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# DETERMINING the ASPHALT CEMENT CONTENT of BITUMINOUS MIXTURES Using The NCAT ASPHALT CONTENT OVEN.

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ral Highway Administration

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The purpose of this study was to develop a procedure for accurately and efficiently measuring the AC content of bituminous mixtures using the NCAT Asphalt Content Oven. The results were documented and a test procedure was written which incorporated the studies findings.

The results of this study demonstrate that the NCAT Asphalt Content Oven can be used to measure AC contents accurately. In addition to evaluating the NCAT Asphalt Content measurement method, an external scale method using the NCAT Asphalt Content Oven was developed. Using the external scale method the standard deviation for the differences between the actual and measured AC contents was 0.073 when applying a two-specimen mixture correction factor. The study set included 41 bituminous specimens. A mixture correction factor is required when measuring the AC contents of field produced samples.

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TABLE OF CONTENTS

1.0 INTRODUCTION . . . . . . . . . . 1
1.1 Background . . . . . . . . . . 1
1.2 Method of Operation for the NCAT Asphalt Content Oven . . . . . . 2

2.0 PURPOSE . . . . . . . . . . 2

3.0 EXPERIMENTAL . . . . . . . . . . 3

4.0 TERMINOLOGY . . . . . . . . . . 4
4.1 Specimen Correction Factor . . . . . . . . . . 4
4.2 Mixture Correction Factor . . . . . . . . . . 4
4.3 Levels of Specimens Corrections Factors Used for Determining a Mixture Correction Factor . . . . . . . . . . 4
*4.3.1 Different Levels of Specimen Mixture Correction Factors* . . . . 5
4.4 Temperature Compensation Factor . . . . . . . . . . 5
4.5 NCAT Asphalt Content Oven Tape Printout . . . . . . . . . . 6
4.6 Internal Scale . . . . . . . . . . 6
4.7 External Scale . . . . . . . . . . 6
4.8 Lottman Test Specimen (CPL-5109) . . . . . . . . . . 7
4.9 Field Produced Sample . . . . . . . . . . 7

5.0 EQUIPMENT . . . . . . . . . . 7
5.1 NCAT Asphalt Content Oven . . . . . . . . . . 8
*5.1.1 Installation of the NCAT Asphalt Content Oven* . . . . . . . . . . 10
*5.1.2 Initial NCAT Asphalt Content Oven Operation Problems* . . . 10
*5.1.3 Determining the Oven Chamber Set Point for Testing* . . . . . 10
5.2 Additional Equipment . . . . . . . . . . 11

**6.0 PROCEDURE** . . . 12

**6.1 Procedure Development for Testing Bituminous Mixtures** . . . 12

*6.1.1 Changes Proposed to the VDOT Procedure* . . . 12

**6.1.1.1 Mixture Correction Factor Procedure** . . . 12

**6.1.1.2 AC Content of Correction Specimens** . . . 13

**6.1.1.3 Specimen Moisture Content** . . . 14

**6.1.1.4 Method for Reducing a Sample of a Bituminous Mixture to Test Size** . . . 15

**6.1.1.5 External Scale Method for AC Content Measurement** . . . 15

**6.1.1.6 Non-temperature Compensated Internal Scale for AC Content Measurement** . . . 16

*6.1.2 Methods of AC Content Measurement* . . . 17

**6.1.2.1 Temperature Compensated Internal Scale** . . . 17

**6.1.2.2 Non-Temperature Compensated Internal Scale** . . . 18

**6.1.2.3 External Scale Method** . . . 18

*6.1.3 Bituminous Mixture Sources* . . . 19

**6.2 Documenting Accuracy** . . . 22

*6.2.1 Initial Test Report Form* . . . 22

*6.2.2 Method of Analysis* . . . 22

*6.2.3 Evaluating the Level of Correction Specimens Used to Determine Mixture Correction Factors* . . . 22

**6.3 Documenting the Procedure** . . . 23

**7.0 RESULTS AND DISCUSSION** . . . 23

**7.1 Test Procedure Development** . . . 23

**7.2 Documenting the Accuracy** . . . 24

*7.2.1 Zero-Specimen Mixture Correction Factor Results for AC Content Measurement* . . . . . . . . . . . . . . . . . . . . . . . . . . . . 24
*7.2.2 One-Specimen Mixture Correction Factor Results for AC Content Measurement* . . . . . . . . . . . . . . . . . . . . 25
*7.2.3 Two-Specimen Mixture Correction Factor Results for AC Content Measurement* . . . . . . . . . . . . . . . . . . . . . . . . . . . . 25
**7.3 Discontinuing the Evaluation of the Non-Temperature Compensated Internal Scale after Applying a Two-Specimen Correction Factor** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 26
*7.3.1 Importance of the Temperature Compensated Internal Scale* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 27
**7.4 Range of Specimen Correction Factors for Determining a Mixture Correction Factor** . . . . . . . . . . . . . . . . . . . . . . . . . . 27
*7.4.1 Range of Specimen Correction Factors for Determining the Mixture Correction Factor (Temperature Compensated Internal Scale)* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 28
*7.4.2 Range of Specimen Correction Factors for Determining the Mixture Correction Factor (External Scale)* . . . . . . . . . . . . 29
**7.5 Summary of the Mixture Correction Factor Results** . . . . . . . . . . 30
*7.5.1 Temperature Compensated Internal Scale Mixture Correction Factors* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 30
*7.5.2 External Scale Mixture Correction Factors* . . . . . . . . . . . . . 31
**7.6 Measurement of Large Mixture Correction Factors** . . . . . . . . . . . 31
**7.7 Writing a Test Procedure** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 32

**8.0 CONCLUSIONS** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 32
**8.1 Test Procedure Development** . . . . . . . . . . . . . . . . . . . . . . . . . . 33
*8.1.1 Mixture Correction Factor Procedure* . . . . . . . . . . . . . . . . . 33
*8.1.2 Moisture Correction* . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 33

*8.1.3 Measurement Methods Evaluated* . . . . . . . . . . . . . . . . . . . 34
*8.1.4 Range of Specimen Correction Factors* . . . . . . . . . . . . . . . 35
*8.1.5 Probability Distribution for AC Content Determination* . . . . . 35
*8.1.6 Probability for the Range of Mixture Correction Factors* . . . . 35
**8.2 Documenting a Test Procedure** . . . . . . . . . . . . . . . . . . . . . . . . . . 36

*8.2.1 Positive and Negative Mixture Correction Factors* . . . . . . . . . . . 36
*8.2.2 Two Specimens per Field Produced Sample* . . . . . . . . . . . . 36

**9.0 RECOMMENDATIONS** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 36
**9.1 Recommendations Incorporated into CDOT CPL-5120** . . . . . . . . 36

**10.0 FUTURE RESEARCH** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 38

**11.0 REFERENCES** . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 38

## LIST OF FIGURES

FIGURE 1. NCAT Asphalt Content Ovens . . . . . . . . . . . . . . . . . . . . . . . . . 40
FIGURE 2. Electronic Housing Area . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 40
FIGURE 3. Oven Chamber and Exhaust Chamber Shown . . . . . . . . . . . . . 41
FIGURE 4. Filter Assembly Located on the Top of the Interior of the Oven Chamber . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 41
FIGURE 5. Safety Cage, Safety Equipment, and Basket Assembly Handling Utensil . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 42

## APPENDICES

APPENDIX A: Draft of Colorado Procedure L-5120
APPENDIX A-1: Virginia Procedure, VTM 102
APPENDIX B: Correction Factor Determination Test Form
APPENDIX C: Production Specimen AC Determination Test Form
APPENDIX D: Summary of Asphalt Content Accuracy and Precision using a Zero-Specimen Correction Mixture Factor for each Method of AC Measurement.
APPENDIX E: Summary of Asphalt Content Accuracy and Precision using a One-Specimen Correction Mixture Factor for each Method of AC Measurement.

APPENDIX F: Summary of Asphalt Content Accuracy and Precision using a Two-Specimen Correction Mixture Factor for each Method of AC Measurement.
APPENDIX G: Range of Specimen Correction Factors for each Bituminous Mixture. Frequency Range of Correction Factors, High-Low Diff.
APPENDIX H: Range of Positive and Negative Mixture Correction Factors. Mean and Standard Deviation of Mixture Correction Factors used in this Study.

## LIST OF TABLES

TABLE 1. Aggregate Sources Evaluated . . . . . . . . . . . . . . . . . . . . . . . . . . . . 21
Table 2. Mean and Standard Deviation for the Difference in AC Content for the Level of Specimen Correction Factors Used . . . . . . . . . . . . . 24
TABLE 3. Range (Lowest and Highest) Specimen Correction Factors for each Bituminous Mixture . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 28
TABLE 4. Range of Mixture Correction Factors for All Mixes Tested . . . . . 30

# 1.0 INTRODUCTION

The United States Environmental Protection Agency (EPA) is phasing out chlorinated solvents used in the United States. On January 1, 1996 a federal law went into effect banning the manufacture of 1,1,1 trichloroethane because it causes ozone depletion. This chemical was used, along with other chlorinated solvents (such as trichloroethylene), to aid in the determination of asphalt cement content and aggregate gradation of bituminous mixtures *(1)*. A new type of equipment has been introduced to physically burn the asphalt cement (AC) from bituminous mixtures, this eliminates the requirement for chlorinated solvents. This new type of equipment is known as an ignition oven.

Several companies manufacture the ignition ovens, including Barnstead/Thermolyne, Troxler, and Gilson Corporation. The Barnstead/Thermolyne equipment is known as the National Center for Asphalt Technology (NCAT) oven and this equipment was used to generate the data in this report. The ignition oven and the NCAT Asphalt Content Oven refer to the same equipment in this report.

## 1.1 Background

In June of 1995, the Colorado Department of Transportation (CDOT) purchased and received 6 NCAT Asphalt Content Ovens manufactured by Barnstead/Thermolyne Corporation. The CDOT Central laboratory, located in Denver, Colorado retained two of the ovens and distributed the remaining four ovens to different Regions throughout Colorado.

### 1.2 Method of Operation for the NCAT Asphalt Content Oven

A bituminous mixture specimen is placed inside the ignition oven's chamber which has been pre-heated to a temperature of 538° C (1000° F). The high temperature ignites and burns the AC. A scale housed within the ignition oven assembly (the internal scale) measures the weight of the specimen during the test, an electronic controller records the weight of the specimen once per minute on a tape printout. Once the controller has recorded identical weight measurements for two consecutive minutes, the oven sounds an audible beep signaling the end of the test. Identical weight measurements are scale readings which are the same when recorded using a scale accurate to 0.1 grams. It also calculates an AC content which is derived from the weight loss.

An external scale was also used to measure the amount of weight loss before and after using the NCAT Asphalt Content Oven. The measurements obtained by the external scale were used as an alternative method to the internal scale for calculating AC content.

## 2.0 PURPOSE

The purposes for the research conducted on the NCAT Asphalt Content Oven are listed below.

* **To Develop a Test Procedure for Testing Bituminous Mixtures Using the NCAT Asphalt Content Oven.**

* **To Document the Accuracy of the Measurement of AC content of Bituminous Mixtures Using the NCAT Asphalt Content Oven.**

* **To Write a Test Procedure for CDOT Using the NCAT Asphalt Content Oven.**

## 3.0 EXPERIMENTAL

Eighteen different bituminous mixtures from paving projects were heated inside an NCAT Asphalt Content Oven chamber until all of the AC was ignited and burned away. The AC content of the bituminous mixtures was calculated by measuring the amount of specimen weight loss that occurred during the heating process.

The weight loss was measured using three methods of measurement as described in Section 6.1.2.1 - 6.1.2.3, pp 17-18.

Different levels of specimen correction factors were used to adjust the AC content measurement of the bituminous mixtures after testing, as described in Section 4.3.1, page 5. The measured AC content was then compared to the actual AC content of the bituminous mixture and analyzed. The procedure resulting in the most accurate and precise method of AC content determination was then selected.

## 4.0 TERMINOLOGY

### 4.1 Specimen Correction Factor

A specimen correction factor is defined as the difference between the actual AC content and the measured AC content of a bituminous specimen. The correction factor accounts for factors which affect the measured AC content. It is assumed that these factors will be consistent for laboratory and field produced material.

### 4.2 Mixture Correction Factor

A mixture correction factor is defined as the average of the specimen correction factors which are added or subtracted to the measured AC content of a field produced bituminous mixture. The mixture correction factor may be determined by averaging one, two, or three sets of specimen correction factors. A mixture correction factor may be positive or negative.

## 4.3 Levels of Specimens Corrections Factors Used for Determining a Mixture Correction Factor

Three bituminous specimens from each paving project were available for this study.

### *4.3.1 Different Levels of Specimen Mixture Correction Factors*

A zero-, one- or two-specimen correction factor refers to the number of specimens averaged when determining a mixture correction factor. With a zero-specimen mixture correction factor no adjustment for the difference between the actual and measured AC contents from a previously tested specimen are made.
When a one-specimen mixture correction factor is used the difference between the actual AC content minus the measured AC content from one sample is applied to the AC content measurements of future samples from the same bituminous mixture. When a two-specimen mixture correction factor is used the difference between the actual and measured AC contents from the first and second specimen are averaged together and applied to the AC content measurement of future samples from the same bituminous mixture.

## 4.4 Temperature Compensation Factor

The Barnstead/Thermolyne Corporation has programmed a method for calculating the AC contents for bituminous specimens into the NCAT Asphalt Content Oven. The weight loss is represented as a percent weight loss, a temperature compensation factor (represented as a percent) is then subtracted from the percent weight loss to arrive at the calculated AC content. The temperature compensation factor is the apparent loss in weight that the internal scale measures when the basket assembly is heated without a specimen from room temperature to test temperature inside the oven chamber. The direct measurement of the AC content (listed on the tape printout as the calibrated AC content) can be obtained after the test.

### 4.5 NCAT Asphalt Content Oven Tape Printout

The NCAT Asphalt Content Oven produces a tape printout after testing a bituminous specimen. The tape printout lists the weight loss in grams during and after testing, the percent weight loss, a temperature compensation factor, a calibration factor, and the calibrated AC content. The term calibration factor listed on the tape printout is equivalent to the term mixture correction factor.

### 4.6 Internal Scale

The internal scale refers to the scale connected to and located below the NCAT Asphalt Content Oven chamber. This scale is located inside a metal enclosure and is considered to be an internal scale.

### 4.7 External Scale

The external scale is a scale that is not physically attached to the NCAT Asphalt Content Oven.

### 4.8 Lottman Test Specimen (CPL-5109)

Bituminous mixture specimens which were previously used as part of the Lottman moisture sensitivity test were saved for use with the NCAT Asphalt Content Oven. The specimens were mixed at design AC content. The specimens had been immersed in water for 4 $\pm$ 1 minutes to determine their bulk specific gravities following AASHTO T 166 and then tested using a compression machine. After the Lottman test, the specimens were stored on a shelf until they were tested using the NCAT Asphalt Content Oven. The specimens that were treated as described above are termed non-conditioned specimens.

### 4.9 Field Produced Sample

A field produced sample represents a quantity of bituminous mixture gathered from a stockpile or roadway. The word specimen represents a test quantity of bituminous mixture. Two separate identical specimens were taken from each field produced sample. The field produced sample is the bituminous mixture used for compliance testing.

## 5.0 EQUIPMENT

The equipment used in this experiment is as follows.

### 5.1 NCAT Asphalt Content Oven

*The NCAT Asphalt Content Oven* is a *forced-air ignition oven, with internal balance,* capable of maintaining a temperature of 538° C (1000° F). The NCAT Asphalt Content oven, manufactured by Barnstead/Thermolyne Corporation, was tested in this study. The ignition oven is shown in Figure 1. The NCAT Asphalt Content Oven consists of an electronic housing unit, an oven chamber and an exhaust chamber. The electronic housing unit is located underneath the oven chamber and is separated by an air space. This area of the unit houses the electronic controls as well as the internal scale used to monitor weight loss as shown in Figure 2. The oven chamber is located in the middle of the unit. A hearth tray located inside the oven chamber is supported by ceramic tubes which extend down to the internal scale. The accuracy of the internal scale balance was verified by placing calibrated weights on the hearth tray at room temperature. The oven chamber is heated electrically using ceramic heating elements as shown in Figure 3. The exhaust chamber is located above the oven chamber. An exhaust fan and filters are used to control the fumes while testing. Ceramic filters are used to capture larger particulates inside the oven chamber as shown in Figure 4.

A calibration correction factor may be entered using the digital keyboard located on the front of the NCAT Asphalt Content Oven. The NCAT Asphalt Content Oven did not allow for positive calibration correction factors at the time this study was conducted. A positive calibration correction factor is a correction value which is added to the measurement of AC content to adjust the AC content measurement upwards. A later version of the model will allow for positive mixture factors per the manufacturer's correspondence.

Specimen weights rounded to the nearest whole number are entered using the digital key board on the NCAT Asphalt Content Oven.

The NCAT Asphalt Content Oven provides a tape printout which lists the results from each test.

Possible mechanical failure and human error will effect the loss in weight recorded by the NCAT Asphalt Content Oven internal scale. Mechanical failure may occur if the basket assembly tilts inside the oven chamber during the test. The tilting may cause contact with the interior walls, resulting in a faulty weight loss measurement. Human error may occur if an incorrect initial test specimen weight is manually input and used to calculate the AC content by the ignition oven's software. This would result in a faulty percent weight loss recorded on the tape printout.

### *5.1.1 Installation of the NCAT Asphalt Content Oven*

The ignition oven was supported on a table top at a height range of 91cm (36in.) to 107cm (42in.) and leveled. The ignition oven was then wired electrically and vented per the manufacturer's instructions.

### *5.1.2 Initial NCAT Asphalt Content Oven Operation Problems*

An external exhaust system was constructed to prevent smoke from escaping into the laboratory.

The NCAT Asphalt Content Oven aborted tests intermittently. This situation was caused by high temperature readings above 750° C (1382° F) which were reported by the filter thermocouple. The problem was isolated in an electronic micro-chip. A revision to the software labeled as Revision D was made by the manufacturer and the problem was solved. All of the ignition oven's apparent problems were resolved prior to testing the bituminous mixtures used in this study.

