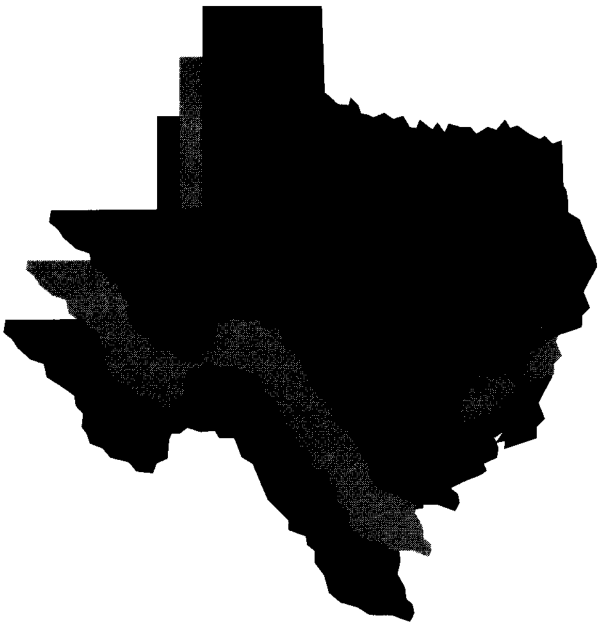
USING IGINITION OVENS TO DETERMINE APHALT CONTENT AND TO PREPARE AGGREGATES FOR SIEVE ANALYSIS

DHT-39



DEPARTMENTAL RESEARCH

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DHT-39		

4. Title and Subtitle	5. Report Date / 6. Performing Organization Code
USING IGNITION OVENS TO DETERMINE ASPHALT CONTENT AND TO PREPARE AGGREGATES FOR SIEVE ANALYSIS	5. Report Date: November 1996 6. Performing Organization Code:
7. Author(s) Robert E. Lee, P.E., and Maghsoud Tahmoressi, P.E., Materials and Tests Division	8. Performing Organization Report No. Research Report DHT-39
9. Performing Organization Name and Address Texas Department of Transportation Materials and Tests Division 39th and Jackson, BLDG 5 Austin, Texas 78731	10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Transfer Office P. O. Box 5080 Austin, Texas 78763-5080	13. Type of Report and Period Covered DHT 14. Sponsoring Agency Code

15. Supplementary Notes

This in-house research study was performed by the MAT Bituminous Section

16. Abstract

The Materials and Tests Division's Bituminous Section evaluated the ignition method as an alternative to the solvent method for determining asphalt content. Three ovens (the Gilson Asphalt Binder Ignition furnace, Model HM 378; the NCAT Asphalt Content Tester; and the Troxler Asphalt Quality) were evaluated for accuracy, precision, and performance.

Ignition was proven to be an appropriate method of determining asphalt content. The test procedure resulting from this work is Tex-236-F, which is included in Appendix A.

17. Key Words	18. Distribution Statement
asphalt content, sieve analysis, ignition oven, Tex-236-F	No restrictions. This document is available to the public through the Texas Department of Transportation Research Library, P.O. Box 5080, Austin, TX, 78763-5080.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	42	

USING IGINITION OVENS TO DETERMINE ASPHALT CONTENT AND TO PREPARE AGGREGATES FOR SIEVE ANALYSIS

RESEARCH REPORT DHT-39

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Bituminous Section

Texas Department of Transportation

November 1996

INTRODUCTION

In 1995, the Bituminous Section of the Materials and Tests Division evaluated the ignition method as an alternative for determining asphalt content. The objectives of the study were:

1. Determine the accuracy and precision of the ignition method.
2. Evaluate the performance of several different ovens.
3. Prepare a test procedure for using the ignition ovens.

The ignition ovens used for the project were the Gilson Asphalt Binder Ignition Furnace, Model HM 378, the NCAT Asphalt Content Tester, and the Troxler Asphalt Quality Analyzer, Model 4155.

MATERIALS

This study consisted of testing five different mixtures. The aggregate types and corresponding mixture types are listed in Table 1.

TABLE 1: Materials

Aggregate Type	LA Abrasion	Soundness	Mixture Type
Soft Limestone	33	38	C
Hard Limestone	30	24	D
Sandstone	26	14	C
Siliceous	22	3	D
Limestone Rock Asphalt	36	28	CC

The asphalt type used was Texas Fuel & Asphalt AC-20, except for the LRA mixture, in which AC-3 and flux oil were used.

SCOPE

This study was divided into two parts. The first part involved igniting aggregate samples (for approximately 40 minutes) to determine aggregate degradation characteristics and loss of fines. The second part involved testing bituminous samples and comparing AC content and gradation.

PART I — Gradation Check with Aggregate Only
Check for Aggregate Degradation and Loss in Aggregate
Weight Caused by Ignition

PART II — Evaluate the Accuracy of Asphalt Content Determination
and Gradation of Resulting Aggregates

EXPERIMENT DESIGN

For each mixture type, nine samples were prepared. Three samples contained 0.5 percent less asphalt than optimum (Low AC), three samples contained 0.5 percent more asphalt than optimum (High AC), and three samples were kept as blank samples with no asphalt. All samples were 1400 grams, except for samples used in the Gilson oven. Gilson oven samples were 2000 grams based on manufacturer's recommendations. Experiment design is shown in Table 2.

TABLE 2: Experiment design.

Mix	Low AC	High AC	No AC
Limestone Type C	3	3	3
Limestone Type D	3	3	3
Sandstone Type C	3	3	3
Siliceous	3	3	3
LRA Type CC	3	3	3

TESTING PROGRAM

Each aggregate type was oven dried and separated into individual sieve sizes to meet the desired gradation. The gradations are shown in Table 3. The approximate batch weight of each aggregate sample was 2000 grams for the Gilson oven and 1400 grams for the NCAT and Troxler ovens. Nine samples were weighed up for each aggregate type. Three samples were mixed with the asphalt content one-half percent above optimum, three samples were mixed with the asphalt content one-half percent below optimum, and three samples had no asphalt added to them. The blank samples were used to determine actual gradation, aggregate loss, and degradation characteristics of the aggregate types.

TABLE 3: Aggregate gradations.

Sieve	Limestone Type C	Limestone Type D	Sandstone Type C	Siliceous	LRA Type CC
5/8"	100		99.1		
1/2"					
3/8"	80.2	99.4	76.2	92.5	99.2
#4	54.6	61.6	61.6	65.4	57.5
#10	33.8	36.3	39.1	35.9	40.5
#40	16.1	15.1	19.1	18.2	25.5
#80	6.3	6.2	8.1	10.7	14.5
#200	3.7	1.0	5.0	6.6	6.5
AC Content	4.2 5.2	4.5 5.5	4.0 5.0	4.0 5.0	2.3 3.3

DISCUSSION OF RESULTS

The results of the study are shown in Tables 4 through 8 and Figures 1 through 6. Figures 1 through 3 compare the job mix formula (JMF) with the average results obtained after ignition for each oven tested. Figure 1 compares AC content, Figure 2 compares the percent passing the #10 sieve, and Figure 3 compares the percent passing the #200 sieve. These figures show there to be no significant difference between the ovens tested. The results from Figures 1 through 3 allowed the data from all three ovens tested for each type of aggregate to be combined and averaged. These results are shown in Tables 4 through 8. Figures 4 through 6 show several different comparisons from the data in Tables 4 through 8. To characterize the amount of aggregate degradation caused by ignition, we added the absolute value of differences between gradation of ignited and nonignited samples for each sieve. The higher the sum of the absolute value of the differences, the higher the degradation. Figure 4 compares the low AC content samples to the high AC content samples. There was no significant trend comparing the low AC content samples to the high AC content samples. Figure 5 compares the aggregate-only samples to mixture samples. The aggregate-only samples degraded less in the limestone aggregates and more in the harder aggregates than the mixture samples. Figure 6 compares the unwashed sieve analysis to the washed sieve analysis. The washed sieve analysis samples showed less degradation than the unwashed sieve analysis samples. The overall results show the procedure to be accurate in determining AC content and to indicate a definite trend as to how the aggregates degrade in the oven. All the aggregates tend to degrade very slightly on the top side (5/8," 1/2," 3/8"), are fairly consistent in the middle (#4, #10), with most degradation occurring on the low side (#40, #80, #200). In most cases, the degraded aggregate shows up passing the #80 sieve, the #200 sieve, or a combination of the two. The LRA Type CC mixture degraded much more than the other mixtures, with most of the degradation occurring on the #10 sieve.

TABLE 4: Comparison of aggregate gradations for ignited and nonignited samples of soft limestone.

Aggregate Only

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	81.7	81.9	-0.2	81.3	82.3	-1.0
#4	57.5	58.6	-1.1	57.5	58.9	-1.4
#10	34.5	35.3	-0.8	33.9	35.5	-1.6
#40	17.3	17.8	-0.5	16.9	18.2	-1.3
#80	6.8	9.0	-2.2	7.3	9.4	-2.1
#200	4.4	6.9	-2.5	6.8	7.3	-0.5
	Sum of Absolute Values		7.3	Sum of Absolute Values		7.9

Mixture

Target AC 4.20% Measured AC 4.36%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8	100.0	100.0	0.0	100.0	100.0	0.0
3/8	81.7	81.7	0.0	81.3	82.0	-0.7
#4	57.5	57.7	-0.2	57.5	58.3	-0.8
#10	34.5	34.6	-0.1	33.9	35.1	-1.2
#40	17.3	17.7	-0.4	16.9	18.4	-1.5
#80	6.8	8.6	-1.8	7.3	10.0	-2.7
#200	4.4	4.8	-0.4	6.8	6.9	-0.1
	Sum of Absolute Values		2.9	Sum of Absolute Values		7.0

Mixture

Target AC 5.20% Measured AC 5.29%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8	100.0	100.0	0.0	100.0	100.0	0.0
3/8	81.7	83.7	-2.0	81.3	82.0	-0.7
#4	57.5	60.2	-2.7	57.5	58.1	-0.6
#10	34.5	37.0	-2.5	33.9	35.1	-1.2
#40	17.3	19.8	-2.5	16.9	18.5	-1.6
#80	6.8	9.7	-2.9	7.3	10.1	-2.8
#200	4.4	5.3	-0.9	6.8	6.9	-0.1
	Sum of Absolute Values		13.5	Sum of Absolute Values		7.0

TABLE 5: Comparison of aggregate gradations for ignited and nonignited samples of hard limestone.

