, similar to the moisture density system in I.M. 309. A single sample would be mixed at the recommended asphalt cement content, tested and the results entered on a chart. The curve closest to that point would be the calibration curve used throughout the project for that mix.

The following was observed from testing when single variables were isolated:

1. The 3 different asphalt cement grades and the 2 different asphalt cement sources produced only minor differences in gauge reading. The largest variation was -0.10% to +0.22% asphalt cement content.

2. The 3 different aggregate combination produced minor differences in gauge reading. The largest variation was -0.26% to +0.15% asphalt cement content.

3. A 10%± variation in the aggregate blend produced insignificant variation in the gauge readings.

4. Extended heating of mixes, (8 hours or more) especially at 275^{0}F or above, will produce a lower gauge reading.

5. Precision of the instrument as measured by a limited number of readings within ASTM Standards.

The Troxler 3241-B Asphalt Content Gauge appears to be a rapid, safe method for determining AC content of mixes. Precision of the current methods (ASTM D2172-81 Quantitative Extraction of Bitumen from Bituminous Paving Mixtures) should not differ by more than 0.52% asphalt for tests on the same batch by the same operator. The nuclear method appears to be well within that limit, even with a one point calibration. The nuclear method does not provide extracted aggregate for gradation determination. However, should Iowa change gradation control on projects from extracted gradation to cold feed gradation, nuclear gauge testing could replace much of our current extraction work.

TABLE 3
CALIBRATION CURVES

Calibration	Slope(%/count)	Intercept(%)	Agg. #	Asphalt	Temperature
1	0.00406	-4.61	1	Koch AC-5	210^{0}
2	0.00407	-4.63	1	Koch AC-5	230^{0}
3	0.00388	-4.28	1	Koch AC-10	75^{0}
4	0.00446	-5.48	1	Koch AC-20	200^{0}
5	0.00433	-5.11	1	Koch AC-20	210^{0}
6	0.00423	-4.83	1	Koch AC-20	230^{0}
7	0.00422	-4.79	1	Koch AC-20	210^{0}
8	0.00414	-4 76	1	Koch AC-20	75^{0}
9	0.00440	-5.22	1	Koch AC-20	250^{0}
10	0.00415	-4.72	1	Shell AC-5	210^{0}
11	0.00418	-4.80	1	Shell AC-5	230^{0}
12	0.00451	-4.72	1	Shell AC-10	220^{0}
13	0.00427	-4.94	1	Shell AC-20	200^{0}
14	0.00425	-4.94	1 (70%/30%)	Koch AC-10	190^{0}
15	0.00412	-4.96	2	Koch AC-10	190^{0}
16	0.00420	-5.09	2	Koch AC-10	250^{0}
17	0.00400	-4.71	2	Koch AC-10	75^{0}
18	0.00407	-4.70	3	Koch AC-10	185^{0}

RECOMMENDATION:

In the event that Iowa changes gradation control on asphalt projects from extracted gradation to cold feed gradation, nuclear asphalt content gauges should be purchased for use in each of the districts. The estimated cost is $6,700. per unit

FURTHER TESTING:

Assurance samples from 1986 projects are being tested by both the extraction method and the nuclear method as time permits to obtain more data. In addition, it would be desirable to verify the precision of the gauge according to ASTM D4125-83. If nuclear asphalt gauges are purchased for routine testing, the practicality of using a one point calibration system should be investigated.