### *5.1.3 Determining the Oven Chamber Set Point for Testing*

The NCAT and Virginia Department of Transportation (VDOT) determined that a temperature of 538° C (1000° F), resulted in complete burning of the asphalt binder in a bituminous mixture. This temperature was recommended as the temperature which allows the AC to burn without adversely affecting the aggregate. Set point temperatures higher than 550° C for a sustained period may cause an excessive amount of aggregate, such as limestone, to be burned inside the oven *(2).*

## 5.2 Additional Equipment

*Two stainless steel 2.36mm (No. 8) mesh perforated basket assemblies.*

The two basket assemblies are nested on top of each other with a drip pan located on the bottom of the assembly. This configuration allowed the bituminous mixture more surface area exposure and facilitated more complete burning of the AC.

*Asphalt mixer and mixing bowl.* A HOBART mixer (model N50) with an approximate capacity of 5 liters and capable of mixing approximately 1250 grams of aggregate.

*External scale.* A AND 20kg capacity scale accurate to 0.1 gram was used in this experiment.

*Miscellaneous equipment.* A pan having dimensions of approximately (L x W x H) 38 x 38 x 5 cm was used to contain the specimen after ignition. A steel wire brush was used to remove residual aggregate from the steel baskets after burn off. Handling equipment includes: gloves, face shield, and basket assembly transferring utensil as shown in Figure 5.

# 6.0 PROCEDURE

## 6.1 Procedure Development for Testing Bituminous Mixtures

The initial step in developing a Colorado test procedure using the NCAT Asphalt Content Oven involved reviewing the Virginia Department of Transportation's (VDOT) procedure *(3)*. See Appendix A-1.

Some portions of the VDOT procedure were modified to increase accuracy and reduce laboratory time required for testing. The Colorado procedure is similar to the VDOT procedure except as listed below.

### *6.1.1 Changes Proposed to the VDOT Procedure*

**6.1.1.1 Mixture Correction Factor Procedure** The VDOT procedure allows the option of using a bituminous mixture or an aggregate only method for determining a mixture correction factor.

It was decided that bituminous mixtures would be used to determine mixture correction factors. This decision was made because the bituminous correction specimens would better represent the field produced bituminous mixtures that will be ultimately tested for AC content. The AC and aggregate mixture may reveal weight loss properties that may not be present with an aggregate only specimen. Properties such as oxidation, oil volatilization, and flames would be present in a mixture and absent in an aggregate only specimen.

**6.1.1.2 AC Content of Correction Specimens** The VDOT procedure requires two specimens at design AC content as well as at $\pm$ 0.5 percent of the design AC content for a total of six correction specimens.

A decision was made to use three bituminous non-conditioned specimens (previously used in Lottman testing) for determining a mixture correction factor. This method was selected to decrease the testing required for each mix design. Mixing of Lottman specimens is currently required for each mix design, and will also be required under the SUPERPAVE mix design system which is being adopted by CDOT. Since these specimens are already needed, the additional work to obtain correction factor specimens would be minimal (recording oven dry aggregate and asphalt weights). Laboratories which do not perform mix designs would be required to mix three extra specimens at design AC content weighing approximately 1200 grams each. This may be done when mixing aggregate and AC blends for calibration pans used for nuclear gauges.

The correction factor specimens that were used to determine the mixture correction factors in this study were all mixed at the design AC content. Correction factor specimens at different AC contents were not used. The effect of different AC contents using the same aggregate has been shown to be statistically insignificant for measuring the AC contents of bituminous mixtures. The research was conducted and documented in a paper by Dr. Elton R. Brown, at Auburn University *(2)*.

**6.1.1.3 Specimen Moisture Content** The VDOT procedure requires a "separate specimen to be made for a moisture correction if deemed necessary". The moisture specimen may not be used for AC content measurement.

The Colorado procedure requires a forced air oven for removing the moisture from a bituminous mixture. The bituminous test specimens in this study were dried inside an oven at a temperature of 121° C (250° F) for 6 $\pm$ 1 hours to remove the moisture. The time of 6 $\pm$ 1 hours was determined as a result of an internal CDOT investigation in which 12 compacted bituminous mixtures were vacuum saturated and placed inside an oven at a temperature of 121° C (250° F) for 5 hours. The results showed that none of the samples retained more than 0.15 percent moisture and most retained none.

A 121° C oven was thought to be more favorable than a hot plate or microwave oven since these methods may not remove all moisture from the specimen and may cause the aggregate to break apart or explode in the intense heat produced inside the oven chamber of the NCAT Asphalt Content Oven.

Bituminous mixtures which are mixed in the laboratory and are stored for less than 24 hours may be dried inside an oven at 121° C (250° F) for 3 ± 1 hours. Bituminous mixtures that have been exposed to water saturation or sampled from the field must be dried inside a 121° C (250° F) oven for 10 ± 5 hours. This time specification allows samples obtained from the field to be tested efficiently during a normal 8-10 hour work day. The forced air oven may be turned on by a timer during off-work hours.

**6.1.1.4 Method for Reducing a Sample of a Bituminous Mixture to Test Size**

The VDOT procedure recommends that the sample be reduced by the quartering method.

Colorado procedures allow reduction of field produced samples to be reduced to test size using a scoop method, quartering or riffle splitter, CP-55 *(4)*.

**6.1.1.5 External Scale Method for AC Content Measurement** The VDOT procedure uses the temperature compensated internal scale alone to measure the weight loss and calculate the AC content of a bituminous specimen.

The Colorado DOT procedure requires the use of an external scale to measure the weight loss of the specimen after heating in the NCAT Asphalt Content Oven. The external scale method provides an easily understood method for measuring the AC content of a bituminous specimen.

**6.1.1.6 Non-temperature Compensated Internal Scale for AC Content Measurement** The precision obtained for the measurement of AC content using the non-temperature compensated internal scale was evaluated in addition to the external scale method. The results were then compared to the temperature compensated internal scale (VDOT method).

**NOTE:** The tolerance between the internal and the external scales measurements should be within ± 5 grams at the beginning of the NCAT Asphalt Content Oven test *(3)*. If the scales differ by more than 5 grams, one of the scales' readings is suspected to be a faulty measurement. The operator shall check to see if the basket assembly is contacting the interior walls of the NCAT Asphalt Content Oven chamber. If this is not the case both scales should be checked for calibration using calibrated weights.

### *6.1.2 Methods of AC Content Measurement*

The known or actual AC content of the specimens that were tested using the NCAT Asphalt Content Oven were compared using three methods for measuring the AC content. The three types of measurements were the temperature compensated internal scale, the non-temperature compensated internal scale, and the external scale. These methods are explained in more detail below.

**6.1.2.1 Temperature Compensated Internal Scale** The temperature compensated internal scale method measures the weight loss (at a set point oven chamber temperature of 538° C (1000° F)) by the NCAT Asphalt Content Oven Scale during the burn-off minus a temperature compensation factor, as described in Section 4.4. The AC content calculation is accomplished by measuring the weight loss inside the oven at a chamber temperature set point of 538° C (1000° F), representing this value as a percent weight loss, and then subtracting a temperature compensation factor. This is defined as the temperature compensated internal scale method for the calculation of AC content. This is done automatically by the manufacturer's software, to arrive at a calibrated AC content.

Note: A calibration correction factor of 0.0 was entered into the NCAT Asphalt

Content Oven using the keyboard in this study, since all correction factors were manually calculated.

**6.1.2.2 Non-Temperature Compensated Internal Scale** This method measures the weight loss (at a set point oven chamber temperature of 538° C (1000° F)) by the NCAT Asphalt Content Oven during the burn-off without subtracting a temperature compensation factor. The non-temperature compensated internal scale method does not compensate for the apparent loss in weight measured by the internal scale for the basket assembly. This method calculates the entire weight loss (measured by the internal scale at chamber temperature) as the percent of AC that was burned off while testing with the NCAT Asphalt Content Oven. The AC content is calculated by measuring the weight loss. The percent weight loss is reported as the percent AC content. The percent weight loss is a line item entry that can be obtained from the tape print out at the conclusion of each test. This calculation is defined as the non-temperature compensated internal scale method for the determination of AC content.

**6.1.2.3 External Scale Method** This method of measurement uses an external scale to weigh the bituminous mixture at 121° C (250° F) and basket assembly (at room temperature) before and after using the NCAT Asphalt Content Oven.

The procedure for calculating the AC content is as follows: The empty basket assembly is weighed at room temperature using an external scale and recorded. The total weight of the bituminous mixture specimen (placed inside the basket assembly) at a temperature of 121° C (250° F) is weighed before testing with the NCAT Asphalt Content Oven using an external scale (accurate to 0.1 gram) and recorded. The basket assembly is at room temperature. The weight of the empty basket assembly is subtracted from the total weight of the basket assembly with the specimen to obtain the specimen weight. The residual aggregate specimen and the basket assembly are weighed at room temperature after testing using the NCAT Asphalt Content Oven. The loss in weight of the basket assembly containing the residual aggregate after testing with the NCAT Asphalt Content Oven is represented as a percent weight loss. The percent weight loss is assumed to be AC loss only when field produced samples are tested in which a mixture correction factor was applied.

*6.1.3 Bituminous Mixture Sources* -

During the 1995 construction season, three previously tested non-conditioned CPL-5109 (Lottman) specimens were saved from each paving project for use with the NCAT Asphalt Content Oven. The oven dry aggregate and AC weights were recorded for each specimen at the time of mixing, so the actual AC content of each specimen could be calculated.

Several different asphalt paving projects were selected and tested according to the test procedure outlined in the "Virginia Test Method For Determination of Asphalt Paving Mixtures By the Ignition Method" (VTM-102), see Appendix A-1. Some of the measurements of AC content from the asphalt paving projects were lost during testing due to operator error or to NCAT Asphalt Content Oven malfunction. The aggregate sources are shown in Table 1. The measured AC contents using the three methods found in section 6.1.2 were compared to the actual AC content of each of the specimens.

**TABLE 1. Aggregate Sources Evaluated**

| LAB # | CDOT S/A # | PIT | CDOT REG. | LOCATION |
|---|---|---|---|---|
| 94X | 10057 | SMITH | 5 | ALAMOSA AREA |
| 102X | 10054 | PIKE VIEW | 2 | CO. SPRGS |
| 112X | 10514 | 25TH AVE | 4 | EAST PROSPECT VALLEY |
| 137X | 90026 | FOUNTAIN | 2 | WOODMAN RD. |
| 152X | 93151 | HARDROCK | 3 | SOUTH OF MALTA |
| 160X | 92019 | BESTWAY | 4 | GREELEY,I-76 BIJOU |
| 166X | 10671 | POUDRE TECH. | 4 | FORT COLLINS |
| 168X | 10736 | FREI | 4 | BRIGHTON |
| 177X | 10088 | VALCO | 3 | GUNNISON EAST |
| 184X | 10984 | SOUTHWAY | 5 | DEL NORTE TO 285 |
| 239X | 93029 | VAGNEUR | 3 | ROARING FORK RD. |
| 255X | 90025 | STATE | 2 | CUERNO VERDE |
| 261X | 10370 | MCLAUGLIN | 3 | SOUTH OF RANGLEY |
| 315X | 10654 | MENZER | 2 | PUEBLO AREA |
| 414X | 10944 | PENROSE | 2 | COLORADO SPRGS |
| 415X | 10944 | PIKEVIEW | 2 | COLORADO SPRGS |
| 417X | 10944 | PIKEVIEW | 2 | COLORADO SPRGS |
| 443X | 10945 | FRANCISCOTTI | 2 | M. P. TRINIDAD AREA |

The bituminous mixtures were obtained from mix design samples submitted to CDOT Central laboratory. Bituminous mixtures incorporating, rubberized, polymerized asphalt or RAP materials were not evaluated in this experiment

## 6.2 Documenting Accuracy

### *6.2.1 Initial Test Report Form*

The initial test form recorded data concerning specimen and basket assembly weights, before and after using the NCAT Asphalt Content Oven. The initial test form recorded the data listed on the NCAT Asphalt Content Oven tape printout and the AC content calculated by the external scale method.

### *6.2.2 Method of Analysis*

The actual AC content of all specimens were calculated from the information recorded at the time the specimens were mixed in the laboratory. The AC content for each of the specimens was then determined by three measurement methods. The results from each of the three measurement methods had a zero-, one-, or two-specimen correction factor applied.

The differences between measured AC contents and the actual AC content were tabulated in a computer spreadsheet program, and analyzed.

### *6.2.3 Evaluating the Level of Correction Specimens Used to Determine Mixture Correction Factors*

The different levels of specimen mixture correction factors were evaluated for each method (as described in Section 4.3.1) of measurement of AC content (temperature compensated internal scale, non-temperature compensated internal scale and external scale). The mean and standard deviation were calculated for the difference between the actual and measured AC contents for each of the three methods of AC content measurement.

### 6.3 Documenting the Procedure

The Colorado procedure for testing bituminous mixture specimens was similar to VDOT procedure with the exception of the changes mentioned in Section 6.1.

## 7.0 RESULTS AND DISCUSSION

### 7.1 Test Procedure Development

The changes that were proposed to the VDOT procedure appeared to yield accurate and precise results concerning the measurement of AC content. Most of the changes that were proposed to the VDOT procedure addressed the determination of the mixture correction factor. It was deduced from the results of the data, that positive as well as negative mixture correction factors were needed. Positive mixture correction factors were needed for some tests to bring the measured AC content up to the actual AC content of the bituminous mixture. The reason for positive correction factors is unknown at this time.

The accuracy and precision for the differences between the actual and the measured AC contents were calculated for each of the nine combinations (three specimen correction levels and three measurement methods). The results are shown in Table 2.

**Table 2. Mean and Standard Deviation for the Difference in AC Content for the Level of Specimen Correction Factors Used**

| Method of Measurement | Mean Error (0) Spec. Corr. | Std. Dev. (0) Spec. Corr. | Mean Error (1) Spec. Corr. | Std. Dev. (1) Spec. Corr. | Mean Error (2) Spec. Corr. | Std. Dev. (2) Spec. Corr. |
|---|---|---|---|---|---|---|
| Temp. Comp. Scale | 0.015 | 0.165 | 0.0 | 0.097 | 0.0 | 0.087 |
| Non-Temp. Comp. Scale | 0.263 | 0.170 | 0.0 | 0.102 | 0.0 | 0.087 |
| External Scale | 0.073 | 0.159 | 0.0 | 0.083 | 0.0 | 0.073 |

## 7.2 Documenting the Accuracy

### *7.2.1 Zero-Specimen Mixture Correction Factor Results for AC Content Measurement*

The difference between the actual and measured AC content for the temperature compensated internal scale was the most accurate when no mixture correction factor was applied, with a mean of 0.015 and standard deviation of 0.165.

The external scale method was the next most accurate method when no mixture correction factor was applied with a mean of 0.073 and a standard deviation of 0.159.

The non-temperature compensated internal scale yielded the least accurate method of AC measurement when no mixture correction factor was applied with a mean of 0.263 and a standard deviation of 0.170.

**Note:** The measured AC content for field produced samples may be inaccurate when no mixture correction factor is applied, if the bituminous mixture requires a one. Therefore, testing field produced samples for AC content without applying a mixture correction factor should be avoided if possible.

*7.2.2 One-Specimen Mixture Correction Factor Results for AC Content Measurement*

Using a one-specimen mixture correction factor applied to two other specimens for determining AC contents resulted in a standard deviation of 0.097 for the temperature compensated internal scale, 0.102 for the non-temperature compensated internal scale and 0.083 for the external scale.

*7.2.3 Two-Specimen Mixture Correction Factor Results for AC Content Measurement*

After applying a two-specimen correction factor, the temperature compensated internal scale and the non-temperature compensated internal scale had identical standard deviation values of 0.087 for the difference between the measured and actual AC contents. However the external scale measurement yielded a standard deviation of 0.073, 0.014 less than the other two measurement methods. **The external scale method was the most precise of the three methods evaluated when a two-specimen mixture correction factor was applied.** (See Appendix F).

The probability distribution for the error in AC measurement is the normal distribution function, Bell curve. The precision was increased significantly from a standard deviation of 0.159 (using a zero-specimen mixture correction factor) to 0.073 (using a two-specimen mixture correction factor). This would mean that the error in AC content determination using the NCAT Asphalt Content Oven would exceed approximately 0.15 percent one time in twenty. Two times the standard deviation (2 x 0.073 = 0.146) represents a 95 percent probability that the AC content will be less than or equal to 0.146 percent. A three-specimen correction factor would increase the precision even more.

A standard deviation between the actual and measured AC content of 0.06 percent was reported after a round robin study (in the Spring of 1995) conducted by NCAT using the more labor intensive VDOT procedure *(5)*. The study included 12 different laboratories.

**7.3 Discontinuing the Evaluation of the Non-Temperature Compensated Internal Scale after Applying a Two-Specimen Correction Factor**

The standard deviations for the temperature and non-temperature compensated scale were identical (when a two-specimen correction factor was used to determine the mixture correction factor) as shown in Table 2. The weight losses were identical because both measurements used the same internal scale. The difference between the two scale's measurements of AC content was equal to the temperature compensation factor.

Further evaluation of the non-temperature compensated scale was terminated. The temperature compensated internal scale was selected because the result of the AC content measurement is automatically calculated by the NCAT Asphalt Content Oven software. The draft of the Colorado procedure for the NCAT Asphalt Content Oven (CPL-5120) incorporates both the external and the temperature compensated internal scale methods for measuring AC contents, as shown in Appendix A.

*7.3.1 Importance of the Temperature Compensated Internal Scale*

The temperature compensated internal scale is important because it monitors when the bituminous mixture specimen reaches constant weight while inside the NCAT Asphalt Content Oven chamber. This constant weight monitoring system allows for the determination of the endpoint of the AC burn-off, (when the bituminous mixture is no longer losing weight, i.e. AC). The measured AC content print out from the NCAT Asphalt Content Oven may be used for acceptance at a future date, but is used only for information at this time. The temperature compensation factor is subtracted from the percent weight loss at the completion of the test. The calculation to derive the temperature compensation factor has not been disclosed by the manufacturer at this time. For this reason the NCAT Asphalt Content Oven printout is used as a cross reference, but will not be the AC content reported for project acceptance at this time. The calculation to determine the temperature compensation factor is currently a proprietary "industry patented entity" owned by Barnstead/Thermolyne Corporation. The calculation is programmed into their firmware, Programmable Read Only Memory, (PROM) electronic micro-chip. Therefore, CDOT could not support the value derived for measuring AC content, if required to do so in a contract compliance situation. CDOT would be unable to supply supporting documentation concerning the derivation for the temperature compensation factor.

**7.4 Range of Specimen Correction Factors for Determining a Mixture Correction Factor**

Table 3 shows the lowest and highest specimen correction factors, for the three specimens tested per paving project. Table 3 also shows the range between specimen correction factors (low and high values). Thirteen of the original eighteen paving projects had three specimens in which a range was calculated.