Aggregate Only

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	99.5	99.5	0.0	99.7	99.6	0.1
#4	66.0	66.2	-0.2	66.4	66.6	-0.2
#10	36.7	37.2	-0.5	36.9	37.3	-0.4
#40	14.5	15.6	-1.1	14.6	15.7	-1.1
#80	6.9	8.2	-1.3	7.0	8.0	-1.0
#200	1.0	1.6	-0.6	1.6	2.4	-0.8
	Sum of Absolute Values		3.7	Sum of Absolute Values		3.3

Target AC 4.50% **Mixture** Measured AC 4.59%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	99.5	99.4	0.1	99.7	99.5	0.2
#4	66.0	65.9	0.1	66.4	66.3	0.1
#10	36.7	37.1	-0.4	36.9	36.8	0.1
#40	14.5	16.9	-2.4	14.6	17.7	-3.1
#80	6.9	8.3	-1.4	7.0	8.3	-1.3
#200	1.0	1.9	-0.9	1.6	2.4	-0.8
	Sum of Absolute Values		5.3	Sum of Absolute Values		5.6

Target AC 5.50% **Mixture** Measured AC 5.45%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	99.5	99.5	0.0	99.7	99.4	0.3
#4	66.0	65.7	0.3	66.4	66.1	0.3
#10	36.7	37.4	-0.7	36.9	36.7	0.2
#40	14.5	15.7	-1.2	14.6	15.5	-0.9
#80	6.9	8.5	-1.6	7.0	9.0	-2.0
#200	1.0	2.0	-1.0	1.6	2.4	-0.8
	Sum of Absolute Values		4.7	Sum of Absolute Values		4.5

TABLE 6: Comparison of aggregate gradations for ignited and nonignited samples of sandstone.

Aggregate Only

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	98.8	98.8	0.0	98.9	99.0	-0.1
3/8"	77.7	77.9	-0.2	77.5	77.5	0.0
#4	61.9	62.3	-0.4	62.2	62.3	-0.1
#10	39.7	40.3	-0.6	40.1	40.4	-0.3
#40	20.6	22.4	-1.8	22.1	22.5	-0.4
#80	10.4	13.4	-3.1	13.1	13.8	-0.7
#200	5.4	8.2	-2.8	7.9	8.4	-0.5
Sum of Absolute Values			9.1			2.1

Mixture

Target AC 4.00% Measured AC 4.22%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	98.8	98.6	0.2	98.9	98.8	0.1
3/8"	77.7	77.4	0.3	77.5	78.2	-0.7
#4	61.9	61.9	0.0	62.2	62.1	0.1
#10	39.7	39.9	-0.2	40.1	40.2	-0.1
#40	20.6	21.1	-0.5	22.1	22.0	0.1
#80	10.4	11.0	-0.6	13.1	13.1	0.0
#200	5.4	5.4	0.0	7.9	8.2	-0.3
Sum of Absolute Values			1.7			1.3

Mixture

Target AC 5.00% Measured AC 5.17%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I			Washed Sieve Analysis Tex-200-F Part II		
	Nonignited	Ignited	Difference	Nonignited	Ignited	Difference
5/8"	98.8	98.5	0.3	98.9	98.8	0.1
3/8"	77.7	77.2	0.5	77.5	76.9	0.6
#4	61.9	62.6	-0.7	62.2	62.0	0.2
#10	39.7	40.5	-0.8	40.1	40.1	0.0
#40	20.6	22.0	-1.4	22.1	22.2	-0.1
#80	10.4	11.9	-1.5	13.1	13.6	-0.5
#200	5.4	5.0	-0.4	7.9	8.1	-0.2
Sum of Absolute Values			5.6			1.6

TABLE 7: Comparison of aggregate gradations for ignited and nonignited samples of siliceous material.

Aggregate Only

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	93.1	93.8	-0.7	93.5	93.4	0.1
#4	67.9	68.1	-0.2	67.9	69.0	-1.1
#10	36.1	36.6	-0.5	36.2	37.1	-0.9
#40	18.6	19.6	-1.0	19.2	20.2	-1.0
#80	11.3	13.0	-1.7	12.5	13.8	-1.3
#200	7.1	9.4	-2.3	9.1	9.5	-0.4
Sum of Absolute Values			6.4			4.9

Mixture

Target AC 4.00% Measured AC 4.12%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	93.1	93.0	0.1	93.5	92.9	0.6
#4	67.9	68.5	-0.6	67.9	68.3	-0.4
#10	36.1	36.0	0.1	36.2	36.2	0.0
#40	18.6	19.0	-0.4	19.2	19.5	-0.3
#80	11.3	11.6	-0.3	12.5	13.1	-0.6
#200	7.1	7.1	0.0	9.1	9.6	-0.5
Sum of Absolute Values			1.5			2.4

Mixture

Target AC 5.00% Measured AC 5.05%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	93.1	93.2	-0.1	93.5	93.1	0.4
#4	67.9	67.6	0.3	67.9	68.1	-0.2
#10	36.1	36.2	-0.1	36.2	36.2	0.0
#40	18.6	18.9	-0.3	19.2	19.5	-0.3
#80	11.3	12.0	-0.7	12.5	13.2	-0.7
#200	7.1	7.2	-0.1	9.1	9.6	-0.5
Sum of Absolute Values			1.6			2.1

TABLE 8: Comparison of aggregate gradations for ignited and nonignited samples of limestone rock asphalt.

Aggregate Only

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	98.1	99.2	-1.1	98.6	99.4	-0.8
#4	64.0	75.4	-11.4	63.6	78.3	-14.7
#10	40.9	54.1	-13.2	41.2	57.2	-16.0
#40	15.1	28.1	-13.0	15.3	31.1	-15.8
#80	4.0	14.8	-10.8	5.8	16.5	-10.8
#200	0.8	8.8	-8.0	3.2	9.6	-6.4
Sum of Absolute Values			57.7			64.4

Target Flux 2.30% **Mixture** Measured AC 8.25%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	98.1	99.3	-1.2	99.7	99.4	0.3
#4	64.0	74.4	-10.4	66.4	78.2	-11.8
#10	40.9	55.3	-14.4	36.9	58.2	-21.3
#40	15.1	28.0	-12.9	14.6	33.0	-18.4
#80	4.0	12.5	-8.5	7.0	18.1	-11.1
#200	0.8	5.7	-4.9	1.6	11.0	-9.4
Sum of Absolute Values			52.3			72.3

Target Flux 3.30% **Mixture** Measured AC 9.16%

Sieve Size	Unwashed Sieve Analysis Tex-200-F Part I: Nonignited	Ignited	Difference	Washed Sieve Analysis Tex-200-F Part II: Nonignited	Ignited	Difference
5/8"	100.0	100.0	0.0	100.0	100.0	0.0
3/8"	98.1	99.2	-1.1	99.7	99.4	0.3
#4	64.0	73.7	-9.7	66.4	76.9	-10.5
#10	40.9	54.4	-13.5	36.9	57.4	-20.5
#40	15.1	27.1	-12.0	14.6	32.1	-17.5
#80	4.0	12.4	-8.4	7.0	17.3	-10.3
#200	0.8	5.9	-5.1	1.6	10.3	-8.7
Sum of Absolute Values			49.8			67.8

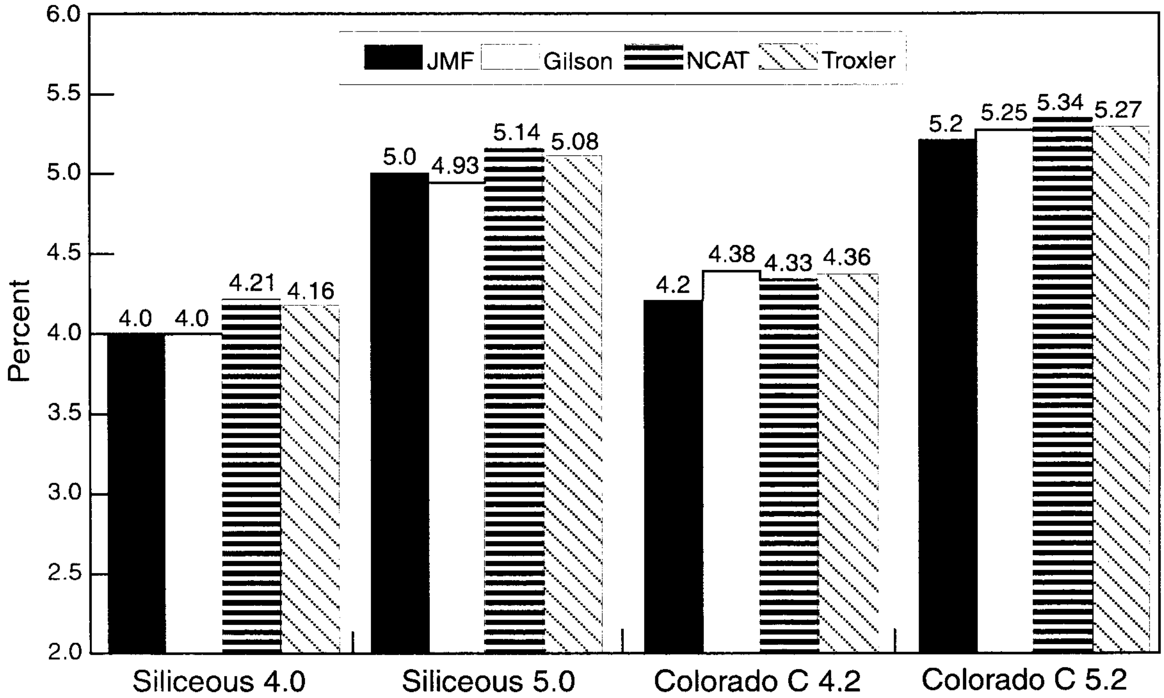

FIGURE 1: Comparison of asphalt content from all ovens.