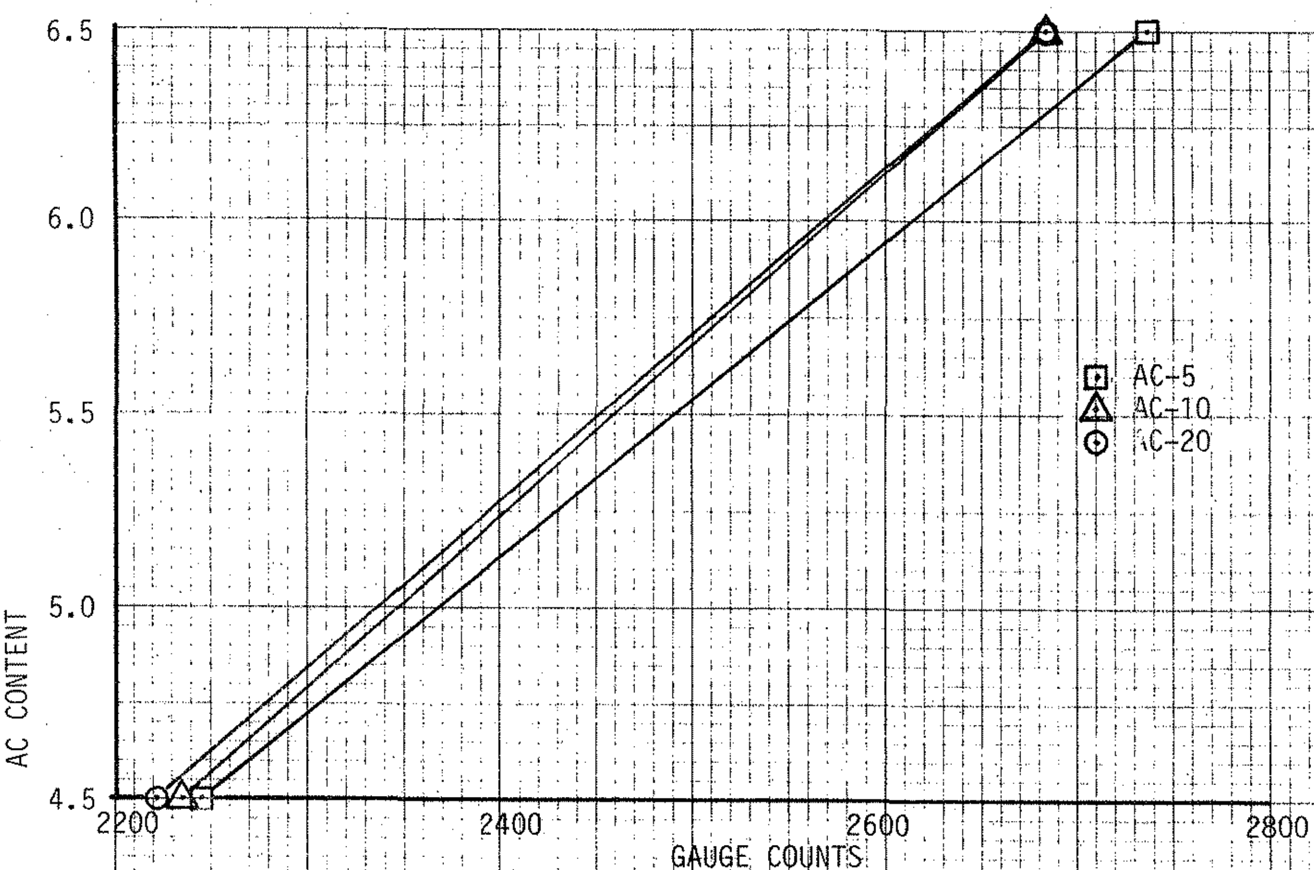

FIGURE 1 ASPHALT CEMENT EFFECT (Koch)