**TABLE 3. Range (Lowest and Highest) Specimen Correction Factors for each Bituminous Mixture**

| LAB # | LOW SPEC. CORR. FACT. | HIGH SPEC. CORR. FACT. | **RANGE TEMP. COMP. INTERNAL SCALE** | LOW SPEC. CORR FACT. | HIGH SPEC. CORR FACT. | **RANGE EXTERNAL SCALE** |
|---|---|---|---|---|---|---|
| 137x | 0 | 0.08 | 0.08 | -0.05 | 0.01 | 0.06 |
| 94x | -0.18 | -0.10 | 0.08 | -0.14 | -0.02 | 0.12 |
| 152x | -0.18 | -0.10 | 0.08 | -0.25 | -0.12 | 0.13 |
| 160x | 0.18 | 0.27 | 0.09 | 0.16 | 0.21 | 0.05 |
| 177x | -0.39 | -0.23 | 0.16 | -0.47 | -0.32 | 0.15 |
| 443x | -0.09 | 0.05 | 0.14 | -0.15 | -0.04 | 0.11 |
| 166x | 0.19 | 0.28 | 0.09 | 0.13 | 0.14 | 0.01 |
| 184x | -0.41 | -0.14 | 0.27 | -0.44 | -0.23 | 0.21 |
| 417x | -0.04 | 0 | 0.04 | -0.1 | 0.01 | 0.11 |
| 315x | 0.05 | 0.17 | 0.12 | -0.03 | 0.02 | 0.05 |
| 415x | -0.09 | 0.07 | 0.16 | -0.13 | -0.02 | 0.11 |
| 239x | 0.05 | 0.07 | 0.02 | 0.03 | 0.08 | 0.05 |
| 414x | -0.08 | 0.05 | 0.13 | -0.14 | -0.02 | 0.12 |

The range between the highest and lowest correction factors is important. If the range is greater than 0.30 percent there is a strong possibility that an error occurred while mixing or reading a scale measurement. This rationale is supported by the data presented below.

*7.4.1 Range of Specimen Correction Factors for Determining the Mixture Correction Factor (Temperature Compensated Internal Scale)*

When the difference between the highest and lowest specimen correction factors were calculated for each bituminous mixture (using the temperature compensated internal scale), the following results were noted. Twelve out of the thirteen bituminous mixtures or 92 percent had ranges of specimen correction factors of ≤ 0.25 percent (high and low values). Ten out thirteen bituminous mixtures or 77 percent had specimen correction factor ranges of ≤ 0.15 percent. The data is tabulated in Appendix G.

*7.4.2 Range of Specimen Correction Factors for Determining the Mixture Correction Factor (External Scale)*

When the difference between the highest and lowest specimen correction factors (range) was calculated for each bituminous mixture using the external scale, the following results were noted. Of the bituminous mixtures tested, thirteen out of thirteen or 100 percent had a range of specimen correction factors of ≤ 0.25 percent (high and low values). Eleven out of thirteen bituminous mixtures or 85 percent had a specimen correction factor range of ≤ 0.15 percent. The data is tabulated in Appendix G. The range of the specimen correction factors was less than 0.25 percent for each of the bituminous mixtures when the external scale was used. The data is tabulated in Appendix D.

### 7.5 Summary of the Mixture Correction Factor Results

Table 4 shows the number of positive and negative mixture correction factors for the bituminous mixtures tested.

**TABLE 4. Range of Mixture Correction Factors for All Mixes Tested**

| TYPE OF MEASURE-MENT | # OF POSITIVE MIXTURE CORR. FACTORS | # OF NEGATIVE MIXTURE CORR. FACTORS | MIXTURE CORR. FACTORS **LOW** | MIXTURE CORR. FACTORS **HIGH** | # OF BIT. MIXES |
|---|---|---|---|---|---|
| **TEMP. COMP. INTERNAL SCALE** | 8 | 8 | -0.24 | 0.33 | 16 |
| **EXTERNAL SCALE** | 6 | 11 | -0.20 | 0.39 | 17 |

#### *7.5.1 Temperature Compensated Internal Scale Mixture Correction Factors*

The range for the lowest and highest mixture correction factors for *all* of the bituminous mixtures tested was nearly 0.6 percent (-0.24 to 0.33) when using the temperature compensated internal scale method. The greatest *positive* mixture correction factor was 0.33 percent and the greatest *negative* mixture correction factor was -0.24 percent for **all** of the bituminous mixtures tested. The data is tabulated in Table 4.

### *7.5.2 External Scale Mixture Correction Factors*

The range between the lowest and highest mixture correction factors for *all* of the bituminous mixtures tested varied by nearly 0.6 percent (-0.20 to 0.39) using the external scale method. The greatest *positive* mixture correction factor was 0.39 and the greatest *negative* mixture correction factor was -0.20. The data is tabulated in Table 4. (The mean was 0.047 and the standard deviation was 0.165 for 17 paving projects). See Appendix H.

## 7.6 Measurement of Large Mixture Correction Factors

Some aggregates may have positive or negative mixture correction factors greater than 0.3 percent. Mixture correction factors greater than $\pm$ 0.3 percent have been reported by the VDOT, which has been attributed to the large amount of limestone contained in their aggregate sources. Large mixture correction factors may be experienced in some areas of Colorado, Grand Junction (Region 3) has reported mixture factors as large as $\pm$ 0.6 percent from unknown aggregate sources.

Mixture correction factors may be either positive or negative depending on the aggregate tested inside the ignition oven. Mixture correction factors for some bituminous mixtures may exceed a lower range limit of -0.4 percent and a upper range limit of +0.4 percent. Possible reasons for some aggregate types exceeding the range limits documented in this study may be due to several factors: including, natural oil in the aggregate oil shale, limestone, or excessive organic material. Table 3 shows the range between the lowest and highest specimen correction factors for each of the bituminous mixtures tested in this study using the temperature compensated internal scale and external scale.

### 7.7 Writing a Test Procedure

A procedure was written which incorporated the most accurate, precise and efficient method of measurement of AC content. The procedure also incorporated the most accurate and precise method for determining a mixture correction factor. See Appendix A.

## 8.0 CONCLUSIONS

The results for the accurate and precise measurement of AC content when using the NCAT Asphalt Content Oven look encouraging. Laboratory work indicates that the accuracy of the ignition oven for measuring AC contents is at least as good as current extraction methods *(2)*. No solvents are required; thus, this method solves an existing waste disposal problem. The purposes for this experiment were to accomplish the following objectives.

## 8.1 Test Procedure Development

### *8.1.1 Mixture Correction Factor Procedure*

The VDOT procedure provides the option of using specimens of bituminous mixtures or aggregate only for determining a mixture correction factor. The procedure using bituminous mixture specimens requires that two specimens be mixed at design content and at $\pm$ 0.5 percent of the design asphalt content for a total of six specimens. The VDOT procedure uses the temperature compensated internal scale only. Using a six-specimen correction factor the standard deviation for the difference between the actual and measured AC content was 0.06.

When the external method was used the standard deviation for the difference between the actual and measured AC content was 0.073 (using a two-specimen mixture correction factor). It was concluded that a three-specimen mixture correction factor would increase the precision even more.

### *8.1.2 Moisture Correction*

The CDOT procedure requires that all bituminous specimens be dried in an oven at a temperature of 121° C (250° F) to remove moisture before they are tested.

It was concluded that bituminous mixtures dried using the CDOT procedure will not require a moisture correction.

*8.1.3 Measurement Methods Evaluated*

The external scale provides the most accurate, precise and simplest method for measuring the AC content of bituminous mixtures. It was determined that the **external scale** method was the most accurate and precise method of the three measurement methods analyzed for AC content determination. The external scale method for AC content measurement is not dependant on a temperature compensation factor and provides the most easily understood method for measuring AC content. The two-specimen correction factor used for determining the mixture correction factor yielded the best precision using the external scale method. (See Appendix F). It was concluded that a three-specimen correction factor used to determine a mixture correction factor would result in a even more precise measurement of AC content.

The CDOT procedure reports the results measured using the external scale method and a three-specimen mixture correction factor. The temperature compensated internal scale is used to monitor the point at which the specimen is no longer losing weight and to verify the correctness of the external scale method.

*8.1.4 Range of Specimen Correction Factors*

The range between the lowest and highest specimen correction factor must be less than 0.30 percent per Section 7.4.2.

*8.1.5 Probability Distribution for AC Content Determination*

The standard deviation for the most precise method, (the external scale) using a two-specimen mixture correction factor was found to be 0.073 when measuring the AC content. This would mean that the error in AC content determination using the external scale method would exceed 0.15 percent one time in twenty (95 percent probability, 2 times the standard deviation). In addition it is expected that a three-specimen correction would improve the precision even more.

The error estimated using the external scale method does not include the cumulative error added during field production sampling and splitting of the bituminous mixture.

*8.1.6 Probability for the Range of Mixture Correction Factors*

The seventeen mixture correction factors had a mean and standard deviation of -0.047 and 0.165 respectively (Appendix G). There was a 95 percent probability that the mixture correction factors would be within the limits of -0.283 and 0.377. This would apply only to the bituminous mixtures tested in this study. Aggregates in other states may have more extreme mixture correction factors. This illustrates that mixture correction factors should be used on all bituminous mixtures tested using the NCAT Asphalt Content Oven.

### 8.2 Documenting a Test Procedure

#### *8.2.1 Positive and Negative Mixture Correction Factors*

Mixture correction factors may be positive or negative.

#### *8.2.2 Two Specimens per Field Produced Sample*

The testing of two specimens per field produced sample would further increase the accuracy of AC content determination.

## 9.0 RECOMMENDATIONS

### 9.1 Recommendations Incorporated into CDOT CPL-5120

Based on the above conclusions, CPL-5120 has been adopted and incorporates the following:

* External Scale Method- It is recommended that the external scale methoa of AC content measurement be reported. It is also recommended that the temperature compensated internal scale method of AC content measurement be used for verification of the external scale measurement.

* Three-Specimen Mixture Correction Factor- A three-specimen mixture correction factor is recommended using the external scale method for the measurement of AC content.

* Bituminous Specimens Mixed at Design Content- It is recommended that bituminous mixtures mixed at the design AC content be used to determine mixture correction factors.

* Moisture Correction- It is recommended that samples be heated to a temperature of 121° C (250° F) for at least 5 hours in a forced air oven to remove the moisture from bituminous mixtures.

* Reducing Samples to Test Size- It is recommended that CP-55 be used to reduce samples to testing size. Since this method has been used sucessfully for reducing

samples for solvent extractions at the CDOT.

* Testing Two Field Produced Specimens- It is recommended that a minimum of two specimens per sample be used to measure the AC contents of field produced samples.

* Bituminous Mixture Specimen Correction Factors- It is recommended that specimens produced from the same aggregate and AC sources as field produced material be used to determine correction factors.

## 10.0 FUTURE RESEARCH

Bituminous mixtures which contain modified AC (polymerized or rubberized) or recycled asphalt pavement should also be included in a study to determine the accuracy for measuring the AC content when using the NCAT Asphalt Content Oven. A second study for the aggregates found in Colorado could be conducted for determining mixture correction factors at several AC contents (developing a mixture curve) ie. optimum AC content, and +/- 0.5 percent.

## 11.0 REFERENCES

1. Banasiak, David (1996). Testing Asphalt with Ignition Burn-

Off Ovens. *Roads and Bridges*, January, 1996, pp. 38-48.

2. Elton R.Brown, Nicholas E. Murphy, Li Yi, and Stuart Mager, (1995). *Historical Development of Asphalt Content Determination by the Ignition Method*, Paper prepared for presentation a the 1995 meeting of the Association of Asphalt Paving Technologists, section IV, pp. 7-13.

3. Prowell, Brian, (1995). *Virginia Test Method for Determination of Asphalt Content from Asphalt Paving Mixtures By the Ignition Method*, Designation VTM 102

4. CP-55, Reducing Samples of Hot Bituminous Pavement to Test Size

5. E. Ray Brown, (Spring 1995). *Asphalt Technology News*, Volume 7, Number 1

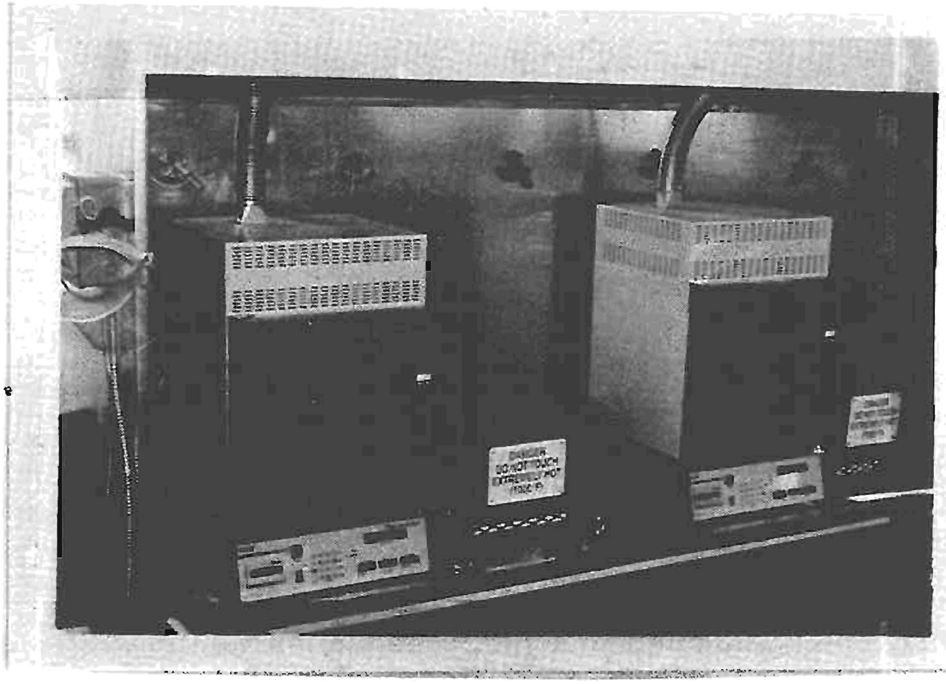


**FIGURE 1. NCAT Asphalt Content Ovens Shown, Manufactured by Barnstead/Thermolyne Corporation, Model # F85938**

**FIGURE 2. Electronic Housing Area**, Showing Electronic Scale

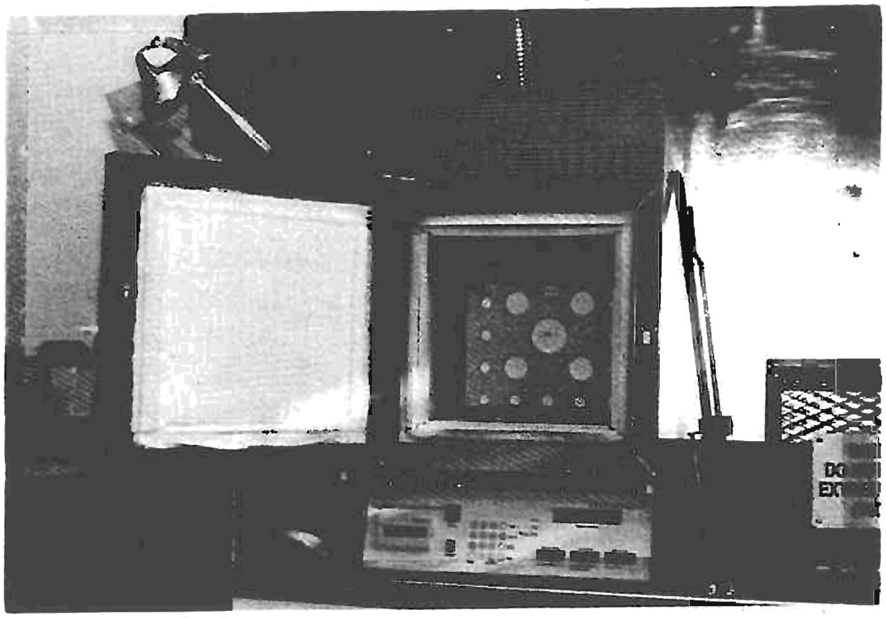


**FIGURE 3. Oven Chamber and Exhaust Chamber Shown**

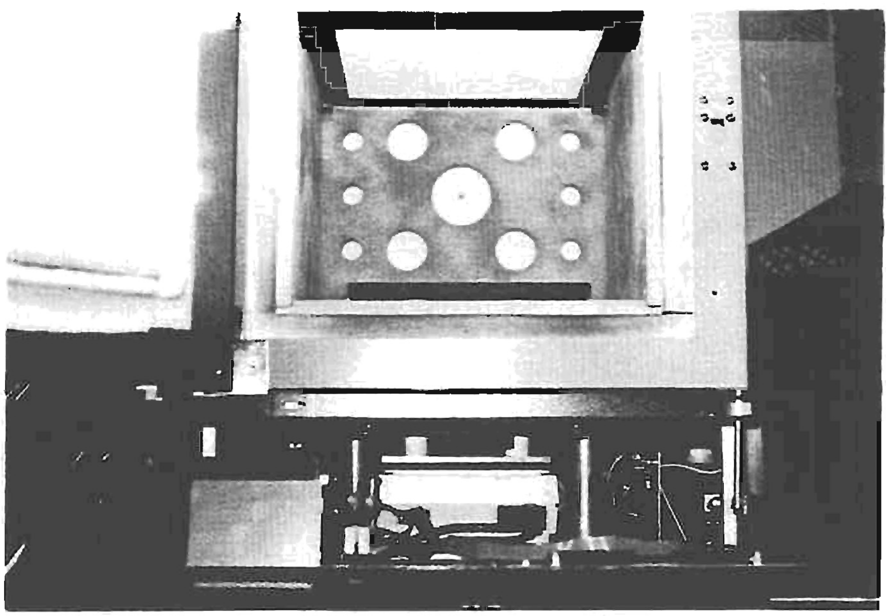


**FIGURE 4. Filter Assembly Located on the Top of the Interior of the Oven Chamber**

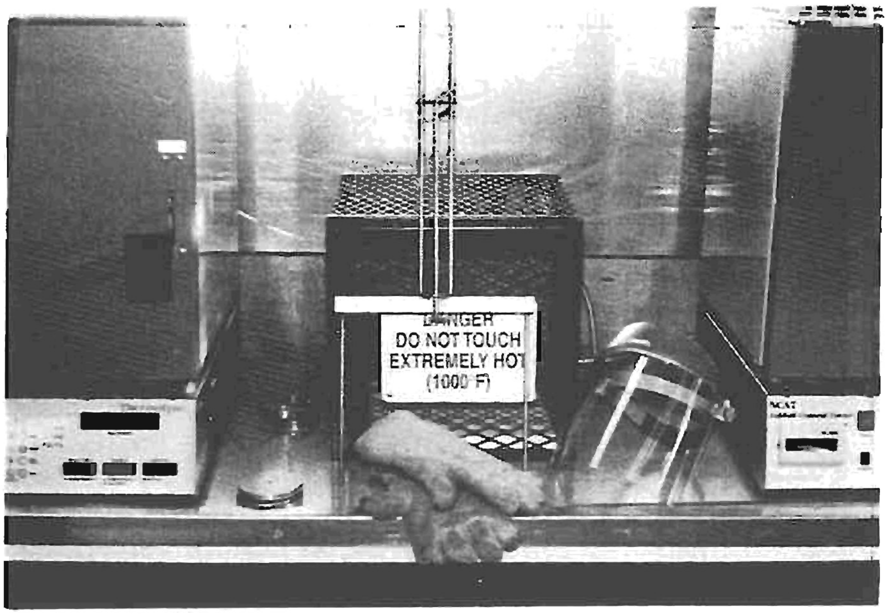



**FIGURE 5. Safety Cage, Safety Equipment, and Basket Assembly Handling Utensil**

## Appendix A

## Draft of CPL-5120

## Method of Test For

## Determination of the Asphalt Binder

## Content of Bituminous Mixtures

## By the Ignition Method

Colorado Procedure
L 5120

Method of Test For

# Determination of the Asphalt Binder Content of Bituminous Mixtures By the Ignition Method

## 1. Scope

1.1 This method of test determines the asphalt binder content of bituminous mixtures by heating the mixture until the asphalt binder fraction of the mix ignites and is burned away. The gradation of the remaining aggregate may then be determined using CP 31. The applicability of this procedure to mixtures containing recycled asphalt pavement (RAP) has not been determined.