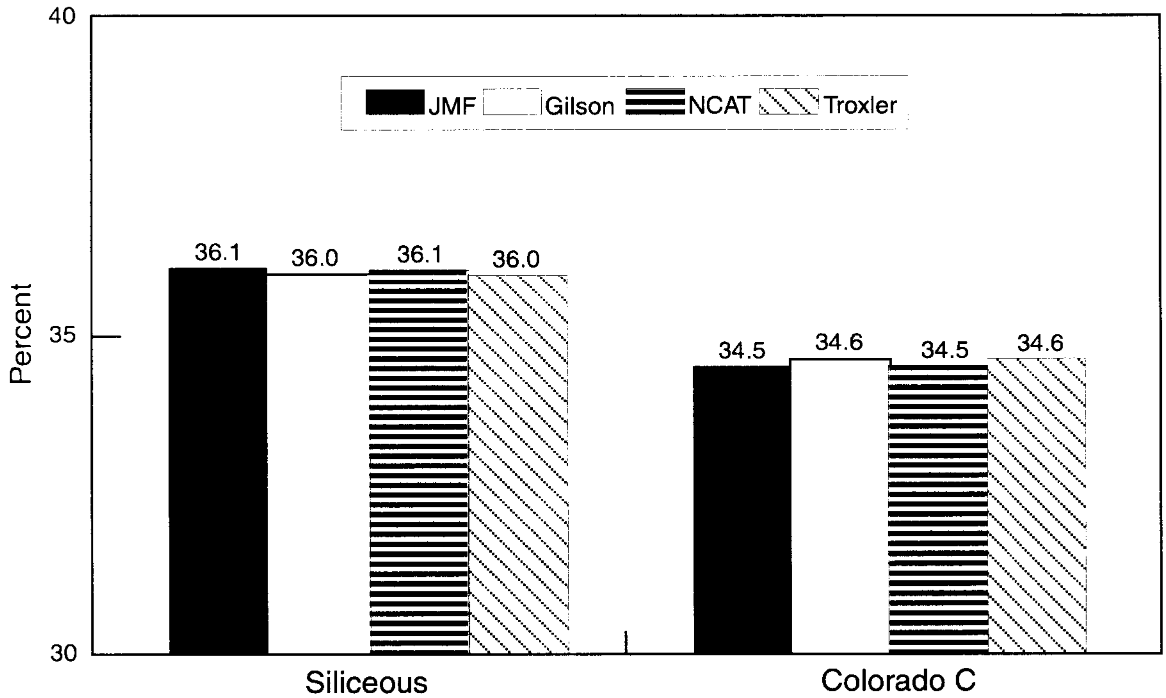

FIGURE 2: Comparison of percent passing #10 sieve for all ovens.

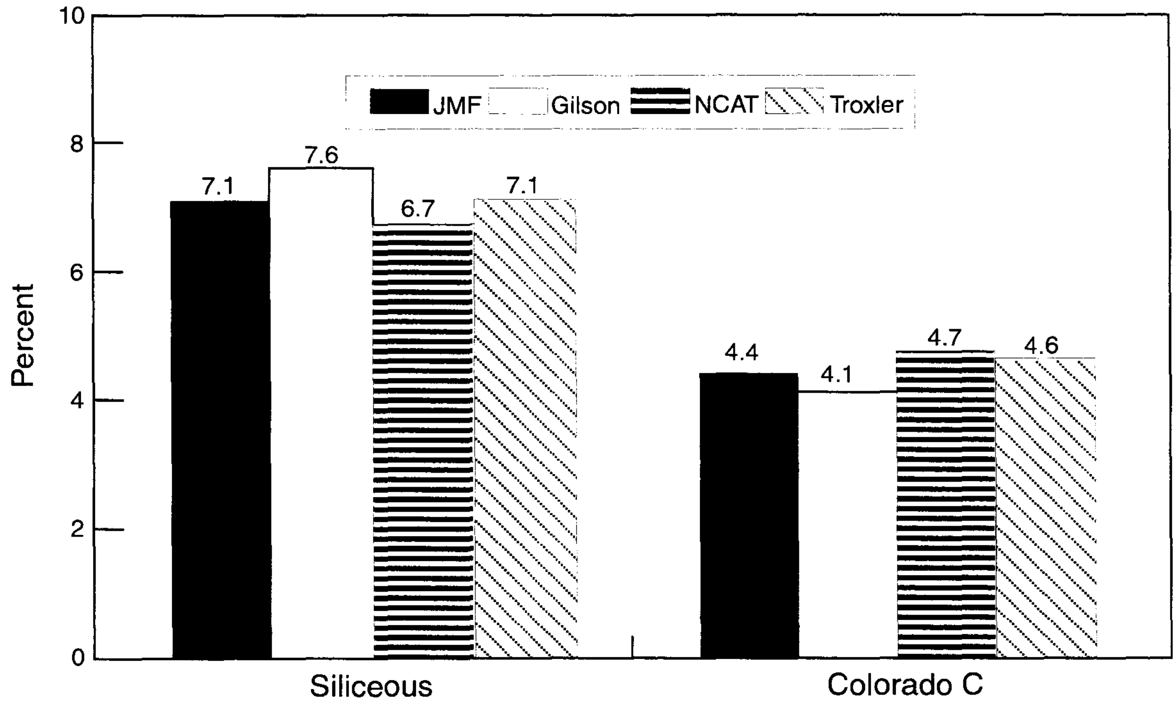

FIGURE 3: Comparison of percent passing #200 sieve for all ovens.

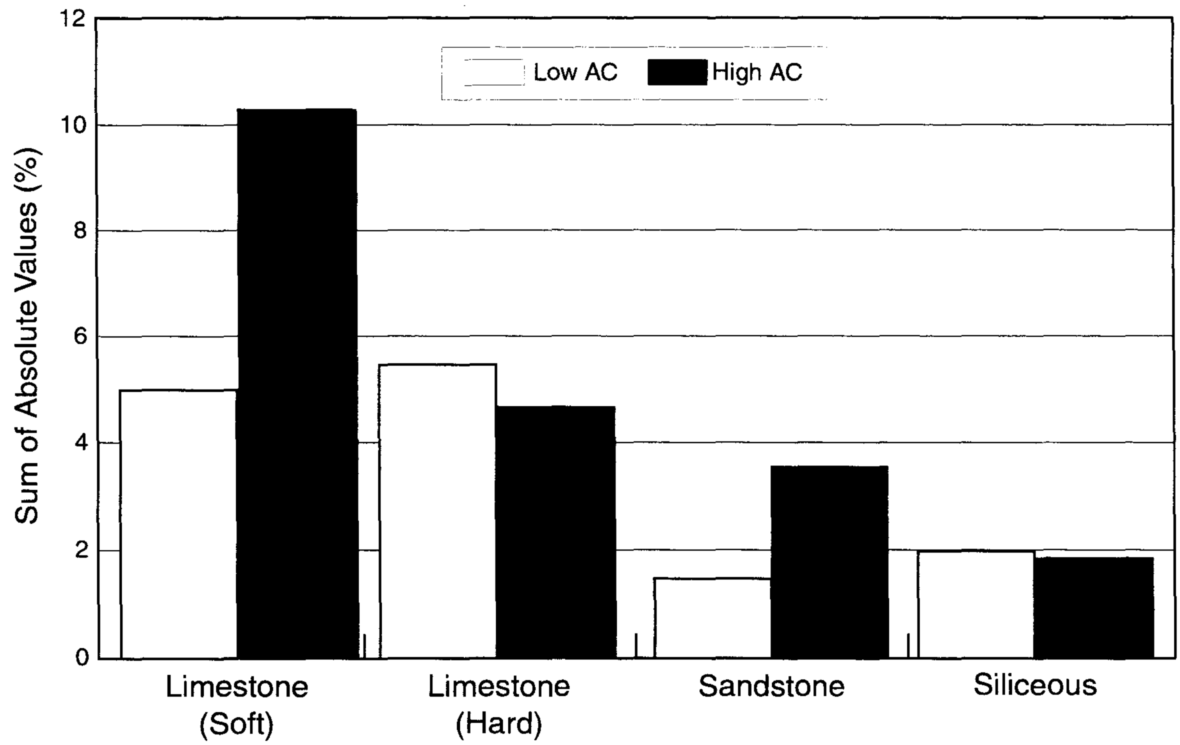

FIGURE 4: Extent of aggregate degradation as measured by the sum of absolute value of differences for high and low asphalt content samples.