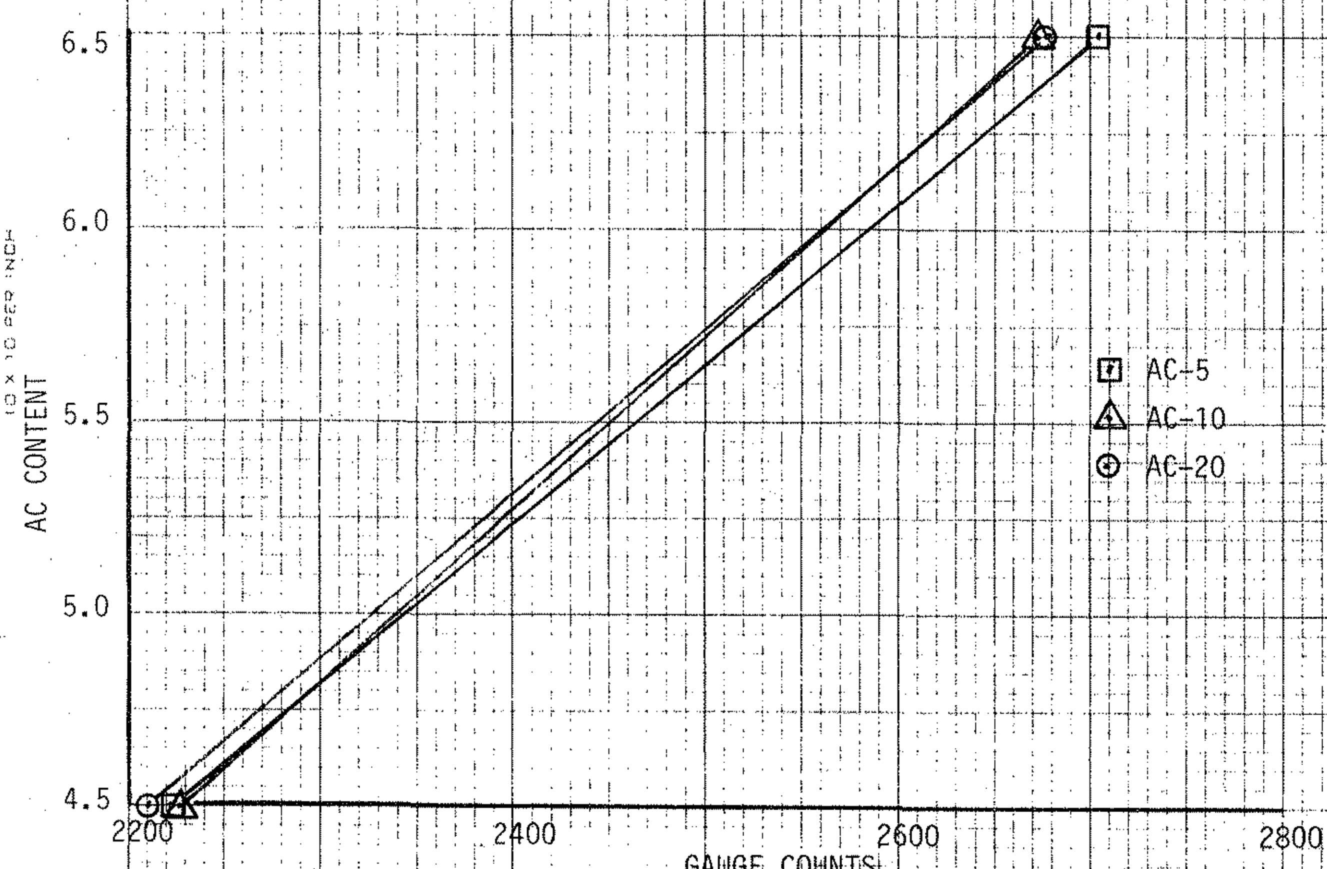

FIGURE 2 ASPHALT CEMENT EFFECT (Shell)