1.2 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

## 2. Referenced Documents

*Colorado Procedures:*

| | |
|---|---|
| CP-30 | Field Sampling Aggregates for use as Highway Material |
| CP-31 | Sieve analysis, -200 Washed Gradation |
| CP-41 | Sampling Fresh Bituminous Paving Mixtures |
| CP-55 | Method for reducing samples of Hot Bituminous Pavements to Test size |
| CP-L 5105 | Standard Practice for Preparation of Test Specimens of Bituminous Mixtures by Means of Gyratory Shear Compactor |
| CP-L 5115 | Standard Method for Preparing and Determining the Density of Bituminous Mixture Test Specimens by Means of the SHRP Gyratory Compactor |

## 3. Summary of Test Methods

3.1 A specimen of bituminous mixture is heated in an oven having a temperature of 538° C (1000° F) until the asphalt binder fraction ignites and is burned away. The asphalt binder content is calculated by dividing the weight loss of the specimen during ignition by the mass of the bituminous mixture before ignition. A correction factor is determined for each bituminous mixture and then applied to the measured asphalt binder content of field produced bituminous mixture.

## 4. Apparatus

4.1.1 *Forced-air ignition furnace, with internal balance,* capable of maintaining a temperature of 500° C (930° F) to 650° C (1200° F), having an internal balance thermally isolated from the furnace chamber and accurate at room temperature to 0.1 gram. The balance shall be capable of weighing a 3,500 gram specimen contained in a basket assembly while it is heated. The National Center for Asphalt Technology Asphalt Content Tester (NCAT oven), is an oven containing a temperature compensated internal scale which has been found to be suitable for determining asphalt binder contents. It is the only oven which currently has been evaluated for the purposes of this procedure.

4.1.2 *Forced-air ignition furnace, without internal balance,* capable of maintaining a temperature of 500° C (930° F) to 650° C (1200° F) may also be suitable. A testing procedure has not been developed or tested using this type of equipment. Potential users of this type of equipment will need to develop and use a test procedure which can be shown by statistical methods to provide adequate test result accuracy.

4.2 *Two tempered stainless steel 2.36 mm (No. 8) mesh perforated basket assemblies,* approximate dimensions (L x W x H) 26.7 x 26.7 x 5.1 cm with 5 cm support legs. The baskets shall be nested. The top basket shall be provided with No. 20 mesh screening on the legs to confine the aggregate.

4.3 *Stainless steel catch/drip pan* per basket assembly, approximate dimensions (L x W x H) of 28.0 x 28.0 x 2.6 cm.

4.4 *Oven* - A forced draft oven capable of maintaining a temperature of 121 ± 5°C.

4.5 *External balance*, at least 10 kg capacity, sensitive to 0.1 g.

4.6 *Safety equipment*: High temperature face shield, gloves, and a fire resistant long sleeve coat. In addition, a heat resistant surface capable of withstanding a temperature of 650° C and a protective cage capable of surrounding the basket assembly shall be provided.

4.7 *Miscellaneous equipment*: a pan having dimensions of approximately (L x W x H) 38 x 38 x 5 cm for transferring specimen after ignition, spatulas, bowls, and wire brushes.

## 5. Reducing Production Samples to Test Size

**NOTE 1**: The word *specimen* represents a test quantity of bituminous mixture. When the specimen's mass exceeds the capacity of test equipment, it may be divided into multiple units, tested, and the results recombined.

**NOTE 2**: The word *sample* represents a quantity of bituminous mixture gathered from a stockpile or roadway in accordance with CP-41.

5.1.1 If the bituminous mixture is not sufficiently soft to separate with a spatula or trowel, place it in a pan and warm it in a 121° C (250° F) oven until it can be so handled.

5.1.2 Sampling of HBP shall be done according to CP-30. Two separate, identical specimens shall be selected from each bituminous mixture production sample in accordance with CP-55. The two specimens shall not be combined at any time after they have been taken.

5.2 The specimens shall conform to the mass requirements shown in the appropriate column of Table 1 depending on whether or not an aggregate gradation is required.

## 6. Determination of Mix Correction Factors Using Laboratory Mixed Specimens

6.1 The results measured by this procedure may be affected by the types of aggregate and asphalt binder contained in the bituminous mixture. To ensure accuracy, a correction factor shall be established for each mix design.

6.2 At least three laboratory produced specimens conforming to the mass requirements of Table 1 (gradation not required) shall be prepared at the design asphalt binder content. Record the weights according to Section 6.2.1

**TABLE 1: Size of Specimen**

| Nominal Maximum Aggregate size, mm | Sieve size | Minimum mass of specimen (g). **(If a gradation is required)** | Minimum mass of specimen (g). **(If a gradation is not required)** |
|---|---|---|---|
| 4.75 | (no. 4) | 1200 | 1100 |
| 9.5 | 3/8 in. | 1200 | 1100 |
| 12.5 | ½ in. | 1700 | 1100 |
| 19.0 | 3/4 in. | 2200 | 1500 |
| 25.0 | 1 in. | 3000 | 2200 |
| 37.5 | 1 ½ in. | 5500 | 3300 |

Some specimen weights specified here may exceed the capacity of the temperature compensated internal oven scale. These specimens may be divided, the separate parts tested and the results recombined.

and follow the instructions for the Preparation of Laboratory Produced Specimens contained within CP-L 5105 or CP-L 5115.

6.2.1 Before mixing the specimens, record the weights of both the oven-dry aggregate and the asphalt binder contained in each specimen to the nearest 0.1 gram.

6.3 Follow Sections 7.1 through 7.14 to obtain an uncorrected asphalt binder content determination for each of the three specimens.

6.4 Determine the difference, or correction factor, between the actual asphalt binder content and the uncorrected asphalt binder content measured using both the temperature compensated internal oven scale and the external scale for each of the three specimens as specified in Sections 6.4.1 to 6.5.

6.4.1 Determine the actual asphalt binder content for each of the specimens (Section 9.1).

6.4.2 Following Section 7, determine the measured asphalt binder content for each of the specimens using both the external scale (Section 9.2.1) and the temperature compensated internal oven scale (Section 9.2.2).

6.4.3 Determine the correction factors for each of the specimens (Section 9.3).

**NOTE 3**: If the difference between the lowest and highest correction factor is greater than 0.30 percent, then mix and burn another specimen or specimens until the correction factors determined using three specimens of the same bituminous mixture are within 0.30 percent of each other.

6.5 Calculate the average correction factors for both the external scale and the temperature compensated internal oven scale.

**7. Test Procedure**

7.1 All production specimens shall be dried as specified in Section 7.1.1. Laboratory mixed specimens which have been exposed to moisture or have been stored at less than 100° C (212° F) for greater than 48 hours shall be dried according to Section 7.1.1. Laboratory mixed specimens which have not been exposed to moisture and which have not been stored at less than 100° C (212° F) for greater than 48 hours shall be heated according to Section 7.1.2.

7.1.1 Specimens as specified in Section 7.1 shall be dried in a 121° C (250° F) oven for 10 ± 5 hours.

7.1.2 Initially dry specimens (as specified in Section 7.1) shall be heated by placing them into a 121° C (250° F) oven for 3 ± 1 hours.

7.2 Set the test temperature to 538° C (1000° F) by pressing the "TEMP" key on the NCAT oven, entering "538" and pressing the "ENTER" key. Allow a minimum of 2-1/2 hours for the NCAT oven to reach test temperature. Record the temperature set point prior to the initiation of the test.

7.2.1 Enter a correction factor of zero into the NCAT oven keyboard for all mixes by pressing the "CALIB" key, entering "0" and pressing the "ENTER" key. Press the "CALIB. FACTOR" key on the NCAT oven panel to verify that the correction factor is zero. The correction factor is labeled as the "calib. factor" on the NCAT oven tape printout

7.3 Weigh the empty basket assembly, consisting of the two baskets and drip pan with wire guards in place, on an external scale and record the weight.

7.4 Remove the top basket of the assembly and evenly distribute approximately ½ of the testing specimen in the bottom basket. Spread the bituminous mixture to a uniform depth in the tray, leaving a gap of approximately 10 mm between the specimen and the edge of the basket. Finer material should be kept near the center of the basket tray.

7.5 Place the top tray onto the bottom tray and load the remaining specimen into the top tray. Place the top cover over the basket and fasten the restraining wire into the slots on the drip tray of the basket assembly.

7.6 Weigh the loaded basket assembly on an external scale and record the weight. Determine the net weight of the mix contained in the basket assembly.

7.7 Press the "WEIGHT" button on the NCAT oven keyboard and enter the weight of the bituminous mixture being tested, rounded to the nearest whole gram, into the temperature compensated internal scale oven and then press the "ENTER" button.

7.8 Tare the temperature compensated scale oven digital readout by pressing a wire into the hole at the right hand end of the display panel.

**NOTE 4: Wear protective clothing (Section 4.6) whenever working near the NCAT oven while the oven door is open.**

7.9 Open the chamber door. Lift the loaded basket assembly using the locking handle tool and place it into the NCAT oven. Close the oven door and allow 2 to 3 seconds for the oven scale to stabilize. Compare the external scale reading of the loaded basket assembly weight to the NCAT oven scale reading. Verify that the NCAT oven scale's weight reading equals the weight determined in Section 7.6 within ± 5 grams. Differences greater than 5 grams or failure of the oven scale to stabilize may indicate that the basket assembly is contacting the interior walls of the oven.

7.10 Initiate the test within 10 seconds of closing the oven door by pressing the "START/STOP" button. This will lock the oven door. After approximately 20 seconds the temperature compensated internal oven scale will zero itself and the digital timer will start running.

**NOTE 5: Do not attempt to open the oven door while Error 11 is flashing since the oven's contents may ignite violently. Turn off the oven and allow the contents to cool before opening the oven door.**

7.11 Once the specimen weight is stable for a period of 2-3 consecutive minutes the light indicating a stable weight will illuminate without blinking and an audible beep will sound. Press the "START/STOP" button to stop the test and unlock the oven door. Use the locking handle to remove the basket assembly within 5 minutes of the illumination of the light signaling the end of the test.

7.12 Place the hot basket assembly on top of the ceramic cooling plate and place the safety cage over it.

7.13 Remove the printed tape from the temperature compensated internal oven scale and record the weight loss in percent, the temperature compensation, and the calculated asphalt binder content for the specimen. Record the specimen number and retain the printout as a record of the test.

7.14 Allow a minimum of 35 minutes for the basket assembly to cool to room temperature or until it is warm to the touch. Weigh the basket assembly containing the residual aggregate on an external scale and record the weight.

7.15 Determine the uncorrected asphalt binder content for the external scale and the temperature compensated internal oven scale (Sections 9.2.1 and 9.2.2).

7.16 Determine the corrected asphalt binder content for the external scale and the temperature compensated internal oven scale (Section 9.4)

**8. Gradation (Optional)**

8.1 Empty the residual aggregate from the baskets into a flat pan. Use a small wire brush to ensure that any residual fines are removed from the baskets. Weigh the residual aggregate on an external scale and record the weight.

8.2 Perform a gradation analysis in accordance with CP 31.

8.3 CDOT has verified that the gradation results are the same with and without exposure to heat for aggregates from a wide variety of sources. However, there may be aggregates which degrade when exposed to the heat required to burn asphalt binder. If aggregate degradation is suspected, or if the test results will be used for project acceptance, Sections 8.3.1 to 8.3.6 may be used to verify whether aggregates have a tendency to degrade.

8.3.1 Obtain a sample of the final aggregate blend in question from a conveyor belt discharge or a stopped conveyor belt according to CP 30.

8.3.2 Using a sample splitter, split a sample weighing at least 8 times the sample size specified in Table 1 (gradation required) into 8 specimens having approximately equal mass. Set 4 specimens aside.

8.3.3 Mix 4 of the aggregate specimens with asphalt cement to yield specimens having an asphalt binder content within 0.5 percent of the mix in question.

8.3.4 Test the 4 mixed specimens as specified in Section 7.

8.3.5 Using CP-31, determine the gradation of the 4 specimens which were mixed with asphalt binder and burned. Determine the gradation of the 4 specimens which were set aside in Section 8.3.2.

8.3.6 Calculate the average percent passing each sieve size for the 2 sets of 4 specimens. Compare the average gradation at each sieve size for the two sets of specimens. If the gradation of the aggregate exposed to the heat applied in Section 8.3.4 is more than 3 percent finer than the untreated aggregate on any of the sieves, the aggregate may be sensitive to heat degradation. If the average gradation is within 3 percent on all screens, the aggregate is not sensitive to heat degradation.

8.3.7 If an aggregate has been found to be sensitive to heat degradation in Section 8.3.6, apply a correction factor to the percent passing each screen to account for the degradation caused by the NCAT oven.

## 9. Calculations

9.1 The actual asphalt binder content of a laboratory mixed specimen is determined as follows:

$$P_{b(actual)} = \frac{W_b}{W_s + W_b} \times 100$$

where,

$P_{b(actual)}$ = percent of asphalt binder in specimen
$W_s$ = weight of aggregate in specimen
$W_b$ = weight of asphalt binder in specimen

9.2.1 The uncorrected asphalt binder content of a specimen is determined using an external scale as follows:

$$P_{b(uncorr)} = \frac{(W_{m(initial)} + W_{basket}) - (W_{m(final)} + W_{basket})}{(W_{m(initial)} + W_{basket})} \times 100$$

where,

$P_{b(uncorr)}$ = uncorrected asphalt binder content, in percent, determined by the mass loss measured on an external scale.
$W_{m(initial)}$ = Weight of the bituminous mixture specimen before using the temperature compensated internal oven scale measured at 121° C (250° F).
$W_{m(final)}$ = Weight of the bituminous mixture specimen after using the temperature compensated internal oven scale measured at room temperature.
$W_{basket}$ = Weight of the empty basket assembly at room temperature.

9.2.2 The uncorrected asphalt binder content of a specimen is automatically calculated by the temperature compensated internal oven's scale software using the bituminous mixture weight input in Section 7.7. At the end of each test, the uncorrected asphalt binder content is printed on a paper tape.

9.3 The mix correction factor is determined for asphalt binder contents determined using each method of measurement (both the external scale and the temperature compensated internal oven scale) as follows:

$$C_f = P_{b(actual)} - P_{b(measured)}$$

where,

$C_f$ = asphalt binder correction factor determined for a specific method of measurement e.g. using the external or the temperature compensated internal oven scales.

$P_{b(measured)}$ = uncorrected asphalt binder content of a specimen as determined in Sections 9.2.1 or 9.2.2.

9.4 The corrected asphalt binder content for field produced specimens using both the external scale and the temperature compensated internal oven scale is determined as follows:

$$P_{b(corr)} = P_{b(uncorr)} + C_f$$

where,

$P_{b(corr)}$ = asphalt binder content of field produced specimens corrected for the aggregate and asphalt binder sources.

## 10. Report

10.1 Report the corrected asphalt binder contents determined using the external scale. Results from the temperature compensated internal oven scale should be reported for information only.

## Appendix A-1

## Virginia Test Method For Determination Of Asphalt Content From Asphalt Paving Mixtures By the Ignition Method, VTM 102

Revised April 25, 1995

# Virginia Test Method For Determination of Asphalt Content From Asphalt Paving Mixtures By the Ignition Method

## Designation: VTM 102

## COMPLETE TEST METHODOLOGY

INDEX


1. Scope....................................................Page 2
2. Referenced Documents............................Page 2
3. Summary of Test Methods........................Page 2
4. Apparatus...............................................Page 2
5. Sampling.................................................Page 3

CALIBRATION

6a. Mixture Calibration................................Page 4

ALTERNATE CALIBRATION

6b. Aggregate Only Calibration...................Page 5
7. Test Procedure.......................................Page 6
8. Gradation...............................................Page 6
9. Report...................................................Page 6
10. Precision and Bias................................Page 6

## 1. Scope

**1.1** This test method covers the determination of asphalt content of hot-mixed paving mixtures by ignition of the asphalt cement at 538° C (1000° F)in a furnace. The aggregate remaining can be used for sieve analysis using AASHTO Test Method T 30.
**1.2** The values stated in metric units are to be regarded as the standard.
**1.3** This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

## 2. Referenced Documents

**AASHTO Standards:**

**T 248** Practice for Sampling Bituminous Paving Materials
**T 30** Mechanical Analysis of Extracted Aggregate

## 3. Summary of Test Methods

**3.1** The asphalt in a sample of hot-mix paving material is burned by ignition at 538° C (1000° F).The asphalt content is calculated from the mass of ignited aggregate, moisture content, and temperature compensation for the change in mass of the sample container. The asphalt content is expressed as mass percentage of the moisture-free mixtures. This method may not be applicable to mixes containing fibers or ground tire rubber (dry process).