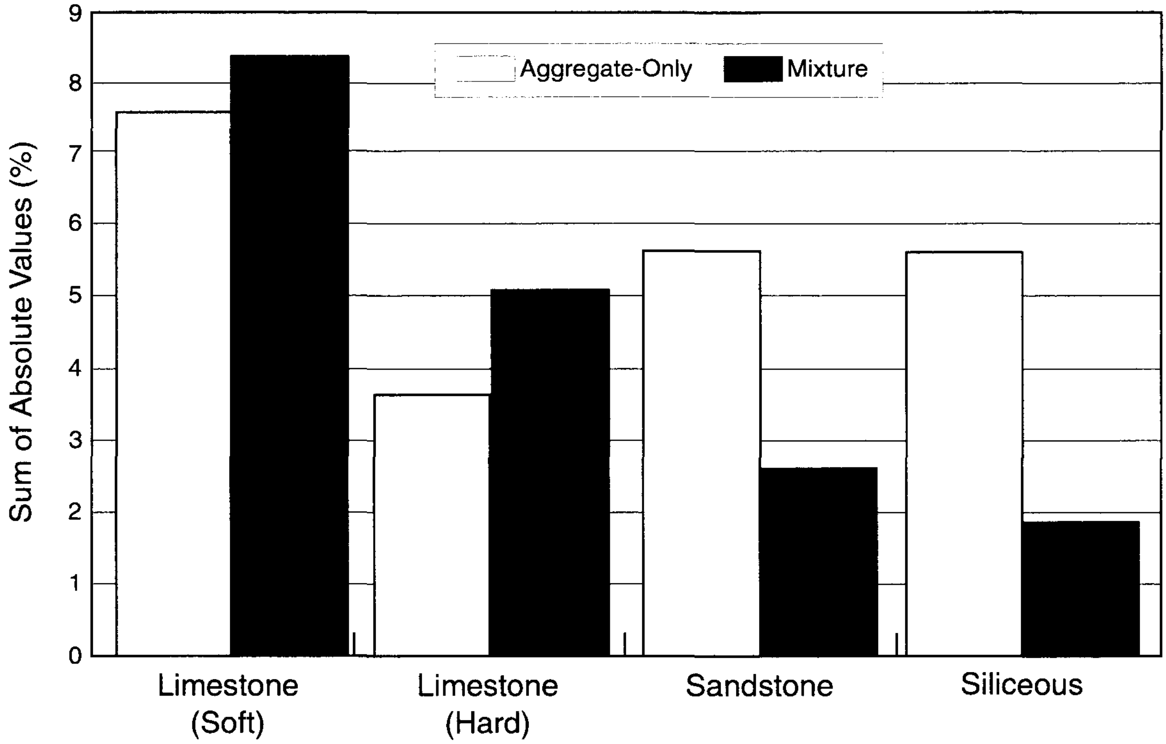

FIGURE 5: Comparison of sum of absolute value of differences for aggregate-only and mixture samples.

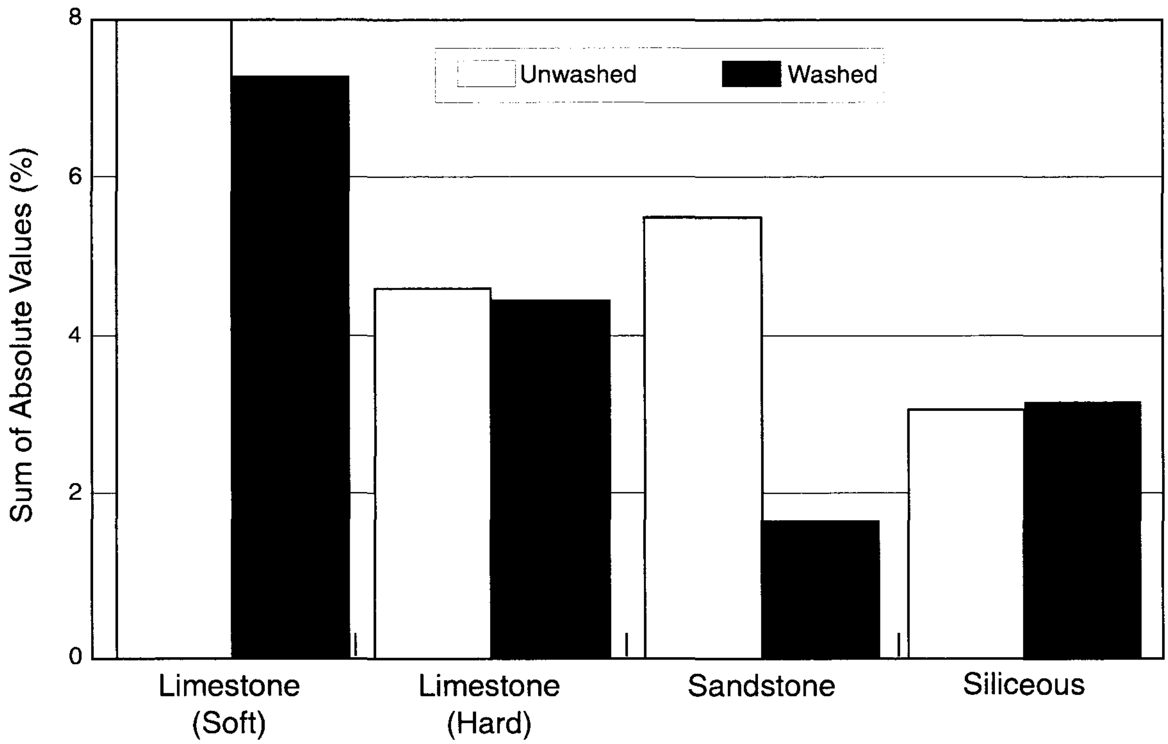

FIGURE 6: Comparison of sum of absolute value of differences for unwashed and washed sieve analysis samples.

ERRORS IN TESTING

During testing, several problems occurred that need to be addressed. The first problem is determining the correct temperature (all ovens) and the amount of time (Gilson oven only) to run the test. These parameters are adjustable on the oven control panel. The ideal situation would have been to have had one setting for all mixtures. After running several different mixes, it was concluded that this would not be possible. By trial and error, the approximate time and temperature for each mixture was determined. Time and temperature are very important issues in running the test. Too much time or too high a temperature causes degradation of the aggregate and/or loss of fines. Not enough time or too low a temperature causes a carbon deposit left on the aggregate. It should be noted that the time is not a factor when the oven has an internal scale (NCAT and Troxler).

ERRORS IN SAMPLE PREPARATION AND HANDLING

While the samples were being prepared for testing, several factors were noted that affected the accuracy of the results. There were notable differences when shaking the rock with the large Gilson shaker during sample preparation and shaking it with the Ro-Tap shaker after testing. If a comparison of gradation before and after ignition is desired, then the same type of sieve analysis, i.e., washed or dry, must be conducted both before and after. Mixing the aggregate with asphalt is also a possible source of aggregate gradation. The aggregate-only samples degraded less than the mixture samples in the limestone aggregates, but the mixture samples degraded less than the aggregate-only samples in the harder aggregates. In this study, aggregate gradation during mixing did not appear to be a major factor. In sample handling, it is sometimes difficult to remove the ignited aggregate from the sample tray without losing any fines. This factor is important when performing a sieve analysis on the sample.

CONCLUSIONS AND RECOMMENDATIONS

After the tests and data analysis were completed, the ignition furnace was proven to be a viable option in determining AC content and yielding aggregates for gradation testing. There are several steps that should be taken to ensure accurate and viable results. First, the oven must be calibrated for each mixture. This calibration could be done in the design stage. Next, an optimum temperature should be determined, along with an optimum sample size. The sample size will depend largely on the maximum nominal aggregate size. Softer and more porous aggregates will degrade more than harder aggregates. Degradation will occur with all mixes and aggregates, but can be minimized by determining the optimum temperature to run the test. Next, the sample should be cured but not overheated to remove any moisture. Moisture not removed from the sample will show up as asphalt when tested. The sample should be placed in the sample tray loosely, not tight or packed.

The test method which resulted from this study is Tex-236-F. The procedure is included in Appendix A. All the available test results are included in Appendix B.

APPENDIX A:

TEX-236-F
"DETERMINATION OF ASPHALT CONTENT FROM ASPHALT PAVING MIXTURES BY THE IGNITION METHOD"

DETERMINATION OF ASPHALT CONTENT FROM ASPHALT PAVING MIXTURES BY THE IGNITION METHOD

Use this test method to determine the asphalt content of hot mixed paving mixtures by ignition of the asphalt cement. The remaining aggregate can be used for sieve analysis in accordance with Test Method Tex-200-F.

Apparatus

- A forced air ignition furnace, capable of maintaining the temperature of 650 °C (1202 °F), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g (0.0035 oz.). The balance shall be capable of weighing a 3500 g (122.5 oz.) sample in addition to the sample baskets. The furnace shall calculate a temperature compensation factor for the change in weight of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall have the means for providing the following information:

  - the initial specimen weight
  - specimen weight loss
  - temperature compensation
  - correction factor
  - corrected asphalt content (%)
  - test time
  - test temperature.

  The sample chamber dimensions shall be at least 30.5 x 25.4 x 30.5 cm (WxHxD) (12 x 10 x 12 in.). A method for reducing furnace emissions shall be provided. The furnace shall provide an audible alarm and indicator light when the sample reaches constant weight. The furnace door shall automatically lock when the test procedure begins and shall remain locked until the test procedure is completed.

- A tempered stainless steel 2.36 mm (No. 8) mesh or otherwise perforated basket, or combination of baskets capable of handling at least a 1500 g (52.5 oz.) sample. The basket shall incorporate a design which confines the sample during testing.

- A tempered stainless steel catch pan, to fit under the basket assembly.

- Oven capable of maintaining 121 ± 3 °C (250 ± 5 °F).

- Balance, 8 kg (17.6 lbs.) or greater capacity, accurate to 0.1 g (0.0035 oz.) for weighing sample in baskets.

Apparatus (continued)

- Safety Equipment: safety glasses or face shield, high temperature gloves, and long sleeve jacket. Additionally, a heat resistant surface capable of withstanding 650 °C (1202 °F) and a protective cage capable of surrounding the sample baskets shall be provided.

- Miscellaneous Equipment: pan for transferring samples after ignition, spatulas, bowls and wire brushes.

Sample Preparation

- The test sample shall be the end result of quartering a larger sample taken in accordance with Test Method Tex-222-F.

- Preparation of Test Specimens: If the mixture is not sufficiently workable to separate with a spatula or trowel, place it in a large flat pan and warm to 121 ± 3 °C (250 ± 5 °F) for 30 minutes. The sample shall not be heated for more than 1 hour.

- The size of the test sample shall be governed by the nominal maximum aggregate size of the mixture and shall conform to the mass requirement shown in Table 1 (**NOTE 1**):

Table 1
Size of Sample

Nominal Maximum Aggregate Size, mm	Sieve Size	Minimum Mass of Sample, g
4.75	No. 4	1200
9.5	3/8 in.	1200
12.5	1/2 in.	1500
19.0	3/4 in.	2000
25.0	1 in.	3000
37.5	1-1/2 in.	4000

Sample Preparation (continued)

NOTE 1: Nominal maximum aggregate size is defined as the largest sieve that retains 10% or more of the total aggregate mixture. Sample sizes should not be more than 400 g (14 oz.) greater than the minimum recommended sample mass. Large samples of fine mixes tend to result in incomplete ignition of the asphalt. When the mass of the test specimen exceeds the recommended maximum capacity of the equipment used, the test specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt content (weighted average).