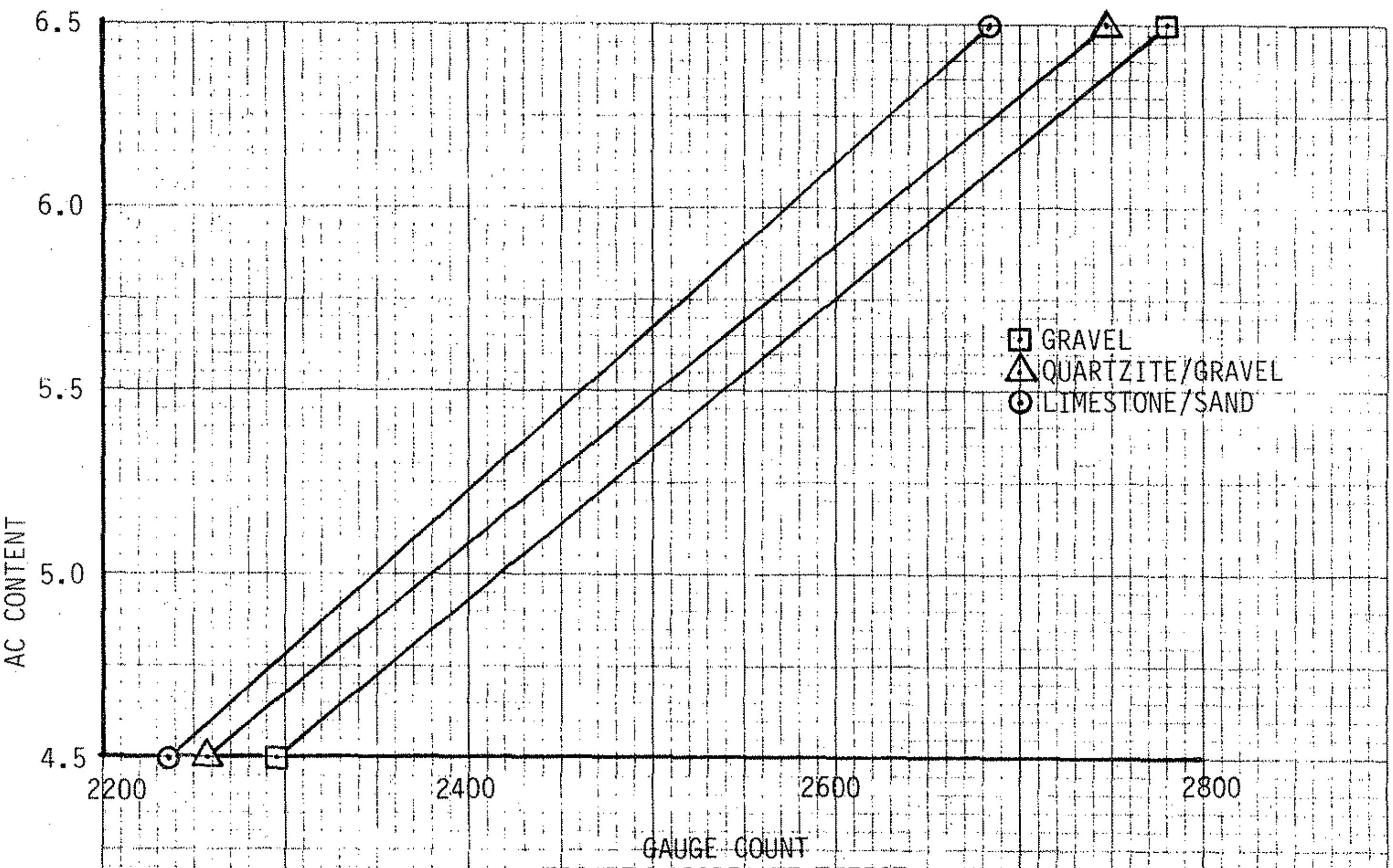

FIGURE 3 AGGREGATE EFFECT

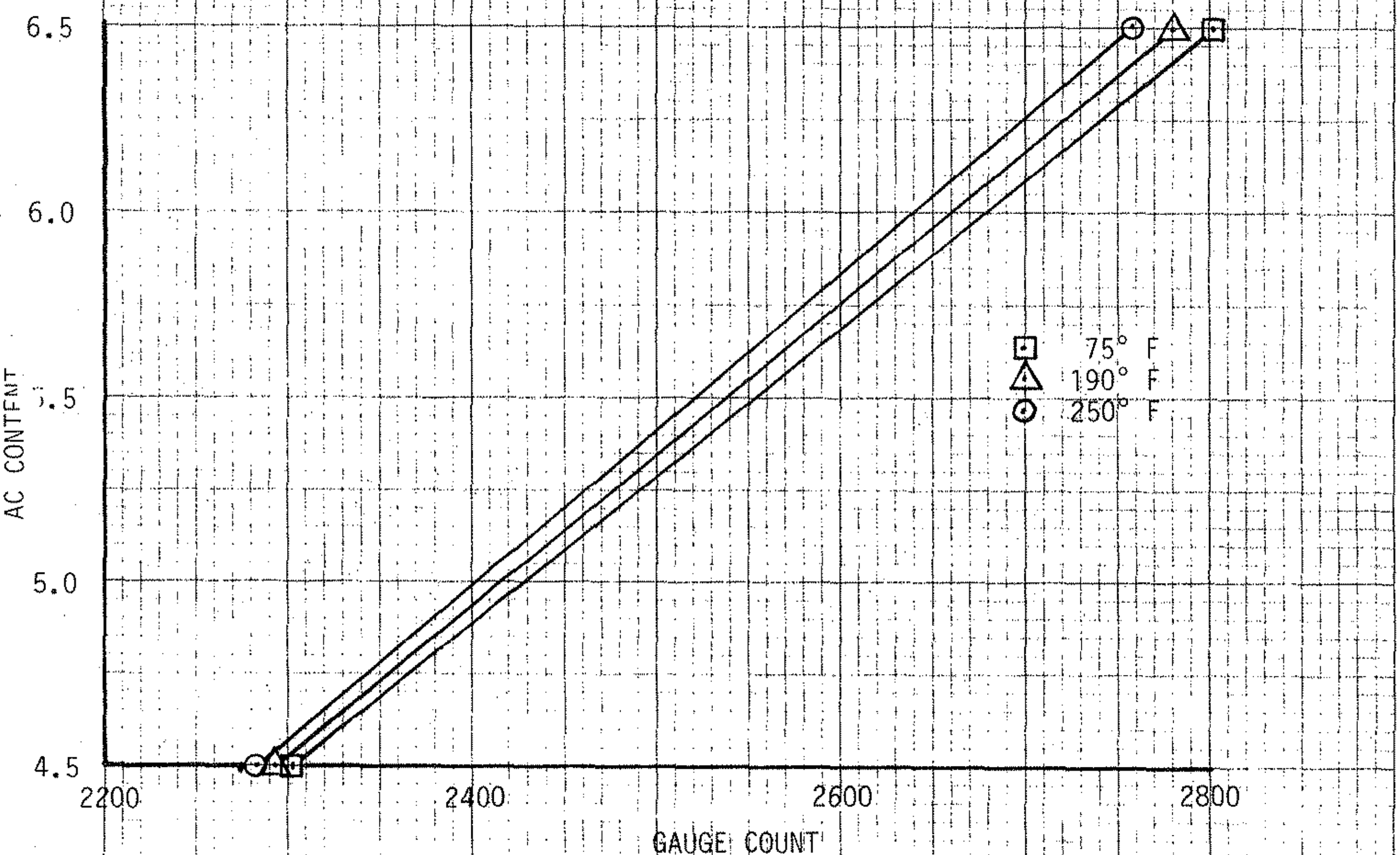