## 4. Apparatus

**4.1** A forced air ignition furnace, capable of maintaining the temperature at 650° C (1200° F), with an internal balance thermally isolated from the furnace chamber accurate to 0.1 g. The balance shall be capable of weighing a 3,500 gram 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 provide a printed ticket with the initial specimen weight, specimen weight loss, temperature compensation, correction factor, corrected asphalt content (%), test time, and test temperature. The sample chamber dimensions shall be at least 35.6 x 26.7 x 35.6 cm (W x H x D) (14 x 10.5 x 14 inches). A method for reducing furnace emissions shall be provided. The furnace shall provide an audible alarm and indicator light when the sample weight loss remains constant for two consecutive minutes. The furnace door shall be locked until the completion of the test procedure.
*Note:* The National Center for Asphalt Technology (NCAT) Asphalt Content Tester manufactured by Barnstead/Thermolyne and distributed exclusively by **Q/C Resource (800) 296-7171** has been found to be suitable.
**4.2** Two tempered stainless steel 2.36 mm (No. 8) mesh or otherwise perforated baskets, dimensions (L x

W x H) 26.7 x 26.7 x 5.1 cm (10.5 x 10.5 x 2.0 in. with 5 cm (2 in) support legs. The baskets shall be nested. The baskets shall be provided with screening on the legs to confine the aggregate.
**4.3** One stainless steel catch pan, dimensions (L x W x H) of 28.0x28.0x2.6 cm (11.0 x 11.0x1.0 in).
**4.4** Oven capable of maintaining 125° ±5° C (257° ±9° F).
**4.5** Balance, 8-kg capacity, sensitive to 1.0 g for weighing sample in baskets.
**4.6** 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.
**4.7** Miscellaneous Equipment: pan dimensions (L x W x D) 38 x 38 x 5 cm (15 x 15 x 2 in) minimum for transferring samples after ignition, spatulas, bowls, and wire brushes.

## 5. Sampling

**5.1** The test sample shall be the end result of quartering a larger sample taken in accordance with VTM-48 (AASHTO T 248 may be used as a guide to quartering.)

**5.2** Preparation of Test Specimens:

**5.2.1** If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan and warm to 125° C ±5° C (257° F ±9° F) for 25 minutes. The sample shall not be heated for more than 1. hour.

**5.2.2** 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):

Note 1-When the mass of the test specimen exceeds the 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)

### 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 | ½ in. | 1500 |
| 19.0 | 3/4 in. | 2000 |
| 25.0 | 1 in. | 3000 |
| 37.5 | 1 ½ in. | 4000 |

**5.2.3** In addition, a test specimen for moisture determination (VTM-49) will be made as deemed necessary. The specimen used for moisture determination may not be used for asphalt content determination.

## 6. CALIBRATION

Two calibration procedures are provided. Either method may be required by the engineer. For mix designs containing RAP, 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 portions of RAP should be obtained using a sample splitter.

Certain aggregate types 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) or as approved by the Engineer.

## 6a. Mixture Calibration

**6a.1** This method may be effected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established with the testing of a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed.

**6a.2** Two calibration specimens conforming to the mass requirements of Section 5.2.2 shall be prepared at the design asphalt content and at ± 0.5% of the design asphalt content for a total of six specimens. A butter 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. Any method may be used to combine the aggregates, however an additional "blank" specimen shall be batched and tested according to AASHTO T 30. The washed gradation shall fall within the JMF tolerances.

**6a.3** The freshly mixed specimens may be placed directly in the sample baskets. If allowed to cool, the samples must be preheated in a 125° C (257° F) oven for 25 minutes.

**6a.4** Preheat the ignition furnace to 538° C (1000° F) Record the furnace temperature (set point) prior to the initiation of the test.

**6a.4** Enter a correction factor of **0.00** in the ignition furnace.

**6a.5** Weigh and record the weight of the two sample baskets and catch pan (with guards in place).

**6a.6** Place the bottom sample basket in the catch pan. Evenly distribute approximately one half of the calibration specimen in the lower basket taking care to keep the material away from the basket edges.

**6a.7** Place the upper sample basket on the bottom basket assembly. Evenly distribute the remaining specimen in the top basket. Use a spatula or trowel to level the specimen.

**6a.8** Weigh and record the sample, baskets, catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly).

**6a.9** Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.

**6a.10** Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample weight (including the baskets) displayed on the furnaces scale equals the total weight recorded in Section 6.8 within ± 5g. Differences greater than 5 grams or failure of the furnace scale to stabilize may indicate that the sample baskets are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

**6a.11** Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

**6a.12** Open the chamber door, remove the sample baskets and allow to cool to room temperature (approx. 30 minutes).

**6a.13** Perform a gradation analysis on the residual aggregate as indicted in Section 8.

**6a.14** Once all of the calibration specimens have been burned, determine the difference between the actual and measured asphalt contents for each sample. The mix correction factor is the average of the measured differences.

## Alternate Calibration Procedure:

## 6b. Aggregate Only Calibration

**6b.1** This method may be effected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, a calibration factor will be established with the testing of a set of calibration samples for each mix type. This procedure must be performed before any acceptance testing is completed.

**6b.2** Four blank (aggregate only) calibration specimens conforming to the mass requirements of Section 5.2.2 shall be prepared to meet the JMF. Aggregate used for the calibration specimens shall be sampled from stockpiled material produced in the current construction season. Any method may be used to combine the aggregates, however an additional "blank" specimen shall be batched and tested according to AASHTO T 30. The washed gradation shall fall within the JMF tolerances.

**6b.3** Preheat a specimen in a 125° C (257° F) oven for 20 minutes. thoroughly mix the specimen with a spatula prior to introducing it into the sample baskets

**6b.4** Preheat the ignition furnace to **575° C (1067° F.)** Record the furnace temperature set point prior to the initiation of the test.

**6b.4** Enter a correction factor of **0.00** in the ignition furnace.

**6b.5** Weigh and record the weight of the two sample baskets and catch pan (with guards in place).

**6b.6** Place the bottom sample basket in the catch pan. Evenly distribute approximately one half of the calibration specimen in the lower basket, carefully keeping the material away from the basket edges.

**6b.7** Place the upper sample basket on the bottom basket assembly. Evenly distribute the remaining specimen in the top basket. Use a spatula or trowel to level the specimen.

**6b.8** Weigh and record the specimen, baskets, catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly)

**6b.9** Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.

**6b.10** Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample weight (including the baskets) displayed on the furnaces scale equals the total weight recorded in Section 6.8 ± 5 grams. Differences greater than 5 grams or failure of the furnace scale to stabilize may indicate that the sample baskets are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

**6b.11** Allow the specimen to remain in the furnace for 40 minutes. The stable light and audible stable indicator will come on after 15-30 minutes; do not stop the test at this time. Press the start/stop button when the furnace timer indicates **40:00**. This will unlock the sample chamber and cause the printer to print out the test results.

**6b.12** Open the chamber door, remove the sample baskets and allow to cool to near room temperature (approximately 30 minutes).

**6b.13** Perform a gradation analysis on the residual aggregate as indicted in Section 8.

**6b.14** The mix calibration factor is calculated as follows:
* If RAP is used in mix.

Agg. ~Corr. SUB { Avg. } ~ = ~ { SUM Agg.
Corrected ~ AC% SUB { 1-4 } } OVER 4
Mix ~ Calibration ~ Factor ~ = ~ Agg. ~Corr. SUB
{Avg } ~- ~ ( Avg ~ RAP ~ AC% ~ TIMES ~ { %
` RAP } OVER 100 ) SUP *

**6b.15** The calibration procedure for a given mix should be repeated for every 50,000 tons of material produced or as requested by the engineer.

## 7. Test Procedure

**7.1** Preheat the ignition furnace to 538° C (1000° F) Record the furnace temperature (set point) prior to the initiation of the test.

**7.2** Enter the correction factor for the specific mix to be tested as determined in Section 6 in the ignition furnace.

**7.3** Weigh and record the weight of the two sample baskets and catch pan (with guards in place).

**7.4** Prepare the sample as described in Section 5.2. Place the bottom sample basket in the catch pan. Evenly distribute approximately one half of the specimen in the lower basket taking care to keep the material away from the edges of the basket.

**7.5** Place the upper sample basket on the bottom basket assembly. Evenly distribute the remaining specimen in the top basket. Use a spatula or trowel to level the specimen.

**7.6** Weigh and record the sample, baskets, catch pan, and basket guards. Calculate and record the initial weight of the sample specimen (total weight - the weight of the sample basket assembly)

**7.7** Input the initial weight of the sample specimen in whole grams into the ignition furnace controller. Verify that the correct weight has been entered.

**7.8** Open the chamber door and place the sample baskets in the furnace. Close the chamber door and verify that the sample weight (including the baskets) displayed on the furnaces scale equals the total weight recorded in Section 6.8 ± 5 grams. Differences greater than 5 grams or failure of the furnace scale to stabilize may indicate that the sample baskets are contacting the furnace wall. Initiate the test by pressing the start/stop button. This will lock the sample chamber and start the combustion blower.

**7.9** Allow the test to continue until the stable light and audible stable indicator indicate the test is complete. Press the start/stop button. This will unlock the sample chamber and cause the printer to print out the test results.

**7.10** Open the chamber door, remove the sample baskets and allow to cool to room temperature (approximately 30 minutes).

## 8. Gradation

**8.1** Allow the specimen to cool to room temperature in the sample baskets.

**8.2** Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets.

**8.3** Perform the gradation analysis according to AASHTO T 30.

## 9. Report

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

# Appendix B

## Mixture Correction Factor Determination Test Form

COLORADO DEPARTMENT OF TRANSPORTATION

# INTERNAL SCALE OVEN ASPHALT BINDER CONTENT CORRECTION FACTOR DETERMINATION

Lab No ______________

Date: ______________

| SA # | Information |
|---|---|

Internal Scale Oven, Set Point: 538 C or ______________

**Measured Specimen A.C. Contents:**

| | 1) Specimen | 2) Specimen | 3) Specimen | Average | |
|---|---|---|---|---|---|
| Aggregate (grams) | | | | | |
| A.C. (grams) | | | | | |
| Total Weight | | | | | |
| Percent A.C. | | | | | A1 |

**Asphalt Cement Content Determination**

| | | | |
|---|---|---|---|
| Basket Weight (Ext. Scale) | | | |
| Basket + Specimen Wt. (Ext. Scale) | | | |
| Specimen Weight | | | |
| Basket + Specimen Wt. (Int. Scale) | | | |
| Difference Int. & Ext. Scale Wts. | | | |

If H> 5 grams, check basket for contact with oven walls.

**External Scale A.C. Content Determination**

| | | | | | |
|---|---|---|---|---|---|
| Basket + Specimen Wt. After Burnoff | | | | | |
| Weight Loss After Burnoff | | | | | |
| Measured A.C. Content (Ext. Scale) | | | | | B1 |

**Internal Scale Oven A.C. Content Determination**

| | | | | | |
|---|---|---|---|---|---|
| Weight Loss After Burnoff | | | | | |
| Percent Weight Loss from Printout | | | | | |
| Temp. Compensation (percent) | | | | | |
| Calibrated A.C. Content from Printout | | | | | C1 |

## Correction Factor Calculations:

**External Scale A.C. Content Correction Factor**

Actual A.C. Content - Ext. Scale A.C. Content ( A1 - B1 ) ______________ Ignition Oven Extraction Gradation Form - 'A'

**Internal Scale A.C. Content Correction Factor**

Actual A.C. Content - Oven Scale A.C. Content ( A1 - C1 ) ______________ Ignition Oven Extraction Gradation Form - 'B'

Rev: 6-25-96

# Appendix C

## Field Produced Specimen AC Determination Test Form

COLORADO DEPARTMENT OF TRANSPORTATION

# IGNITION OVEN EXTRACTION GRADATION

| | | | | |
|---|---|---|---|---|
| Lab No. | | | | |
| Subaccount No. | Project No. | End Point Stress | | |
| DOT 157 No. | Information | Item No. | Grading | Code 3 |

| | | | |
|---|---|---|---|
| Correcton Factor (External) From Correction Factor Worksheet | A | Correction Factor (Internal) From Correction Factor Worksheet | B |

## Asphalt Cement Content Determination

| | Sample 1 | Sample 2 | |
|---|---|---|---|
| Oven Set Point (Degrees Celcius) | 538 | 538 | C |
| Basket Weight (Ext. Scale) | | | D |
| Basket + Specimen Wt. (Ext. Scale) | | | E |
| Specimen Weight ( E - D ) | | | F |
| Basket + Specimen Wt. (Int. Scale) | | | G |
| Difference Int. & Ext. Scale Wts. ( E - G ) **See Note 1 if H > 5 grams** | | | H |
| **External Scale A.C. Content Determination** | | | |
| Basket + Specimen Wt. After Burnoff | | | J |
| Weight of Aggregate (Ext. Scale) | | | K |
| Weight Loss After Burnoff ( E - J ) | | | L |
| Uncorrected A.C. Content (Ext. Scale) ( 100 x L / F ) | | | M |
| Corrected A.C. Content (Ext. Scale) ( M + A ) | | | N |
| **Internal Scale A.C. Content Determination** | | | |
| Wt. Loss After Burnoff ( Int. Scale) | | | P |
| Percent Weight Loss from Printout | | | Q |
| Temp. Compensation (percent) | | | R |
| Calibrated A.C. Content from Printout | | | S |
| Corrected A.C. Content (Int.) ( S + B ) | | | T |

**Note 1:** If E - G is greater than 5 grams, check basket placement for possible contact with oven walls

**Note 2:** Weights K and AB Must Be Within 0.2% of Each Other

## -200 and Gradation Determination

| | Sample 1 | Sample 2 | |
|---|---|---|---|
| Marked Pan Weight | | | U |
| Actual Pan Weight | | | V |
| Gross Sample Weight After Wash ( Aggregate + Pan ) | | | W |
| Is Lime Visible on Aggregate Surface? | Yes ☐ No ☐ **If No, Notify Project Engineer Immediately** | | X |
| Net Weight of Aggregate After Wash ( W - V ) | | | Y |
| Weight of - #200 Material Removed ( K - Y ) | | | Z |

| Sieve | Weight Retained in Each Sieve Sample 1 | Sample 2 | Total | Percent Passing Each Sieve Size |
|---|---|---|---|---|
| 1 1/2" | | | | |
| 1" | | | | |
| 3/4" | | | | |
| 1/2" | | | | |
| 3/8" | | | | |
| #4 | | | | |
| #8 | | | | |
| #16 | | | | |
| #30 | | | | |
| #50 | | | | |
| #100 | | | | |
| #200 | | | | |
| - #200 | | | AA | |
| Tot -#200 ( Z + AA ) | | | | |
| Total Weight | | | | AB (See Note 2) |

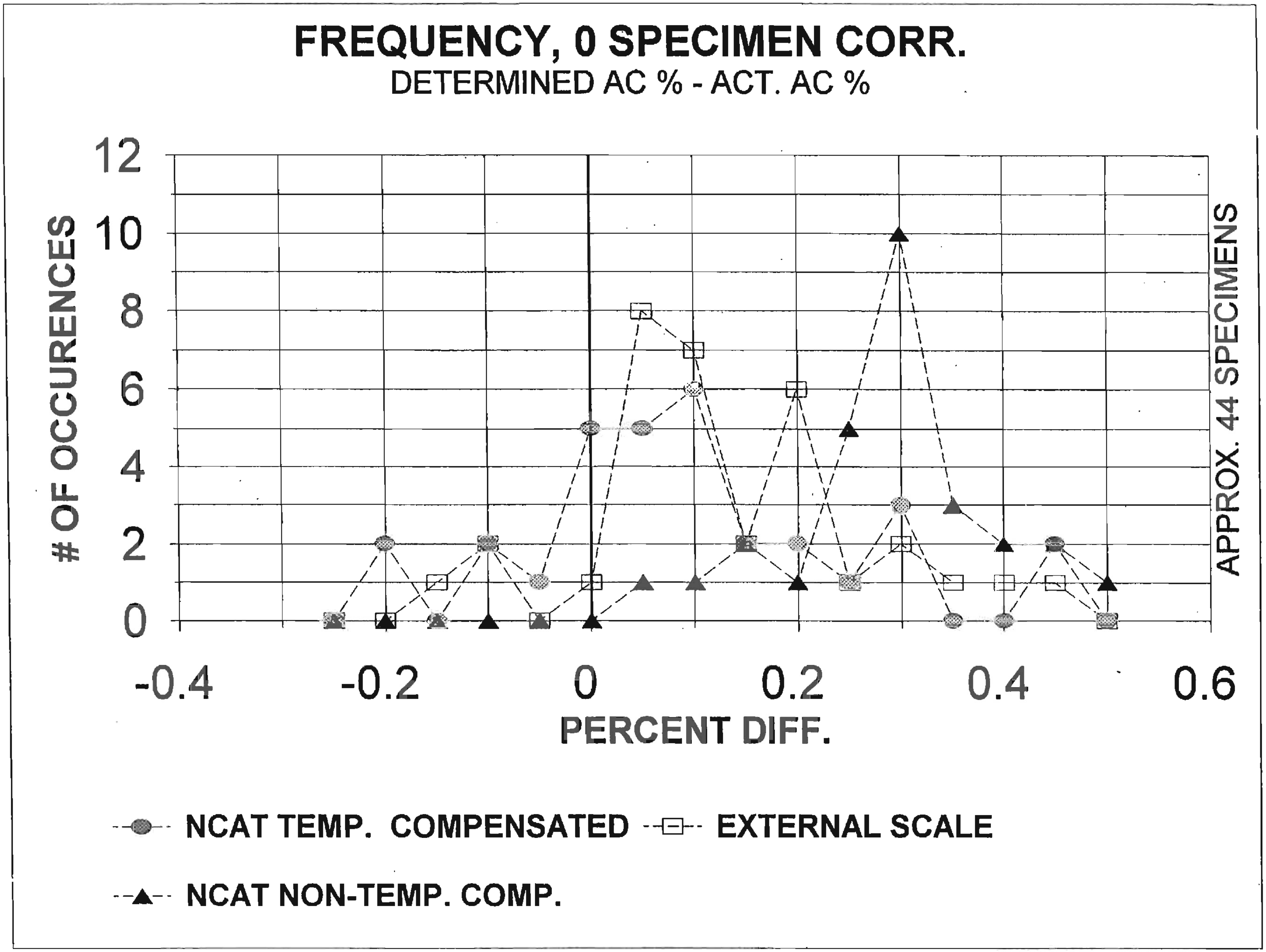
| | |
|---|---|
| Average Asphalt Cement Determination (Internal Scale) | ( T ) |
| Average Asphalt Cement Determination (External Scale and Reported) | ( N ) |



CDOT Form #1018D 4/96

## Appendix D

## Summary of Asphalt Content Accuracy and Precision using a zero-Specimen Correction for each Method of AC Measurement


FREQUENCY, 0 SPECIMEN CORR.
DETERMINED AC % - ACT. AC %
# OF OCCURENCES
APPROX. 44 SPECIMENS
12
10
8
6
4
2
0
-0.4
-0.2
0
0.2
0.4
0.6
PERCENT DIFF.
NCAT TEMP. COMPENSATED
EXTERNAL SCALE
NCAT NON-TEMP. COMP.