- A test specimen for moisture determination will be made as deemed necessary. The specimen used for moisture determination may not be used for asphalt content determination.

Calibration

An asphalt content calibration factor shall be determined for each mixture. For mixtures containing RAP, a sufficient quantity of RAP should be sampled such that the binder content of the RAP may be estimated, and to provide for the RAP to be used in the mix calibration. The binder content of the RAP will be estimated from the average of four samples (RAP only) burned in the furnace. The RAP shall be heated at 60 °C (140 °F), broken apart until friable and quartered to obtain a representative sample.

Certain aggregate types (softer aggregates) may result in an unusually high correction factor and erroneous gradation results. Such mixes should be calibrated and tested at a lower temperature, typically 482 °C (900 °F).

Mixture Calibration

This ignition procedure may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established by testing a set of samples for each mix type. It is recommended that the mixture calibration be performed during the mixture design process.

Mixture Calibration (continued)

Step	Action
1	Prepare six calibration specimens conforming to the mass requirements of Table 1. Two at the design asphalt content, and two each at ± 0.5% of the design asphalt content. A butter batch mix shall be prepared at the design asphalt content, mixed and discarded prior to mixing any of the calibration specimens to ensure an accurate asphalt content. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season. Aggregate shall be combined in accordance with the procedure outlined in Test Method Tex-204-F. An additional "blank" specimen shall be batched and tested according to Test Method Tex-200-F.
2	Place the freshly mixed specimens directly in the sample baskets. If allowed to cool, the samples must be reheated in a 121 °C (250 °F) oven for 30 minutes. Do not preheat the sample baskets.
3	Preheat the ignition furnace to a temperature between 500 and 538 °C (932 and 1000 °F). The exact temperature of the furnace depends on the aggregate type and asphalt type. Record the furnace temperature (set point) prior to the initiation of the test.
4	Enter an aggregate correction factor of 0.00 in the ignition furnace.
5	Weigh and record the weight of the basket assembly to the nearest 0.1 g (0.0035 oz.).
6	Evenly distribute the calibration specimen in the basket assembly taking care to keep the material away from the edges of the basket.
7	Weigh and record the sample and basket assembly to the nearest 0.1 g (0.0035 oz.). Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly).
8	Input the initial weight of the sample specimen into the ignition furnace controller. Verify that the correct weight has been entered.
9	Open the chamber door and place the sample and basket assembly in the furnace. Failure of the furnace scale to stabilize may indicate that the sample basket assembly is contacting the furnace wall. If this occurs, adjust the sample basket inside the furnace.
10	Close the chamber door and start the test. This should lock the furnace chamber for the duration of the test.
11	Allow the test to continue until the stable light and audible stable indicator indicate the test is complete. Press the start/stop button. This should unlock the furnace chamber.
12	Open the chamber door, remove the sample and allow it to cool to room temperature (approx. 45 minutes). Do not use a fan to assist in cooling the specimen to room temperature due to the possibility of losing fines.
13	Perform a gradation analysis on the residual aggregate in accordance with Test Method Tex-200-F, Part II. The aggregate gradation shall be compared to the washed sieve analysis performed in Step 2.
14	Once all six of the calibration specimens have been burned, determine the difference between the actual and measured asphalt contents for each sample. The asphalt content correction factor is the average of the six measured differences.

Procedure

Step	Action
1	Preheat the ignition furnace to a temperature between 500 and 538 °C (932 and 1000 °F). Use the temperature established from the calibration section of the procedure.
2	Enter the correction factor for the specific mix to be tested as determined in the calibration section of this procedure.
3	Weigh and record the weight of the sample basket assembly.
4	Prepare the sample as described under "Preparation of Specimens" in the **Sample Preparation** section.
5	Evenly distribute the specimen in the basket assembly taking care to keep the material away from the edges of the basket.
6	Weigh and record the sample and basket assembly to the nearest 0.1 g (0.0035 oz.). Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly).
7	Input the initial weight of the sample specimen into the ignition furnace controller. Verify that the correct weight has been entered.
8	Open the chamber door and place the sample and basket assembly in the furnace. Failure of the furnace scale to stabilize may indicate that the sample basket assembly is contacting the furnace wall. If this occurs, adjust the sample basket inside the furnace. Close the chamber door and start the test. This should lock the furnace chamber for the duration of the test.
9	Allow the test to continue until the stable light and audible stable indicator indicate the test is complete. Press the start/stop button. This should unlock the furnace chamber.
10	Open the chamber door, remove the sample and allow it to cool to room temperature (approx. 45 minutes). Do not use a fan to assist in cooling the specimen to room temperature due to the possibility of losing fines.

Gradation

Step	Action
1	Empty the contents of the baskets into a flat pan.
2	Use a small wire sieve brush to ensure that any residual fines are removed from the basket, and add those fines to the contents in the flat pan.
3	Perform the gradation analysis according to Test Method Tex-200-F, Part II.

Report

Always report corrected asphalt content, mix correction factor, temperature compensation factor, total percent loss, sample mass and test temperature. Attach any original printed ticket to the report. An example data sheet is attached.

TEXAS DEPARTMENT OF TRANSPORTATION
MATERIALS AND TESTS DIVISION
AUSTIN, TX. 78703

IGNITION METHOD OF EXTRACTION (TEX-236-F)

Laboratory No.:	Contract No.:	Mat'l. Code:
District:	Date Sampled:	Spec. Item:
County:	Date Received:	Material: Type "D"
Engr./Foreman:	Date Reported:	Quantity:
CSJ#:	Contractor:	Unit:
Fed. Proj.#:	Producer:	I.D. Marks:
Highway:	Prod. Code	Samp. From:

ASPHALT CONTENT

ASPHALT CONTENT (From Ignition Oven) ? %

* Asphalt Content Correction Factor Entered * For Information Only
* Original Sample Weight (Before Ignition) Grams

SIEVE ANALYSIS

Original Dry Sample Weight = grams
Sample Wt. After Washing = grams

Sieve Size	Weight In Grams	Individual % Retained	Cumulative % Retained	Total % Passing	Correction Factor	Corr. Total % Passing	Specifications	
							Minimum	Maximum
7/8"					%			
5/8"					%			
1/2"					%			100
3/8"					%		85	100
#4					%		50	70
#10					%		32	42
#40					%		11	26
#80					%		4	14
#200					%		1	6
Pan								
Loss from washing								
Loss from sieving								
Total Passing #200								
Total								

% Enter Correction Factor Data!!

Remarks:

Technician: ?

TEXAS DEPARTMENT OF TRANSPORTATION
MATERIALS AND TESTS DIVISION
AUSTIN, TX. 78703

IGNITION METHOD OF EXTRACTION (TEX-236-F)

Laboratory No.:	?	Contract No.:	?	Mat'l. Code:	?
District:	?	Date Sampled:	?	Spec. Item:	?
County:	?	Date Received:	?	Material:	Type "D"
Engr./Foreman:	?	Date Reported:	?	Quantity:	?
CSJ#:	?	Contractor:	?	Unit:	?
Fed. Proj.#:	?	Producer:	?	I.D. Marks:	?
Highway:	?	Prod. Code	?	Samp. From:	?

Note: For correction factor determination, enter weight (in grams) as instructed for each sample OR enter Total Percentage Passing in the "Correction Factor Determination" area below. Enter Asphalt Content for each sample as instructed in the area below.

SIEVE ANALYSIS WORKSHEET FOR CALIBRATION SAMPLES

	Blank Sample	Ignited Sample 1	Ignited Sample 2	Ignited Sample 3	Ignited Sample 4	Ignited Sample 5	Ignited Sample 6
Original Sample Weight	?	?	?	?	?	?	?
Dry Weight (After Wash)	?	?	?	?	?	?	?
Sieve Size							
7/8"	?	?	?	?	?	?	?
5/8"	?	?	?	?	?	?	?
1/2"	?	?	?	?	?	?	?
3/8"	?	?	?	?	?	?	?
#4	?	?	?	?	?	?	?
#10	?	?	?	?	?	?	?
#40	?	?	?	?	?	?	?
#80	?	?	?	?	?	?	?
#200	?	?	?	?	?	?	?
Pan	?	?	?	?	?	?	?

CORRECTION FACTOR DETERMINATION

	Total % Passing							
Sieve Size	Blank Sample	Ignited Sample 1	Ignited Sample 2	Ignited Sample 3	Ignited Sample 4	Ignited Sample 5	Ignited Sample 6	Correction Factor
7/8"	?	?	?	?	?	?	?	
5/8"	?	?	?	?	?	?	?	
1/2"	?	?	?	?	?	?	?	
3/8"	?	?	?	?	?	?	?	
#4	?	?	?	?	?	?	?	
#10	?	?	?	?	?	?	?	
#40	?	?	?	?	?	?	?	
#80	?	?	?	?	?	?	?	
#200	?	?	?	?	?	?	?	
Pan								

Target AC	?	?	?	?	?	?	
Measured AC	?	?	?	?	?	?	

Technician: ?