FIGURE 4 TEMPERATURE EFFECT

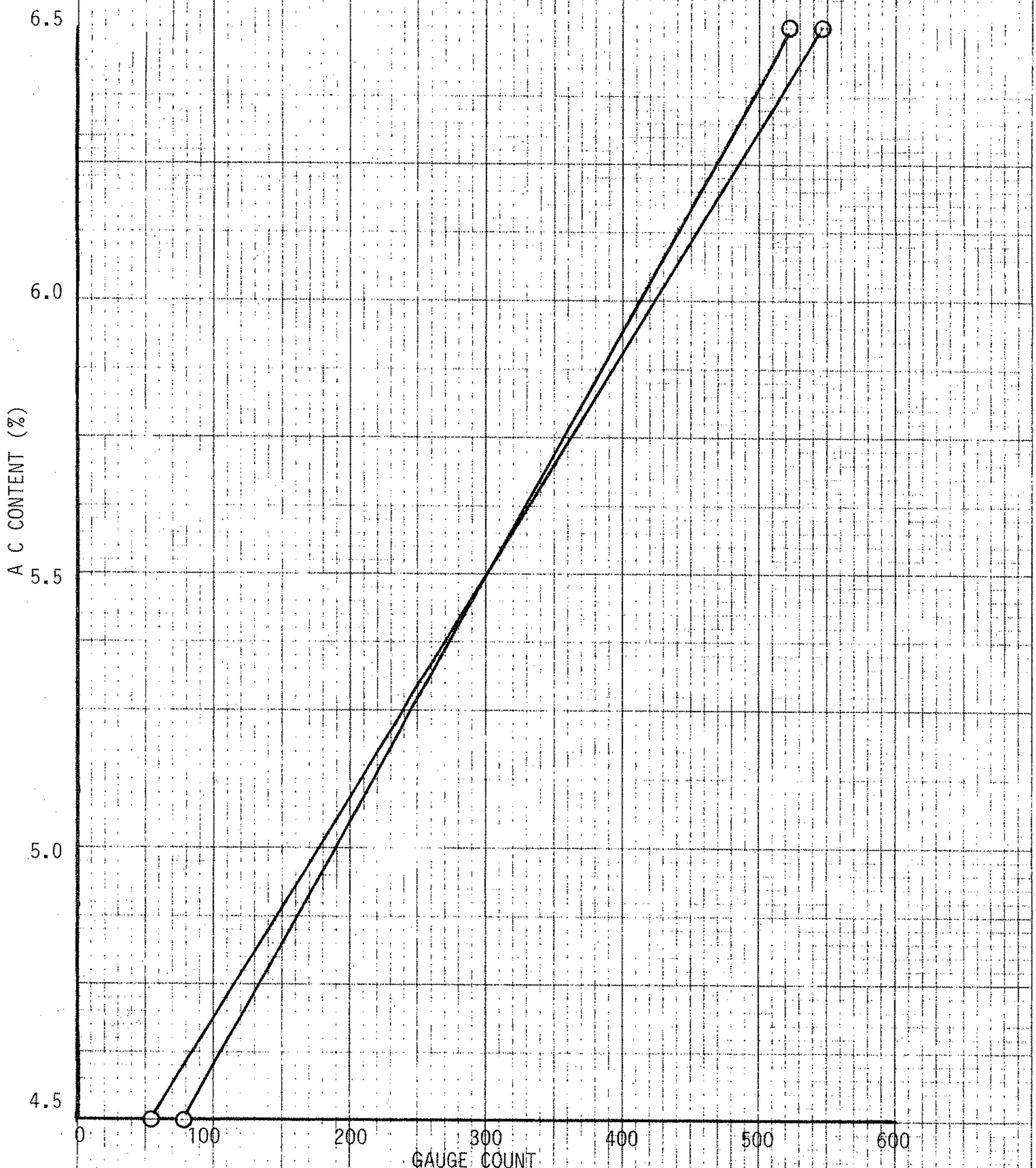

FIGURE 5. CALIBRATION CURVES PLOTTED WITHOUT REGARD TO INTERCEPTS