## 0 SPECIMEN CORRECTION

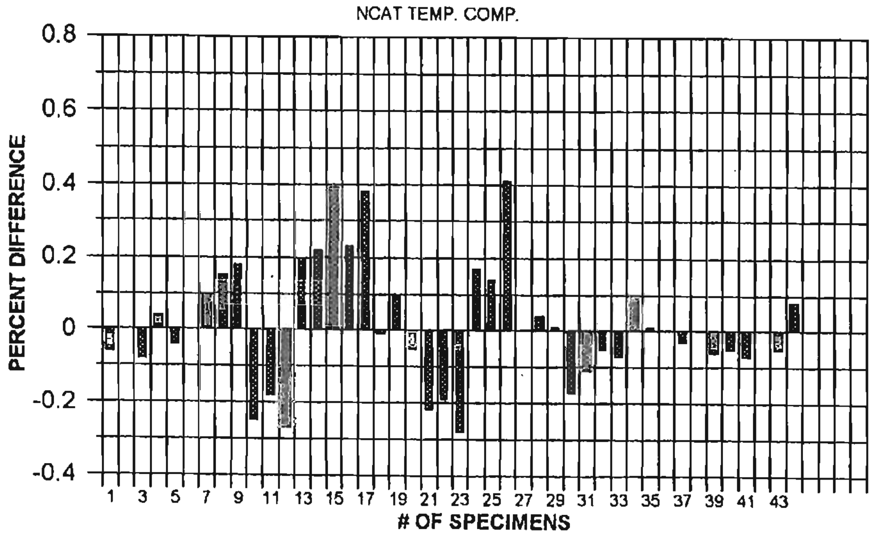
| PERCENT DIFF. RANGE | NCAT TEMP. COMPENSATED FREQUENCY | NCAT NON-TEMP. COMP. FREQUENCY | EXTERNAL SCALE FREQUENCY |
|---|---|---|---|
| -0.300 | 0.000 | 0.000 | 0.000 |
| -0.250 | 2.000 | 0.000 | 0.000 |
| -0.200 | 0.000 | 0.000 | 1.000 |
| -0.150 | 2.000 | 0.000 | 2.000 |
| -0.100 | 1.000 | 0.000 | 0.000 |
| -0.050 | 5.000 | 0.000 | 1.000 |
| -0.000 | 5.000 | 1.000 | 8.000 |
| 0.050 | 6.000 | 1.000 | 7.000 |
| 0.100 | 2.000 | 2.000 | 2.000 |
| 0.150 | 2.000 | 1.000 | 6.000 |
| 0.200 | 1.000 | 5.000 | 1.000 |
| 0.250 | 3.000 | 10.000 | 2.000 |
| 0.300 | 0.000 | 3.000 | 1.000 |
| 0.350 | 0.000 | 2.000 | 1.000 |
| 0.400 | 2.000 | 2.000 | 1.000 |
| 0.450 | 0.000 | 1.000 | 0.000 |
| 0.500 | 0.000 | 3.000 | 1.000 |
| | | 2.000 | 0.000 |

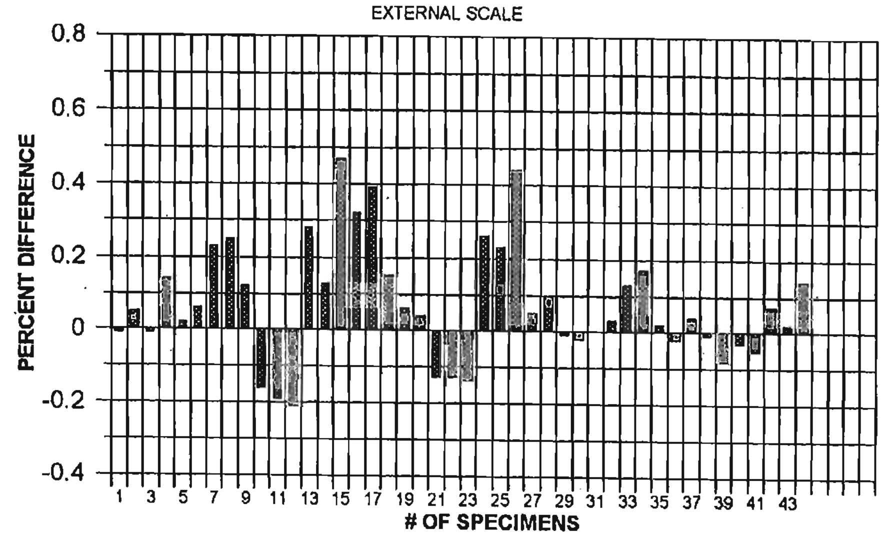
## 0 SAMPLE CORRECTION

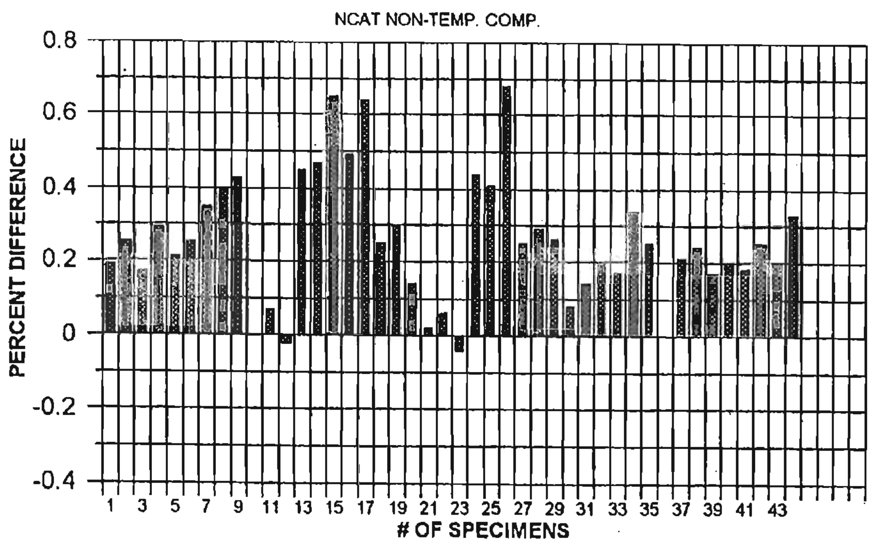
| PROJECT ID | TEST # | (A') % WT. LOSS NCAT | (A) NCAT CAL. AC CON | (B) % WT. LOSS, EXT. | (C) ACTUAL AC CONTENT | DIFF. (A-C) | DIFF. (B-C) | DIFF. (A'-C) | TEST TEMP. |
|---|---|---|---|---|---|---|---|---|---|
| 137X-2 | 51 | 5.700 | 5.450 | 5.500 | 5.510 | -0.060 | -0.010 | 0.190 | 538 |
| 137X-3 | 52 | 5.760 | 5.510 | 5.560 | 5.510 | 0.000 | 0.050 | 0.250 | 538 |
| 137X-5 | 53 | 5.700 | 5.450 | 5.520 | 5.530 | -0.080 | -0.010 | 0.170 | 538 |
| 94x-6 | 54 | 5.540 | 5.290 | 5.390 | 5.250 | 0.040 | 0.140 | 0.290 | 538 |
| 94x-5 | 55 | 5.500 | 5.250 | 5.310 | 5.290 | -0.040 | 0.020 | 0.210 | 538 |
| 94x-3 | 56 | 5.500 | 5.250 | 5.310 | 5.250 | 0.000 | 0.060 | 0.250 | 538 |
| 152x-5 | 57 | 6.150 | 5.900 | 6.030 | 5.800 | 0.100 | 0.230 | 0.350 | 538 |
| 152x-2 | 58 | 6.220 | 5.970 | 6.070 | 5.820 | 0.150 | 0.250 | 0.400 | 538 |
| 152x-3 | 59 | 6.180 | 5.930 | 5.870 | 5.750 | 0.180 | 0.120 | 0.430 | 538 |
| 160x-1 | 60 | 5.380 | 5.130 | 5.220 | 5.380 | -0.250 | -0.160 | 0.000 | 538 |
| 160x-2 | 61 | 5.500 | 5.250 | 5.240 | 5.430 | -0.180 | -0.190 | 0.070 | 538 |
| 160x-5 | 62 | 5.380 | 5.130 | 5.190 | 5.400 | -0.270 | -0.210 | -0.020 | 538 |
| 261x-3 | 63 | 5.490 | 5.240 | 5.320 | 5.040 | 0.200 | 0.280 | 0.450 | 538 |
| 261x-5 | 64 | 5.490 | 5.240 | 5.150 | 5.020 | 0.220 | 0.130 | 0.470 | 538 |
| 177X-4 | 65 | 6.830 | 6.570 | 6.650 | 6.180 | 0.390 | 0.470 | 0.650 | 538 |
| 177X-1 | 66 | 6.700 | 6.440 | 6.530 | 6.210 | 0.230 | 0.320 | 0.490 | 538 |
| 177X-6 | 67 | 6.830 | 6.570 | 6.580 | 6.190 | 0.380 | 0.390 | 0.640 | 538 |
| 443X-4 | 68 | 5.510 | 5.250 | 5.410 | 5.260 | -0.010 | 0.150 | 0.250 | 538 |
| 443X-6 | 69 | 5.550 | 5.340 | 5.310 | 5.250 | 0.090 | 0.060 | 0.300 | 538 |
| 443X-2 | 70 | 5.340 | 5.150 | 5.240 | 5.200 | -0.050 | 0.040 | 0.140 | 538 |
| 166X-6 | 71 | 5.230 | 4.990 | 5.080 | 5.210 | -0.220 | -0.130 | 0.020 | 538 |
| 166X-2 | 72 | 5.260 | 5.010 | 5.070 | 5.200 | -0.190 | -0.130 | 0.060 | 538 |
| 166X-4 | 73 | 5.160 | 4.920 | 5.060 | 5.200 | -0.280 | -0.140 | -0.040 | 538 |
| 184x-3 | 74 | 7.490 | 7.220 | 7.310 | 7.050 | 0.170 | 0.260 | 0.440 | 538 |
| 184x-2 | 75 | 7.470 | 7.200 | 7.290 | 7.060 | 0.140 | 0.230 | 0.410 | 538 |
| 184x4 | 76 | 7.710 | 7.440 | 7.470 | 7.030 | 0.410 | 0.440 | 0.680 | 538 |
| 417x-2 | 77 | 5.580 | 5.330 | 5.380 | 5.330 | 0.000 | 0.050 | 0.250 | 538 |
| 417x-3 | 78 | 5.670 | 5.420 | 5.480 | 5.380 | 0.040 | 0.100 | 0.290 | 538 |
| 417x5 | 79 | 5.590 | 5.340 | 5.320 | 5.330 | 0.010 | -0.010 | 0.260 | 538 |
| 315x-1 | 80 | 4.800 | 4.550 | 4.700 | 4.720 | -0.170 | -0.020 | 0.080 | 538 |
| 315x-4 | 81 | 4.850 | 4.600 | 4.710 | 4.710 | -0.110 | 0.000 | 0.140 | 538 |
| 315x-6 | 82 | 4.940 | 4.690 | 4.770 | 4.740 | -0.050 | 0.030 | 0.200 | 538 |
| 415x-2 | 83 | 5.580 | 5.340 | 5.540 | 5.410 | -0.070 | 0.130 | 0.170 | 538 |
| 415x-3 | 84 | 5.770 | 5.520 | 5.600 | 5.430 | 0.090 | 0.170 | 0.340 | 538 |
| 415x-6 | 85 | 5.640 | 5.400 | 5.410 | 5.390 | 0.010 | 0.020 | 0.250 | 538 |
| 168x-1 | 86 | | | 5.430 | 5.450 | | -0.020 | | 538 |
| 168x-5 | 87 | 5.660 | 5.420 | 5.490 | 5.450 | -0.030 | 0.040 | 0.210 | 538 |
| 168x-6 | 88 | 5.670 | 5.430 | 5.420 | 5.430 | 0.000 | -0.010 | 0.240 | 538 |
| 239x-3 | 89 | 5.280 | 5.050 | 5.030 | 5.110 | -0.060 | -0.080 | 0.170 | 538 |
| 239x-4 | 90 | 5.340 | 5.090 | 5.110 | 5.140 | -0.050 | -0.030 | 0.200 | 538 |
| 239x-5 | 91 | 5.320 | 5.070 | 5.090 | 5.140 | -0.070 | -0.050 | 0.180 | 538 |
| 414x-2 | 92 | 5.520 | 5.270 | 5.340 | 5.270 | 0.000 | 0.070 | 0.250 | 538 |
| 414x-4 | 93 | 5.470 | 5.220 | 5.290 | 5.270 | -0.050 | 0.020 | 0.200 | 538 |
| 414x-6 | 94 | 5.580 | 5.330 | 5.390 | 5.250 | 0.080 | 0.140 | 0.330 | 538 |

| | NCAT TEMP. COMP. | EXTERNAL SCALE | NCAT NON-TEMP. COMP. |
|---|---|---|---|
| MEAN | **0.015** | **0.073** | **0.263** |
| STAND. DEV. | **0.165** | **0.159** | **0.170** |
| # OF CASES,N= | **43.000** | **44.000** | **43.000** |