APPENDIX B:

"INDIVIDUAL TEST RESULTS"

Limestone Type C Lab Mix TROXLER OVEN

Sieve Size	Target Gradation Cum. Pass	Dry Sample Unwashed Cum. Pass #1	#2	#3	Dry Sample Washed Cum. Pass #1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	80.2	82.1	81.8	82.6	80.7	82.4	82.4
No. 4	54.6	56.6	57.9	57.0	57.5	58.3	57.3
No. 10	33.8	34.5	34.4	34.5	34.9	34.9	35.0
No. 40	16.1	23.3	16.6	16.6	24.3	17.6	17.5
No. 80	6.3	7.0	6.9	7.0	9.6	9.0	8.9
No. 200	3.7	4.2	4.3	4.3	7.1	6.8	6.8
Target % AC		0	0	0	0	0	0
Measured % AC		0	0	0	0	0	0

Sieve Size	Actual Gradation Dry Cum. Pass	Ignited Mix 4.20% Unwashed Cum. Pass #4	#5	#6	Ignited Mix 4.20% Washed Cum. Pass #4	#5	#6	Ignited Mix 5.20% Unwashed Cum. Pass #7	#8	#9	Ignited Mix 5.20% Washed Cum. Pass #7	#8	#9	Actual Gradation Washed Cum. Pass
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	82.2	82.1	81.0	81.9	82.1	82.5	82.2	81.5	81.7	81.3	83.0	81.8	80.9	81.8
No. 4	57.2	56.7	56.7	56.6	57.2	57.3	57.0	57.4	57.1	56.5	57.6	57.4	57.0	57.7
No. 10	34.5	34.5	34.4	35.0	35.0	35.0	35.4	34.8	34.7	34.7	35.1	35.1	35.1	34.9
No. 40	18.8	17.1	16.9	17.8	17.8	17.7	18.5	17.5	17.4	17.3	17.9	18.0	18.0	19.8
No. 80	7.0	8.5	8.9	9.1	9.7	9.7	10.5	9.6	8.8	8.6	9.9	9.9	10.3	9.2
No. 200	4.2	5.1	5.3	5.4	6.8	6.9	7.5	5.6	5.3	5.2	7.2	7.0	7.0	6.9
Target % AC		4.20	4.20	4.20	4.20	4.20	4.20	5.20	5.20	5.20	5.20	5.20	5.20	
Measured % AC		4.39	4.24	4.44	4.39	4.24	4.44	5.20	5.27	5.33	5.20	5.27	5.33	

Limestone Type C Lab Mix NCAT OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	80.2	81.4	80.9	81.7	79.9	80.2	80.4	81.3	81.2	81.9	82.2	81.7	83.0
No. 4	54.6	56.8	58.0	57.4	56.0	56.9	56.6	59.0	58.1	58.9	58.3	59.4	58.4
No. 10	33.8	34.6	34.3	34.7	31.7	31.9	31.8	35.2	34.9	35.1	35.3	35.2	35.5
No. 40	16.1	16.6	16.4	16.8	13.3	13.5	13.5	17.8	17.4	17.7	18.1	17.8	18.2
No. 80	6.3	6.6	6.9	6.8	4.1	4.3	4.3	9.0	8.5	8.8	9.4	9.0	9.1
No. 200	3.7	4.6	4.4	4.4	6.9	6.7	6.6	6.9	6.7	6.7	7.3	7.0	7.1
Target % AC		0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC		0.08	0.12	0.05	0.08	0.12	0.05	0.08	0.12	0.05	0.08	0.12	0.05

Sieve Size	Actual Gradation Dry	Ignited Mix 4.20% Unwashed			Ignited Mix 4.20% Washed			Ignited Mix 5.20% Unwashed			Ignited Mix 5.20% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	81.3	80.5	81.2	81.0	81.2	81.2	80.8	81.0	80.8	81.6	81.6	82.9	81.1	80.2
No. 4	57.4	57.9	58.6	59.2	58.5	59.1	59.4	58.7	58.2	56.7	58.5	58.0	57.9	56.5
No. 10	34.5	34.4	34.5	34.7	34.9	34.9	35.3	34.5	34.4	34.5	35.2	34.9	34.9	31.8
No. 40	16.6	17.3	17.1	17.5	18.0	17.8	18.4	17.6	17.6	17.1	18.2	18.0	18.1	13.4
No. 80	6.8	8.7	8.1	8.1	9.7	9.1	9.5	8.5	8.3	8.0	10.2	9.4	9.2	4.2
No. 200	4.5	5.7	5.1	5.1	7.2	6.5	6.9	5.4	5.2	5.0	7.1	6.8	6.8	6.7
Target % AC		4.20	4.20	4.20	4.20	4.20	4.20	5.20	5.20	5.20	5.20	5.20	5.20	
Measured % AC		4.29	4.37	4.35	4.29	4.37	4.35	5.30	5.40	5.32	5.30	5.40	5.32	

Limestone Type C Lab Mix GILSON OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	80.2	80.9	82.0	81.7	81.5	82.1	81.7	81.7	83.0	82.1	82.6	81.9	82.4
No. 4	54.6	57.9	57.4	58.2	58.6	58.6	57.8	58.1	58.9	58.3	58.4	59.7	59.1
No. 10	33.8	34.3	34.7	34.3	34.9	35.0	35.0	35.6	35.3	35.5	35.7	35.6	35.5
No. 40	16.1	16.4	16.6	16.4	17.4	17.4	17.4	18.2	17.9	18.0	18.4	18.4	18.2
No. 80	6.3	6.7	6.6	6.9	8.7	8.7	8.5	9.2	9.3	9.0	9.5	9.8	9.5
No. 200	3.7	4.4	4.4	4.4	6.7	6.7	6.6	7.0	7.1	7.0	7.4	7.6	7.4

Target % AC	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	0.17	0.15	0.24	0.17	0.15	0.24	0.17	0.15	0.24	0.17	0.15	0.24

Sieve Size	Actual Gradation Dry	Ignited Mix 4.20% Unwashed			Ignited Mix 4.20% Washed			Ignited Mix 5.20% Unwashed			Ignited Mix 5.20% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	81.5	84.2	81.3	82.4	84.1	81.1	82.9	82.2	81.7	83.1	82.2	81.8	82.9	81.8
No. 4	57.8	58.1	58.1	57.7	58.5	59.3	58.3	58.0	56.5	57.9	59.6	56.8	59.9	58.3
No. 10	34.4	34.7	34.5	34.5	35.2	35.1	35.1	34.7	34.7	34.5	35.3	35.0	35.2	35.0
No. 40	16.5	18.5	18.5	18.6	19.3	19.0	19.5	18.9	18.5	18.6	19.6	19.2	19.5	17.4
No. 80	6.7	8.9	8.7	8.7	10.8	10.2	10.7	9.1	9.1	8.8	10.6	10.7	10.7	8.6
No. 200	4.4	4.0	3.9	4.0	6.5	6.9	6.6	4.3	4.3	4.0	6.8	6.7	6.9	6.7

Target % AC	4.20	4.20	4.20	4.20	4.20	4.20	5.20	5.20	5.20	5.20	5.20	5.20
Measured % AC	4.37	4.35	4.42	4.37	4.35	4.42	5.20	5.29	5.26	5.20	5.29	5.26

Limestone Type D Lab Mix GILSON OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	99.4	99.4	99.2	99.4	99.4	99.4	99.5
No. 4	61.6	65.2	66.3	66.7	65.6	66.4	67.0
No. 10	36.3	37.2	36.8	36.2	37.8	37.3	36.8
No. 40	15.1	14.4	14.4	14.4	15.6	15.3	15.9
No. 80	6.2	7.1	7.0	6.9	8.6	8.2	8.2
No. 200	1.0	0.7	0.7	0.6	1.0	1.0	1.0

Target % AC	0	0	0	0	0	0
Measured % AC	0	0	0	0	0	0

Sieve Size	Actual Gradation Dry	Ignited Mix 4.50% Unwashed			Ignited Mix 5.50% Unwashed		
	Cum. Pass	Cum. Pass			Cum. Pass		
		#4	#5	#6	#7	#8	#9
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	99.3	99.6	99.4	99.7	99.4	99.6	99.5
No. 4	66.1	65.5	64.4	65.8	64.8	66.3	66.4
No. 10	36.7	37.8	37.5	37.7	37.5	38.5	37.8
No. 40	14.4	16.3	16.2	16.0	16.1	17.0	15.9
No. 80	7.0	8.1	9.1	8.9	7.9	9.3	8.2
No. 200	0.7	2.0	2.4	1.9	1.9	2.6	2.1

Target % AC	4.50	4.50	4.50	5.50	5.50	5.50
Measured % AC	4.51	4.57	4.53	5.43	5.20	5.40

Limestone Type D Lab Mix NCAT OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	99.4	99.9	99.4	99.4	99.9	99.7	99.4	99.9	99.4	99.4	99.8	99.7	99.4
No. 4	61.6	66.8	65.1	65.7	67.8	65.5	66.0	67.0	65.4	65.8	68.0	65.5	66.2
No. 10	36.3	36.9	36.5	36.5	36.4	37.5	36.8	37.3	37.0	37.0	36.9	37.6	37.3
No. 40	15.1	14.6	14.5	14.4	14.0	15.0	14.9	15.5	15.5	15.5	15.9	15.7	15.6
No. 80	6.2	6.6	7.5	6.4	6.3	7.5	7.3	7.8	8.8	7.7	7.9	8.2	7.9
No. 200	1.0	1.3	1.3	1.3	0.8	2.0	2.1	2.2	2.2	2.2	2.4	2.3	2.4

Target % AC	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	0.12	0.16	0.12	0.12	0.16	0.12	0.12	0.16	0.12	0.12	0.16	0.12

Sieve Size	Actual Gradation Dry	Ignited Mix 4.50% Unwashed			Ignited Mix 4.50% Washed			Ignited Mix 5.50% Unwashed			Ignited Mix 5.50% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	99.6	99.1	99.4	99.2	99.3	99.4	99.7	99.7	99.5	99.4	99.5	99.3	99.4	99.7
No. 4	65.9	65.5	67.5	66.5	66.0	67.2	65.8	66.1	65.5	65.1	67.3	65.4	65.5	66.4
No. 10	36.6	36.7	36.8	35.8	36.9	37.0	36.5	37.4	37.1	35.8	36.8	36.5	36.8	36.9
No. 40	14.5	15.1	22.2	15.4	15.3	22.4	15.5	15.4	15.2	14.8	15.8	15.4	15.4	14.6
No. 80	6.8	8.2	7.9	7.5	8.5	8.5	8.0	7.8	10.2	7.5	8.1	10.9	8.0	7.0
No. 200	1.3	1.7	1.9	1.7	2.2	2.7	2.3	1.9	1.7	1.6	2.5	2.3	2.3	1.6

Target % AC	4.50	4.50	4.50	4.50	4.50	4.50	5.50	5.50	5.50	5.50	5.50	5.50
Measured % AC	4.69	4.63	4.63	4.69	4.63	4.63	5.56	5.58	5.54	5.56	5.58	5.54

Sandstone/Limestone Type C Lab Mix GILSON OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	99.1	98.6	98.8	98.6	98.6	98.8	98.6	98.6	99.2	98.6	99.0	99.2	98.6
3/8"	76.2	78.1	78.4	77.8	77.1	76.9	78.1	78.6	77.4	77.1	77.4	77.4	78.2
No. 4	61.6	61.7	61.8	61.8	62.0	62.1	62.1	61.9	62.3	62.2	62.2	62.2	62.1
No. 10	39.1	39.6	39.6	39.4	39.9	39.9	39.9	40.1	40.2	40.1	40.2	40.3	40.1
No. 40	19.1	20.4	20.5	20.5	22.1	22.3	22.1	21.9	22.6	22.4	22.6	22.4	22.5
No. 80	8.1	9.4	9.9	8.9	13.0	13.4	12.6	13.0	13.7	13.6	13.5	14.4	13.0
No. 200	5.0	4.9	5.1	5.0	7.9	8.0	7.9	8.1	8.2	8.1	8.3	8.3	8.2
Target % AC		0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC		0	0	0.01	0	0	0.01	0	0	0.01	0	0	0.01

Sieve Size	Actual Gradation	Ignited Mix 4.00% Unwashed			Ignited Mix 4.00% Washed			Ignited Mix 5.00% Unwashed			Ignited Mix 5.00% Washed			Actual Gradation
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	98.7	98.1	98.7	99.1	99.1	99.0	99.1	98.1	98.6	98.3	98.4	99.4	99.3	98.7
3/8"	78.1	78.2	77.5	77.9	77.9	79.6	79.9	76.8	77.2	77.1	77.0	77.1	77.0	77.4
No. 4	61.8	61.9	61.9	61.9	62.2	61.8	62.2	62.2	61.8	62.0	62.4	62.0	61.9	62.1
No. 10	39.5	39.8	39.5	39.9	40.1	39.7	40.3	39.9	39.7	40.0	40.2	40.1	40.0	39.9
No. 40	20.5	20.9	21.3	21.7	21.4	22.8	22.8	22.5	22.4	22.6	23.3	22.8	23.1	22.2
No. 80	9.4	11.2	8.3	11.2	12.3	13.7	13.5	12.2	12.1	11.0	15.0	14.3	13.8	13.0
No. 200	5.0	6.9	4.2	5.1	9.1	8.1	8.5	5.0	5.1	4.8	8.6	8.5	8.3	8.0
Target % AC		4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00	
Measured % AC		4.04	4.14	4.15	4.04	4.14	4.15	5.07	5.11	5.14	5.07	5.11	5.14	

Sandstone/Limestone Type C Lab Mix NCAT OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	99.1	99.0	99.1	98.6	99.0	99.5	98.6	99.0	99.0	98.6	99.0	99.5	98.6
3/8"	76.2	77.1	77.5	77.0	77.5	78.9	76.3	79.0	78.9	76.6	77.8	77.4	76.6
No. 4	61.6	62.0	62.1	61.9	62.5	62.3	62.2	62.4	62.4	62.5	62.6	62.4	62.5
No. 10	39.1	39.7	40.0	39.8	40.1	40.4	40.1	40.5	40.7	40.3	40.4	40.6	40.6
No. 40	19.1	20.6	21.0	20.8	22.3	22.2	21.8	22.3	22.6	22.7	22.7	22.4	22.4
No. 80	8.1	11.4	11.3	11.3	13.0	12.7	14.1	13.4	13.1	13.8	13.5	13.9	14.7
No. 200	5.0	5.7	5.7	5.8	7.9	7.9	7.9	8.2	8.2	8.4	8.5	8.5	8.6

Target % AC	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	0.08	0.41	0.1	0.08	0.41	0.1	0.08	0.41	0.1	0.08	0.41	0.1

Sieve Size	Actual Gradation Dry	Ignited Mix 4.00% Unwashed			Ignited Mix 4.00% Washed			Ignited Mix 5.00% Unwashed			Ignited Mix 5.00% Washed			Actual Gradation Washed
	Cum. Pass	% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret			Cum. Pass
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3	
5/8"	98.9	99.0	98.8	97.9	99.0	98.9	97.9	98.8	98.8	98.5	98.7	98.7	98.5	99.0
3/8"	77.2	77.4	77.3	76.2	77.7	77.0	76.9	76.2	79.3	76.8	76.3	76.5	77.3	77.6
No. 4	62.0	61.8	62.1	61.9	62.0	62.1	62.3	61.9	66.0	61.6	62.1	61.9	61.9	62.3
No. 10	39.8	39.9	40.2	39.8	40.2	40.4	40.3	39.6	43.7	39.9	40.0	40.3	40.1	40.2
No. 40	20.8	21.3	21.1	20.5	21.9	21.6	21.7	20.4	23.7	20.6	21.1	21.3	21.6	22.1
No. 80	11.3	11.9	11.5	11.6	13.5	13.0	12.7	11.7	12.4	12.0	13.1	12.7	12.6	13.3
No. 200	5.7	5.3	5.4	5.4	7.9	7.9	7.9	5.1	4.4	5.3	7.7	7.7	7.6	7.9

Target % AC	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00
Measured % AC	4.31	4.36	4.29	4.31	4.36	4.29	5.26	5.27	5.18	5.26	5.27	5.18

Siliceous Gravel Type C Lab Mix GILSON OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.5	93.5	93.8	93.8	93.7	93.6	94.1	93.8	94.6	93.9	95.8	93.5	92.7
No. 4	65.4	67.2	67.6	67.8	67.1	69.1	68.0	67.6	68.1	68.2	70.7	69.2	69.4
No. 10	35.9	36.0	36.0	36.0	36.2	36.1	36.3	36.5	36.5	36.6	39.5	36.5	36.4
No. 40	18.2	18.5	18.4	18.4	19.2	19.3	19.2	19.7	19.5	19.6	22.6	19.9	19.7
No. 80	10.7	10.9	10.8	11.0	12.5	12.5	12.6	13.0	12.9	13.0	16.3	13.1	13.0
No. 200	6.6	6.9	6.9	6.8	9.1	9.1	9.1	9.3	9.4	9.4	9.4	9.5	9.5

Target % AC	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	0	0	0	0	0	0	0	0	0	0	0	0

Sieve Size	Actual Gradation Dry	Ignited Mix 4.00% Unwashed			Ignited Mix 4.00% Washed			Ignited Mix 5.00% Unwashed			Ignited Mix 5.00% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	93.7	93.5	92.8	92.5	92.5	92.5	93.3	92.7	93.0	93.6	93.6	92.3	93.7	93.8
No. 4	67.5	69.1	68.3	69.1	69.0	68.3	68.2	67.9	67.5	67.7	69.4	68.7	67.7	68.1
No. 10	36.0	36.0	36.0	36.2	36.1	36.4	36.4	36.0	36.1	36.3	36.2	36.3	36.3	36.2
No. 40	18.4	18.9	19.0	19.7	19.8	20.0	19.9	18.1	18.6	19.7	19.4	20.0	20.2	19.2
No. 80	10.9	11.5	11.5	12.1	13.3	13.5	13.7	11.1	11.7	13.2	13.0	13.5	14.3	12.5
No. 200	6.8	7.7	7.4	7.7	10.3	10.5	10.5	6.6	7.2	8.7	9.6	10.2	10.9	9.1

Target % AC	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00
Measured % AC	3.99	3.98	4.04	3.99	3.98	4.04	4.86	4.97	4.95	4.86	4.97	4.95

Siliceous Gravel Type C Lab Mix NCAT OVEN

Sieve Size	Target Gradation Cum. Pass	Dry Sample Unwashed Cum. Pass #1	#2	#3	Dry Sample Washed Cum. Pass #1	#2	#3	Dry Sample Ignited Cum. Pass #1	#2	#3	Dry Sample Washed & Ignited Cum. Pass #1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.5	92.4	92.6	93.3	93.4	93.4	93.6	94.2	92.9	93.5	92.9	92.9	92.7
No. 4	65.4	68.0	69.3	67.3	67.9	68.1	67.2	68.6	68.4	67.5	68.6	68.6	67.7
No. 10	35.9	36.1	36.0	36.2	36.2	36.2	36.3	36.6	36.5	36.7	36.7	36.7	36.7
No. 40	18.2	18.6	18.7	18.6	19.2	18.9	19.1	19.7	19.3	19.6	19.7	19.5	19.6
No. 80	10.7	11.9	11.4	11.4	12.5	12.3	12.4	13.0	13.1	12.9	13.5	13.4	13.4
No. 200	6.6	7.3	7.5	7.3	9.1	9.1	9.0	9.4	9.4	9.4	9.6	9.6	9.5
Target % AC		0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC		0.14	0.09	0.11	0.14	0.09	0.11	0.14	0.09	0.11	0.14	0.09	0.11

Sieve Size	Actual Gradation Dry Cum. Pass	Ignited Mix 4.00% Unwashed Cum. Pass #4	#5	#6	Ignited Mix 4.00% Washed Cum. Pass #4	#5	#6	Ignited Mix 5.00% Unwashed Cum. Pass #7	#8	#9	Ignited Mix 5.00% Washed Cum. Pass #7	#8	#9	Actual Gradation Washed Cum. Pass
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.8	93.6	92.1	92.7	93.5	92.3	93.2	93.6	92.3	94.0	93.0	92.3	92.9	93.5
No. 4	68.2	67.5	68.6	69.8	68.7	68.6	68.7	67.7	67.5	68.1	67.8	67.6	69.1	67.7
No. 10	36.1	35.9	36.0	36.3	36.1	36.3	36.3	36.1	36.1	36.3	36.1	36.2	36.3	36.2
No. 40	18.6	18.8	19.1	19.2	19.6	19.7	19.2	19.1	18.9	19.1	19.3	19.3	19.6	19.1
No. 80	11.6	11.8	11.0	11.3	12.7	12.9	13.0	11.8	12.3	11.9	13.1	13.1	12.9	12.4
No. 200	7.4	6.6	6.4	6.6	9.2	9.3	9.0	6.7	7.1	6.8	9.2	9.2	9.3	9.0
Target % AC		4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00	
Measured % AC		4.18	4.23	4.22	4.18	4.23	4.22	5.11	5.14	5.18	5.11	5.14	5.18	