# 0 SPECIMEN CORRECTION

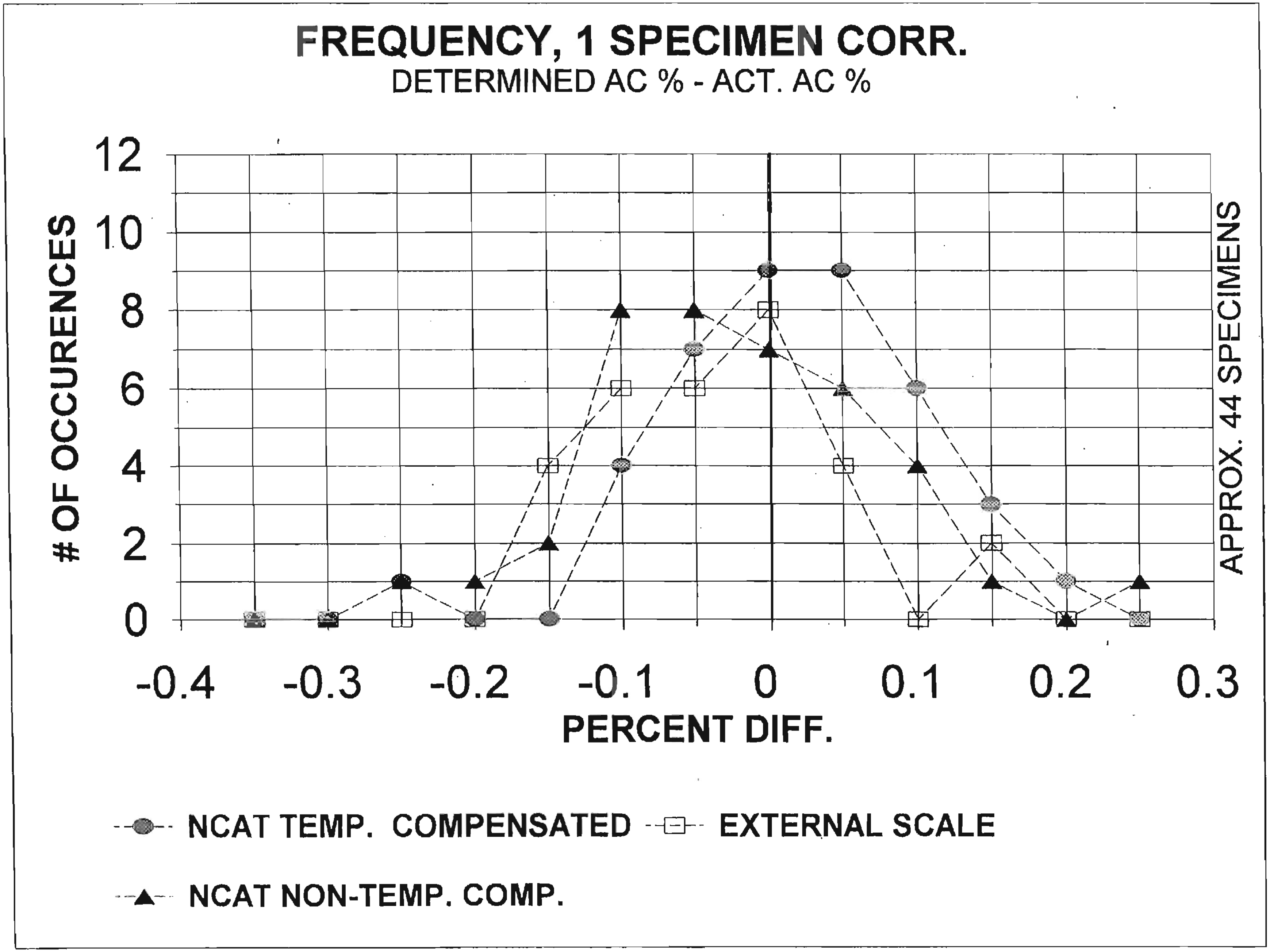


## Appendix E

## Summary of Asphalt Content Accuracy and Precision using a one-Specimen Correction for each Method of AC Measurement

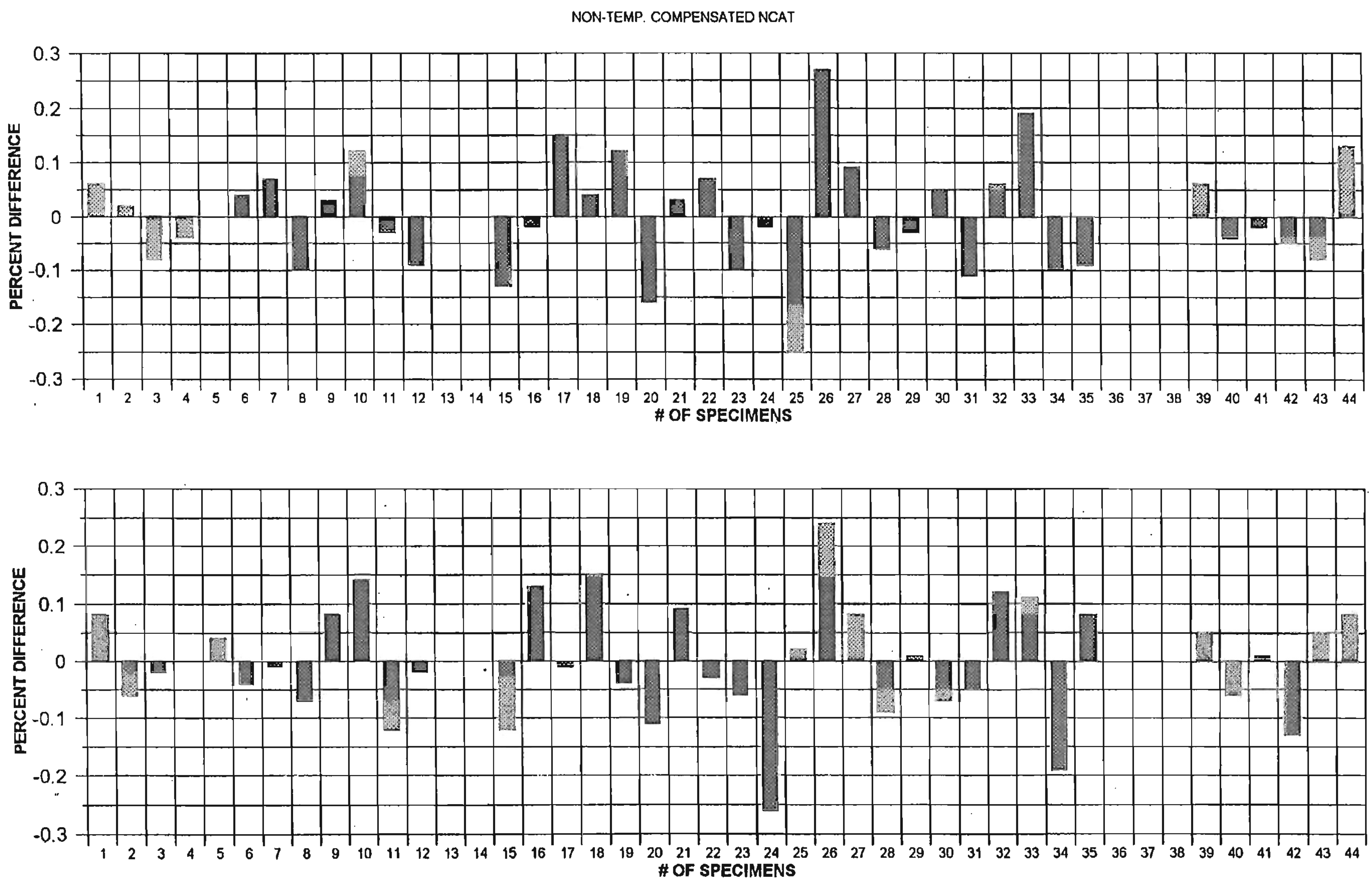


FREQUENCY, 1 SPECIMEN CORR.
DETERMINED AC % - ACT. AC %
# OF OCCURENCES
12
10
8
6
4
2
0
-0.4
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
PERCENT DIFF.
APPROX. 44 SPECIMENS
NCAT TEMP. COMPENSATED
EXTERNAL SCALE
NCAT NON-TEMP. COMP.

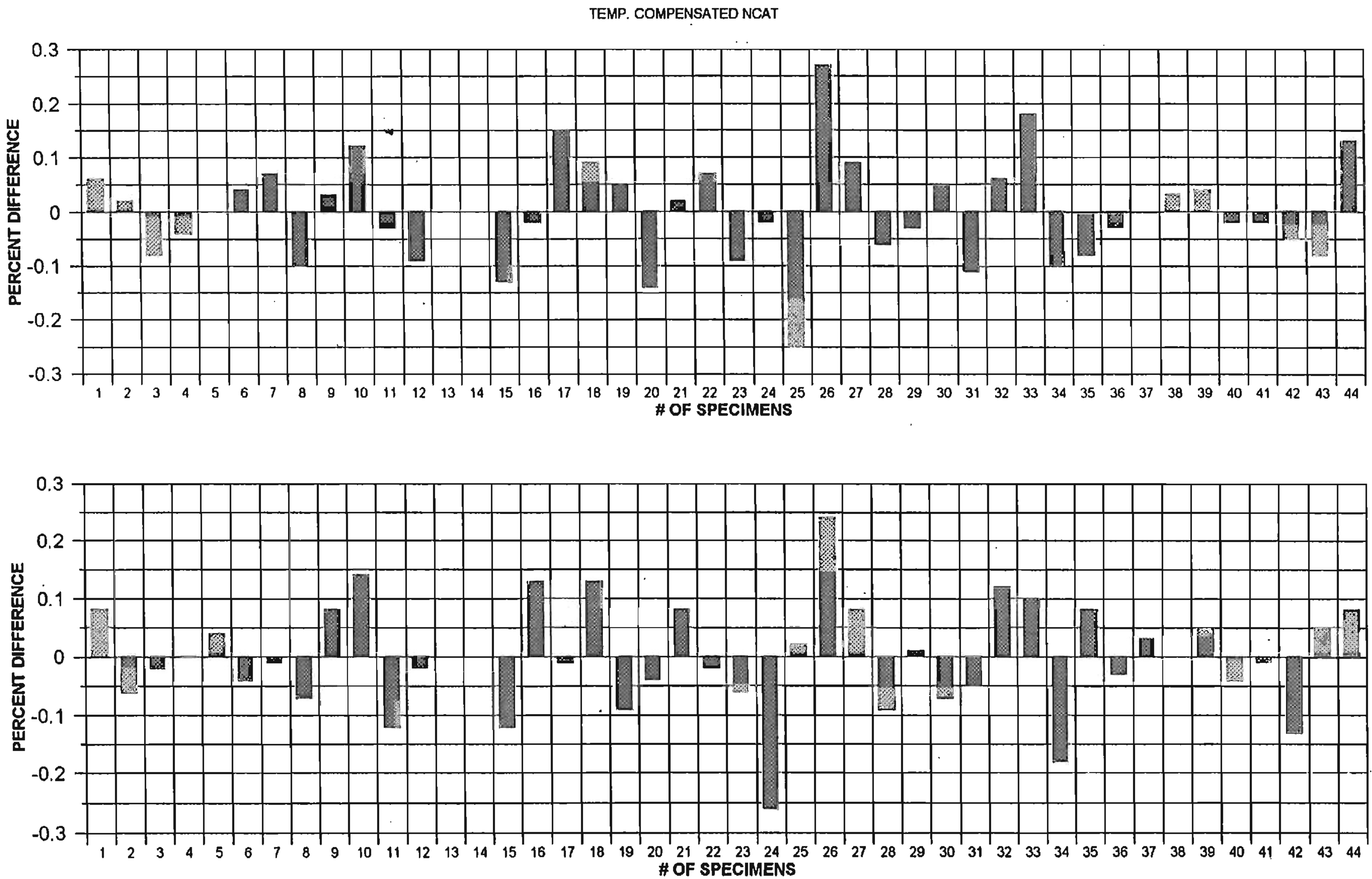
## 1 SPECIMEN CORRECTION

| PERCENT DIFF. RANGE | TEMP. COMPENSATED NCAT FREQUENCY | NON-TEMP. COMP. NCAT FREQUENCY | EXTERNAL SCALE FREQUENCY |
|---|---|---|---|
| -0.350 | 0.000 | 0.000 | 0.000 |
| -0.300 | 0.000 | 0.000 | 0.000 |
| -0.250 | 1.000 | 1.000 | 0.000 |
| -0.200 | 0.000 | 1.000 | 0.000 |
| -0.150 | 0.000 | 2.000 | 4.000 |
| -0.100 | 4.000 | 8.000 | 6.000 |
| -0.050 | 7.000 | 8.000 | 6.000 |
| -0.000 | 9.000 | 7.000 | 8.000 |
| 0.050 | 9.000 | 6.000 | 4.000 |
| 0.100 | 6.000 | 4.000 | 0.000 |
| 0.150 | 3.000 | 1.000 | 2.000 |
| 0.200 | 1.000 | 0.000 | 0.000 |
| 0.250 | 0.000 | 1.000 | 0.000 |
| | | 0.000 | 0.000 |

# 1 SPECIMEN CORRECTION



# 1 SPECIMEN CORRECTION



COMBINATION 1

# 1 SAMPLE CORRECTION

NON-TEMP. COMPENSATED NCAT

| | | | ACT AC' | CORR.-ACT. AC% |
|---|---|---|---|---|
| 137X-2 | SAMPLE 2-CORRECTION 1 | 5.570 | 5.510 | 0.060 |
| 137X-3 | SAMPLE 1- CORRECTION 3 | 5.530 | 5.510 | 0.020 |
| 137X-5 | SAMPLE 3- CORRECTION 2 | 5.450 | 5.530 | -0.080 |
| 94x-6 | SAMPLE 2-CORRECTION 1 | 5.210 | 5.250 | -0.040 |
| 94x-5 | SAMPLE 1- CORRECTION 3 | 5.290 | 5.290 | 0.000 |
| 94x-3 | SAMPLE 3- CORRECTION 2 | 5.290 | 5.250 | 0.040 |
| 152x-5 | SAMPLE 2-CORRECTION 1 | 5.870 | 5.800 | 0.070 |
| 152x-2 | SAMPLE 1- CORRECTION 3 | 5.720 | 5.820 | -0.100 |
| 152x-3 | SAMPLE 3- CORRECTION 2 | 5.780 | 5.750 | 0.030 |
| 160x-1 | SAMPLE 2-CORRECTION 1 | 5.500 | 5.380 | 0.120 |
| 160x-2 | SAMPLE 1- CORRECTION 3 | 5.400 | 5.430 | -0.030 |
| 160x-5 | SAMPLE 3- CORRECTION 2 | 5.310 | 5.400 | -0.090 |
| 261x-3 | | | | |
| 261x-5 | | | | |
| 177X-4 | SAMPLE 2- CORRECTION 1 | 6.050 | 6.180 | -0.130 |
| 177X-1 | SAMPLE 1-CORRECTION 3 | 6.190 | 6.210 | -0.020 |
| 177X-6 | SAMPLE 3- CORRECTION 2 | 6.340 | 6.190 | 0.150 |
| 443X-4 | SAMPLE 2- CORRECTION 1 | 5.300 | 5.260 | 0.040 |
| 443X-6 | SAMPLE 1-CORRECTION 3 | 5.370 | 5.250 | 0.120 |
| 443X-2 | SAMPLE 3- CORRECTION 2 | 5.040 | 5.200 | -0.160 |
| 166X-6 | SAMPLE 2- CORRECTION 1 | 5.240 | 5.210 | 0.030 |
| 166X-2 | SAMPLE 1-CORRECTION 3 | 5.270 | 5.200 | 0.070 |
| 166X-4 | SAMPLE 3- CORRECTION 2 | 5.100 | 5.200 | -0.100 |
| 184x-3 | SAMPLE 2- CORRECTION 1 | 7.030 | 7.050 | -0.020 |
| 184x-2 | SAMPLE 1-CORRECTION 3 | 6.810 | 7.060 | -0.250 |
| 184x4 | SAMPLE 3- CORRECTION 2 | 7.300 | 7.030 | 0.270 |
| 417x-2 | SAMPLE 2- CORRECTION 1 | 5.420 | 5.330 | 0.090 |
| 417x-3 | SAMPLE 1-CORRECTION 3 | 5.320 | 5.380 | -0.060 |
| 417x5 | SAMPLE 3- CORRECTION 2 | 5.300 | 5.330 | -0.030 |
| 315x-1 | SAMPLE 2- CORRECTION 1 | 4.770 | 4.720 | 0.050 |
| 315x-4 | SAMPLE 1-CORRECTION 3 | 4.600 | 4.710 | -0.110 |
| 315x-6 | SAMPLE 3- CORRECTION 2 | 4.800 | 4.740 | 0.060 |
| 415x-2 | SAMPLE 2- CORRECTION 1 | 5.600 | 5.410 | 0.190 |
| 415x-3 | SAMPLE 1-CORRECTION 3 | 5.330 | 5.430 | -0.100 |
| 415x-6 | SAMPLE 3- CORRECTION 2 | 5.300 | 5.390 | -0.090 |
| 168x-1 | SAMPLE 2- CORRECTION 1 | 5.660 | 5.450 | |
| 168x-5 | SAMPLE 1-CORRECTION 3 | | 5.450 | |
| 168x-6 | SAMPLE 3- CORRECTION 2 | 5.460 | 5.430 | |
| 239x-3 | SAMPLE 2- CORRECTION 1 | 5.170 | 5.110 | 0.060 |
| 239x-4 | SAMPLE 1-CORRECTION 3 | 5.100 | 5.140 | -0.040 |
| 239x-5 | SAMPLE 3- CORRECTION 2 | 5.120 | 5.140 | -0.020 |
| 414x-2 | SAMPLE 2- CORRECTION 1 | 5.220 | 5.270 | -0.050 |
| 414x-4 | SAMPLE 1-CORRECTION 3 | 5.190 | 5.270 | -0.080 |
| 414x-6 | SAMPLE 3- CORRECTION 2 | 5.380 | 5.250 | 0.130 |
| | MEAN | | | 0.000 |
| | STD. DEV. | | | 0.103 |
| | # OF SAMPLES | | | 39.000 |

COMBINATION 2

| | | ACT AC% | CORR.-ACT. AC% |
|---|---|---|---|
| SAMPLE 2- CORRECTION 3 | 5.590 | 5.510 | 0.080 |
| SAMPLE 1-CORRECTION 2 | 5.450 | 5.510 | -0.060 |
| SAMPLE 3- CORRECTION 1 | 5.510 | 5.530 | -0.020 |
| SAMPLE 2- CORRECTION 3 | 5.250 | 5.250 | 0.000 |
| SAMPLE 1-CORRECTION 2 | 5.330 | 5.290 | 0.040 |
| SAMPLE 3- CORRECTION 1 | 5.210 | 5.250 | -0.040 |
| SAMPLE 2- CORRECTION 3 | 5.790 | 5.800 | -0.010 |
| SAMPLE 1-CORRECTION 2 | 5.750 | 5.820 | -0.070 |
| SAMPLE 3- CORRECTION 1 | 5.830 | 5.750 | 0.080 |
| SAMPLE 2- CORRECTION 3 | 5.520 | 5.380 | 0.140 |
| SAMPLE 1-CORRECTION 2 | 5.310 | 5.430 | -0.120 |
| SAMPLE 3- CORRECTION 1 | 5.380 | 5.400 | -0.020 |
| | | 5.040 | |
| | | 5.020 | |
| SAMPLE 2- CORRECTION 3 | 6.060 | 6.180 | -0.120 |
| SAMPLE 1-CORRECTION 2 | 6.340 | 6.210 | 0.130 |
| SAMPLE 3- CORRECTION 1 | 6.180 | 6.190 | -0.010 |
| SAMPLE 2- CORRECTION 3 | 5.410 | 5.260 | 0.150 |
| SAMPLE 1-CORRECTION 2 | 5.210 | 5.250 | -0.040 |
| SAMPLE 3- CORRECTION 1 | 5.090 | 5.200 | -0.110 |
| SAMPLE 2- CORRECTION 3 | 5.300 | 5.210 | 0.090 |
| SAMPLE 1-CORRECTION 2 | 5.170 | 5.200 | -0.030 |
| SAMPLE 3- CORRECTION 1 | 5.140 | 5.200 | -0.060 |
| SAMPLE 2- CORRECTION 3 | 6.790 | 7.050 | -0.260 |
| SAMPLE 1-CORRECTION 2 | 7.080 | 7.060 | 0.020 |
| SAMPLE 3- CORRECTION 1 | 7.270 | 7.030 | 0.240 |
| SAMPLE 2- CORRECTION 3 | 5.410 | 5.330 | 0.080 |
| SAMPLE 1-CORRECTION 2 | 5.290 | 5.380 | -0.090 |
| SAMPLE 3- CORRECTION 1 | 5.340 | 5.330 | 0.010 |
| SAMPLE 2- CORRECTION 3 | 4.650 | 4.720 | -0.070 |
| SAMPLE 1-CORRECTION 2 | 4.660 | 4.710 | -0.050 |
| SAMPLE 3- CORRECTION 1 | 4.860 | 4.740 | 0.120 |
| SAMPLE 2- CORRECTION 3 | 5.520 | 5.410 | 0.110 |
| SAMPLE 1-CORRECTION 2 | 5.240 | 5.430 | -0.190 |
| SAMPLE 3- CORRECTION 1 | 5.470 | 5.390 | 0.080 |
| SAMPLE 2- CORRECTION 3 | 5.420 | 5.450 | |
| SAMPLE 1-CORRECTION 2 | | 5.450 | |
| SAMPLE 3- CORRECTION 1 | 5.670 | 5.430 | |
| SAMPLE 2- CORRECTION 3 | 5.160 | 5.110 | 0.050 |
| SAMPLE 1-CORRECTION 2 | 5.080 | 5.140 | -0.060 |
| SAMPLE 3- CORRECTION 1 | 5.150 | 5.140 | 0.010 |
| SAMPLE 2- CORRECTION 3 | 5.140 | 5.270 | -0.130 |
| SAMPLE 1-CORRECTION 2 | 5.320 | 5.270 | 0.050 |
| SAMPLE 3- CORRECTION 1 | 5.330 | 5.250 | 0.080 |
| | | | 0.000 |
| | | | 0.101 |
| | | | 39.000 |