Siliceous Gravel Type C Lab Mix NCAT OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.5	92.4	92.6	93.3	93.4	93.4	93.6	94.2	92.9	93.5	92.9	92.9	92.7
No. 4	65.4	68.0	69.3	67.3	67.9	68.1	67.2	68.6	68.4	67.5	68.6	68.6	67.7
No. 10	35.9	36.1	36.0	36.2	36.2	36.2	36.3	36.6	36.5	36.7	36.7	36.7	36.7
No. 40	18.2	18.6	18.7	18.6	19.2	18.9	19.1	19.7	19.3	19.6	19.7	19.5	19.6
No. 80	10.7	11.9	11.4	11.4	12.5	12.3	12.4	13.0	13.1	12.9	13.5	13.4	13.4
No. 200	6.6	7.3	7.5	7.3	9.1	9.1	9.0	9.4	9.4	9.4	9.6	9.6	9.5

Target % AC	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	0.14	0.09	0.11	0.14	0.09	0.11	0.14	0.09	0.11	0.14	0.09	0.11

Sieve Size	Actual Gradation Dry	Ignited Mix 4.00% Unwashed			Ignited Mix 4.00% Washed			Ignited Mix 5.00% Unwashed			Ignited Mix 5.00% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.8	93.6	92.1	92.7	93.5	92.3	93.2	93.6	92.3	94.0	93.0	92.3	92.9	93.5
No. 4	68.2	67.5	68.6	69.8	68.7	68.6	68.7	67.7	67.5	68.1	67.8	67.6	69.1	67.7
No. 10	36.1	35.9	36.0	36.3	36.1	36.3	36.3	36.1	36.1	36.3	36.1	36.2	36.3	36.2
No. 40	18.6	18.8	19.1	19.2	19.6	19.7	19.2	19.1	18.9	19.1	19.3	19.3	19.6	19.1
No. 80	11.6	11.8	11.0	11.3	12.7	12.9	13.0	11.8	12.3	11.9	13.1	13.1	12.9	12.4
No. 200	7.4	6.6	6.4	6.6	9.2	9.3	9.0	6.7	7.1	6.8	9.2	9.2	9.3	9.0

Target % AC	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00
Measured % AC	4.18	4.23	4.22	4.18	4.23	4.22	5.11	5.14	5.18	5.11	5.14	5.18

Siliceous Gravel Type C Lab Mix TROXLER OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed		
	Cum. Pass	Cum. Pass			Cum. Pass		
		#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.5	93.6	92.4	92.8	93.6	93.3	93.2
No. 4	65.4	67.0	67.0	69.5	66.9	66.9	69.8
No. 10	35.9	36.2	36.1	36.1	36.3	36.2	36.2
No. 40	18.2	18.6	18.5	18.8	19.2	19.0	19.3
No. 80	10.7	11.3	11.8	11.2	12.5	12.3	12.5
No. 200	6.6	6.9	7.5	7.1	9.3	9.1	9.3

Target % AC	0	0	0	0	0	0
Measured % AC	0	0	0	0	0	0

Sieve Size	Actual Gradation Dry	Ignited Mix 4.00% Unwashed			Ignited Mix 4.00% Washed			Ignited Mix 5.00% Unwashed			Ignited Mix 5.00% Washed			Actual Gradation Washed
	Cum. Pass	Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass			Cum. Pass
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	92.9	92.9	93.8	92.8	93.1	92.8	92.9	94.0	92.9	92.6	94.1	93.2	92.5	93.4
No. 4	67.8	68.6	67.3	68.4	67.2	68.3	67.6	67.4	67.4	67.2	67.4	67.5	67.3	67.9
No. 10	36.1	35.9	36.1	35.8	36.3	36.2	36.1	36.1	36.2	36.2	36.2	36.2	36.3	36.2
No. 40	18.6	18.9	18.8	18.7	19.2	19.5	19.0	19.0	18.9	19.1	19.4	19.2	19.5	19.2
No. 80	11.4	11.7	11.8	11.5	12.8	12.8	13.0	12.0	12.0	12.0	13.0	12.8	13.0	12.4
No. 200	7.2	7.2	7.3	7.2	9.4	9.4	9.1	7.1	7.1	7.1	9.5	9.4	9.5	9.2

Target % AC	4.00	4.00	4.00	4.00	4.00	4.00	5.00	5.00	5.00	5.00	5.00	5.00
Measured % AC	4.16	4.17	4.15	4.16	4.17	4.15	5.07	5.14	5.04	5.07	5.14	5.04

LRA Type CC Lab Mix NCAT OVEN

Sieve Size	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	% Ind Ret	% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0		100.0	100.0		100.0	100.0		100.0	100.0
3/8"	99.2	97.8	97.7	98.7		98.2	99.1		99.3	99.3		99.4	99.5
No. 4	57.5	64.3	62.8	62.7		64.8	63.1		73.9	75.6		77.1	79.1
No. 10	40.5	40.8	40.8	40.9		41.3	41.3		52.9	53.1		57.0	58.2
No. 40	14.5	15.3	14.7	15.0		16.5	16.2		27.7	27.6		32.0	32.7
No. 80	3.9	3.9	4.1	4.0		6.3	6.3		14.0	13.6		18.0	17.8
No. 200	0.4	0.8	0.7	0.7		3.6	3.6		7.9	7.6		11.2	11.1

Target % Flux	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	6.1	6.2	6.2	6.1	6.2	6.2	6.1	6.2	6.2	6.1	6.2	6.2

Sieve Size	Actual Gradation Dry	Ignited Mix 2.30% Unwashed			Ignited Mix 2.30% Washed			Ignited Mix 3.30% Unwashed			Ignited Mix 3.30% Washed			Actual Gradation Washed
	% Ind Ret	% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret
		#4	#5	#6	#4	#5	#6	#7	#8	#9	#7	#8	#9	
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	98.1	99.7	98.8	98.7	99.5	99.4	99.4	99.3	98.9	98.9	99.6	99.4	99.2	98.7
No. 4	63.3	73.5	72.8	75.5	78.4	77.2	79.1	73.6	73.2	72.7	77.0	76.4	77.4	64.0
No. 10	40.8	52.2	53.0	54.3	57.3	58.0	59.4	52.9	52.2	52.0	57.4	57.5	57.4	41.3
No. 40	15.0	26.0	26.5	28.4	32.9	32.6	33.5	25.3	26.3	26.4	31.5	32.9	32.0	16.4
No. 80	4.0	11.8	12.4	12.5	18.2	18.0	18.0	11.9	11.7	11.8	16.9	18.3	16.8	6.3
No. 200	0.7	5.4	5.5	5.9	11.2	11.1	10.7	5.4	5.7	5.7	10.0	11.3	9.6	3.6

Target % Flux	2.3	2.3	2.3	2.3	2.3	2.3	3.3	3.3	3.3	3.3	3.3	3.3
Measured % AC	8.3	8.55	8.3	8.3	8.55	8.3	9.52	9.16	9.41	9.52	9.16	9.41

LRA Type CC Lab Mix GILSON OVEN

	Target Gradation	Dry Sample Unwashed			Dry Sample Washed			Dry Sample Ignited			Dry Sample Washed & Ignited		
	% Ind Ret	% Ind Ret			% Ind Ret			% Ind Ret			% Ind Ret		
Sieve Size		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	99.2	98.5	97.8	98.2	98.4	98.8	98.7	99.3	98.8	99.1	99.6	99.3	99.4
No. 4	57.5	65.9	63.4	64.6	63.9	63.6	62.8	77.3	75.6	74.7	79.3	79.3	76.9
No. 10	40.5	40.9	40.9	40.9	41.1	41.3	41.2	55.7	54.0	54.6	57.6	56.2	57.2
No. 40	14.5	15.3	14.8	15.3	13.6	15.6	14.6	28.9	28.1	28.4	30.1	30.1	30.4
No. 80	3.9	4.0	4.3	3.9	5.3	5.8	5.3	16.1	15.6	14.7	16.4	14.8	15.4
No. 200	0.4	0.8	0.7	0.8	2.7	3.4	2.9	9.8	9.4	9.3	8.9	8.1	8.7

Target % Flux	0	0	0	0	0	0	0	0	0	0	0	0
Measured % AC	5.93	5.81	5.73	5.93	5.81	5.73	5.93	5.81	5.73	5.93	5.81	5.73

	Actual Gradation Dry	Ignited Mix 2.30% Unwashed			Ignited Mix 3.30% Unwashed		
	% Ind Ret	% Ind Ret			% Ind Ret		
Sieve Size		#4	#5	#6	#7	#8	#9
5/8"	100.0	100.0	100.0	100.0	100.0	100.0	100.0
3/8"	98.2	99.2	99.5	99.7	99.0	99.6	99.6
No. 4	64.6	74.9	74.1	75.4	73.7	74.0	75.0
No. 10	40.9	56.9	57.6	57.9	55.8	55.9	57.4
No. 40	15.1	27.1	29.9	29.8	27.4	28.2	29.0
No. 80	4.1	10.5	14.0	13.7	11.9	13.3	13.6
No. 200	0.8	4.8	6.2	6.5	5.6	6.3	6.4

Target % Flux	2.3	2.3	2.3	3.3	3.3	3.3
Measured % AC	8.08	7.98	8.31	8.83	9.05	9.00