AVERAGE STD. DEV. = 0.102

# 1 SAMPLE CORRECTION

COMBINATION 1

**TEMP. COMPENSATED NCAT**

| | | | ACT AC% | CORR.-ACT. AC% |
|---|---|---|---|---|
| 137X-2 | SAMPLE 2-CORRECTION 1 | 5.570 | 5.510 | 0.060 |
| 137X-3 | SAMPLE 1- CORRECTION 3 | 5.530 | 5.510 | 0.020 |
| 137X-5 | SAMPLE 3- CORRECTION 2 | 5.450 | 5.530 | -0.080 |
| 94x-6 | SAMPLE 2-CORRECTION 1 | 5.210 | 5.250 | -0.040 |
| 94x-5 | SAMPLE 1- CORRECTION 3 | 5.290 | 5.290 | 0.000 |
| 94x-3 | SAMPLE 3- CORRECTION 2 | 5.290 | 5.250 | 0.040 |
| 152x-5 | SAMPLE 2-CORRECTION 1 | 5.870 | 5.800 | 0.070 |
| 152x-2 | SAMPLE 1- CORRECTION 3 | 5.720 | 5.820 | -0.100 |
| 152x-3 | SAMPLE 3- CORRECTION 2 | 5.780 | 5.750 | 0.030 |
| 160x-1 | SAMPLE 2-CORRECTION 1 | 5.500 | 5.380 | 0.120 |
| 160x-2 | SAMPLE 1- CORRECTION 3 | 5.400 | 5.430 | -0.030 |
| 160x-5 | SAMPLE 3- CORRECTION 2 | 5.310 | 5.400 | -0.090 |
| 261x-3 | | | | |
| 261x-5 | | | | |
| 177X-4 | SAMPLE 2- CORRECTION 1 | 6.050 | 6.180 | -0.130 |
| 177X-1 | SAMPLE 1-CORRECTION 3 | 6.190 | 6.210 | -0.020 |
| 177X-6 | SAMPLE 3- CORRECTION 2 | 6.340 | 6.190 | 0.150 |
| 443X-4 | SAMPLE 2- CORRECTION 1 | 5.350 | 5.260 | 0.090 |
| 443X-6 | SAMPLE 1-CORRECTION 3 | 5.300 | 5.250 | 0.050 |
| 443X-2 | SAMPLE 3- CORRECTION 2 | 5.060 | 5.200 | -0.140 |
| 166X-6 | SAMPLE 2- CORRECTION 1 | 5.230 | 5.210 | 0.020 |
| 166X-2 | SAMPLE 1-CORRECTION 3 | 5.270 | 5.200 | 0.070 |
| 166X-4 | SAMPLE 3- CORRECTION 2 | 5.110 | 5.200 | -0.090 |
| 184x-3 | SAMPLE 2- CORRECTION 1 | 7.030 | 7.050 | -0.020 |
| 184x-2 | SAMPLE 1-CORRECTION 3 | 6.810 | 7.060 | -0.250 |
| 184x4 | SAMPLE 3- CORRECTION 2 | 7.300 | 7.030 | 0.270 |
| 417x-2 | SAMPLE 2- CORRECTION 1 | 5.420 | 5.330 | 0.090 |
| 417x-3 | SAMPLE 1-CORRECTION 3 | 5.320 | 5.380 | -0.060 |
| 417x5 | SAMPLE 3- CORRECTION 2 | 5.300 | 5.330 | -0.030 |
| 315x-1 | SAMPLE 2- CORRECTION 1 | 4.770 | 4.720 | 0.050 |
| 315x-4 | SAMPLE 1-CORRECTION 3 | 4.600 | 4.710 | -0.110 |
| 315x-6 | SAMPLE 3- CORRECTION 2 | 4.800 | 4.740 | 0.060 |
| 415x-2 | SAMPLE 2- CORRECTION 1 | 5.590 | 5.410 | 0.180 |
| 415x-3 | SAMPLE 1-CORRECTION 3 | 5.330 | 5.430 | -0.100 |
| 415x-6 | SAMPLE 3- CORRECTION 2 | 5.310 | 5.390 | -0.080 |
| 168x-1 | SAMPLE 2- CORRECTION 1 | 5.420 | 5.450 | -0.030 |
| 168x-5 | SAMPLE 1-CORRECTION 3 | 0.000 | 5.450 | |
| 168x-6 | SAMPLE 3- CORRECTION 2 | 5.460 | 5.430 | 0.030 |
| 239x-3 | SAMPLE 2- CORRECTION 1 | 5.150 | 5.110 | 0.040 |
| 239x-4 | SAMPLE 1-CORRECTION 3 | 5.120 | 5.140 | -0.020 |
| 239x-5 | SAMPLE 3- CORRECTION 2 | 5.120 | 5.140 | -0.020 |
| 414x-2 | SAMPLE 2- CORRECTION 1 | 5.220 | 5.270 | -0.050 |
| 414x-4 | SAMPLE 1-CORRECTION 3 | 5.190 | 5.270 | -0.080 |
| 414x-6 | SAMPLE 3- CORRECTION 2 | 5.380 | 5.250 | 0.130 |

| | |
|---|---|
| MEAN | 0.000 |
| STD. DEV. | 0.098 |
| # OF SAMPLES | 41.000 |

**AVERAGE STD. DEV. = 0.096**

COMBINATION 2

**TEMP. COMPENSATED NCAT**

| | | ACT AC% | CORR.-ACT. AC% |
|---|---|---|---|
| SAMPLE 2- CORRECTION 3 | 5.590 | 5.510 | 0.080 |
| SAMPLE 1-CORRECTION 2 | 5.450 | 5.510 | -0.060 |
| SAMPLE 3- CORRECTION 1 | 5.510 | 5.530 | -0.020 |
| SAMPLE 2- CORRECTION 3 | 5.250 | 5.250 | 0.000 |
| SAMPLE 1-CORRECTION 2 | 5.330 | 5.290 | 0.040 |
| SAMPLE 3- CORRECTION 1 | 5.210 | 5.250 | -0.040 |
| SAMPLE 2- CORRECTION 3 | 5.790 | 5.800 | -0.010 |
| SAMPLE 1-CORRECTION 2 | 5.750 | 5.820 | -0.070 |
| SAMPLE 3- CORRECTION 1 | 5.830 | 5.750 | 0.080 |
| SAMPLE 2- CORRECTION 3 | 5.520 | 5.380 | 0.140 |
| SAMPLE 1-CORRECTION 2 | 5.310 | 5.430 | -0.120 |
| SAMPLE 3- CORRECTION 1 | 5.380 | 5.400 | -0.020 |
| SAMPLE 2- CORRECTION 3 | 6.060 | 6.180 | -0.120 |
| SAMPLE 1-CORRECTION 2 | 6.340 | 6.210 | 0.130 |
| SAMPLE 3- CORRECTION 1 | 6.180 | 6.190 | -0.010 |
| SAMPLE 2- CORRECTION 3 | 5.390 | 5.260 | 0.130 |
| SAMPLE 1-CORRECTION 2 | 5.160 | 5.250 | -0.090 |
| SAMPLE 3- CORRECTION 1 | 5.160 | 5.200 | -0.040 |
| SAMPLE 2- CORRECTION 3 | 5.290 | 5.210 | 0.080 |
| SAMPLE 1-CORRECTION 2 | 5.180 | 5.200 | -0.020 |
| SAMPLE 3- CORRECTION 1 | 5.140 | 5.200 | -0.060 |
| SAMPLE 2- CORRECTION 3 | 6.790 | 7.050 | -0.260 |
| SAMPLE 1-CORRECTION 2 | 7.080 | 7.060 | 0.020 |
| SAMPLE 3- CORRECTION 1 | 7.270 | 7.030 | 0.240 |
| SAMPLE 2- CORRECTION 3 | 5.410 | 5.330 | 0.080 |
| SAMPLE 1-CORRECTION 2 | 5.290 | 5.380 | -0.090 |
| SAMPLE 3- CORRECTION 1 | 5.340 | 5.330 | 0.010 |
| SAMPLE 2- CORRECTION 3 | 4.650 | 4.720 | -0.070 |
| SAMPLE 1-CORRECTION 2 | 4.660 | 4.710 | -0.050 |
| SAMPLE 3- CORRECTION 1 | 4.860 | 4.740 | 0.120 |
| SAMPLE 2- CORRECTION 3 | 5.510 | 5.410 | 0.100 |
| SAMPLE 1-CORRECTION 2 | 5.250 | 5.430 | -0.180 |
| SAMPLE 3- CORRECTION 1 | 5.470 | 5.390 | 0.080 |
| SAMPLE 2- CORRECTION 3 | 5.420 | 5.450 | -0.030 |
| SAMPLE 1-CORRECTION 2 | | 5.450 | 0.030 |
| SAMPLE 3- CORRECTION 1 | 5.430 | 5.430 | 0.000 |
| SAMPLE 2- CORRECTION 3 | 5.160 | 5.110 | 0.050 |
| SAMPLE 1-CORRECTION 2 | 5.100 | 5.140 | -0.040 |
| SAMPLE 3- CORRECTION 1 | 5.130 | 5.140 | -0.010 |
| SAMPLE 2- CORRECTION 3 | 5.140 | 5.270 | -0.130 |
| SAMPLE 1-CORRECTION 2 | 5.320 | 5.270 | 0.050 |
| SAMPLE 3- CORRECTION 1 | 5.330 | 5.250 | 0.080 |

| |
|---|
| -0.000 |
| 0.095 |
| 42.000 |

# 1 SAMPLE CORRECTION

COMBINATION 1 | COMBINATION 2

EXTERNAL SCALE

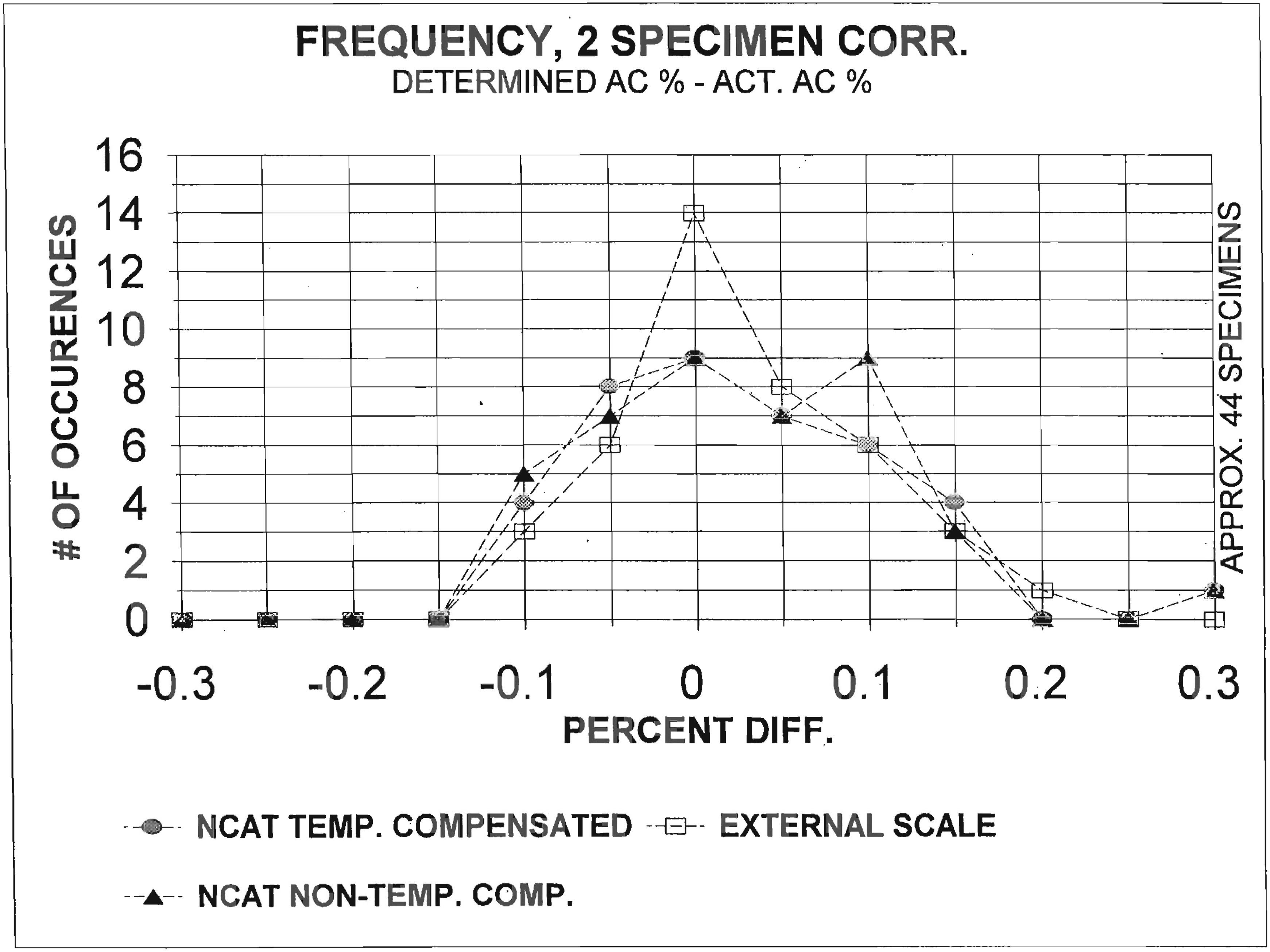
| | Combination 1 | | ACT AC% | CORR.-ACT. AC% | Combination 2 | | ACT AC% | CORR.-ACT. AC% |
|---|---|---|---|---|---|---|---|---|
| 137X-2 | SAMPLE 2-CORRECTION 1 | 5.570 | 5.510 | 0.060 | SAMPLE 2- CORRECTION 3 | 5.570 | 5.510 | 0.060 |
| 137X-3 | SAMPLE 1- CORRECTION 3 | 5.510 | 5.510 | 0.000 | SAMPLE 1-CORRECTION 2 | 5.450 | 5.510 | -0.060 |
| 137X-5 | SAMPLE 3- CORRECTION 2 | 5.470 | 5.530 | -0.060 | SAMPLE 3- CORRECTION 1 | 5.530 | 5.530 | -0.000 |
| 94x-6 | SAMPLE 2-CORRECTION 1 | 5.170 | 5.250 | -0.080 | SAMPLE 2- CORRECTION 3 | 5.250 | 5.250 | 0.000 |
| 94x-5 | SAMPLE 1- CORRECTION 3 | 5.330 | 5.290 | 0.040 | SAMPLE 1-CORRECTION 2 | 5.370 | 5.290 | 0.080 |
| 94x-3 | SAMPLE 3- CORRECTION 2 | 5.290 | 5.250 | 0.040 | SAMPLE 3- CORRECTION 1 | 5.170 | 5.250 | -0.080 |
| 152x-5 | SAMPLE 2-CORRECTION 1 | 5.840 | 5.800 | 0.040 | SAMPLE 2- CORRECTION 3 | 5.950 | 5.800 | 0.150 |
| 152x-2 | SAMPLE 1- CORRECTION 3 | 5.910 | 5.820 | 0.090 | SAMPLE 1-CORRECTION 2 | 5.780 | 5.820 | -0.040 |
| 152x-3 | SAMPLE 3- CORRECTION 2 | 5.620 | 5.750 | -0.130 | SAMPLE 3- CORRECTION 1 | 5.640 | 5.750 | -0.110 |
| 160x-1 | SAMPLE 2-CORRECTION 1 | 5.400 | 5.380 | 0.020 | SAMPLE 2- CORRECTION 3 | 5.450 | 5.380 | 0.070 |
| 160x-2 | SAMPLE 1- CORRECTION 3 | 5.430 | 5.430 | 0.000 | SAMPLE 1-CORRECTION 2 | 5.410 | 5.430 | -0.020 |
| 160x-5 | SAMPLE 3- CORRECTION 2 | 5.380 | 5.400 | -0.020 | SAMPLE 3- CORRECTION 1 | 5.350 | 5.400 | -0.050 |
| 261x-3 | | | | | | | | 0.000 |
| 261x-5 | | | | | | | | 0.000 |
| 177X-4 | SAMPLE 2- CORRECTION 1 | 6.060 | 6.180 | -0.120 | SAMPLE 2- CORRECTION 3 | 6.140 | 6.180 | -0.040 |
| 177X-1 | SAMPLE 1-CORRECTION 3 | 6.260 | 6.210 | 0.050 | SAMPLE 1-CORRECTION 2 | 6.330 | 6.210 | 0.120 |
| 177X-6 | SAMPLE 3- CORRECTION 2 | 6.260 | 6.190 | 0.070 | SAMPLE 3- CORRECTION 1 | 6.110 | 6.190 | -0.080 |
| 443X-4 | SAMPLE 2- CORRECTION 1 | 5.160 | 5.260 | -0.100 | SAMPLE 2- CORRECTION 3 | 5.270 | 5.260 | 0.010 |
| 443X-6 | SAMPLE 1-CORRECTION 3 | 5.370 | 5.250 | 0.120 | SAMPLE 1-CORRECTION 2 | 5.350 | 5.250 | 0.100 |
| 443X-2 | SAMPLE 3- CORRECTION 2 | 5.180 | 5.200 | -0.020 | SAMPLE 3- CORRECTION 1 | 5.090 | 5.200 | -0.110 |
| 166X-6 | SAMPLE 2- CORRECTION 1 | 5.200 | 5.210 | -0.010 | SAMPLE 2- CORRECTION 3 | 5.210 | 5.210 | 0.000 |
| 166X-2 | SAMPLE 1-CORRECTION 3 | 5.220 | 5.200 | 0.020 | SAMPLE 1-CORRECTION 2 | 5.210 | 5.200 | 0.010 |
| 166X-4 | SAMPLE 3- CORRECTION 2 | 5.190 | 5.200 | -0.010 | SAMPLE 3- CORRECTION 1 | 5.190 | 5.200 | -0.010 |
| 184x-3 | SAMPLE 2- CORRECTION 1 | 7.030 | 7.050 | -0.020 | SAMPLE 2- CORRECTION 3 | 6.850 | 7.050 | -0.200 |
| 184x-2 | SAMPLE 1-CORRECTION 3 | 6.870 | 7.060 | -0.190 | SAMPLE 1-CORRECTION 2 | 7.080 | 7.060 | 0.020 |
| 184x4 | SAMPLE 3- CORRECTION 2 | 7.240 | 7.030 | 0.210 | SAMPLE 3- CORRECTION 1 | 7.210 | 7.030 | 0.180 |
| 417x-2 | SAMPLE 2- CORRECTION 1 | 5.430 | 5.330 | 0.100 | SAMPLE 2- CORRECTION 3 | 5.490 | 5.330 | 0.160 |
| 417x-3 | SAMPLE 1-CORRECTION 3 | 5.390 | 5.380 | 0.010 | SAMPLE 1-CORRECTION 2 | 5.280 | 5.380 | -0.100 |
| 417x5 | SAMPLE 3- CORRECTION 2 | 5.220 | 5.330 | -0.110 | SAMPLE 3- CORRECTION 1 | 5.270 | 5.330 | -0.060 |
| 315x-1 | SAMPLE 2- CORRECTION 1 | 4.730 | 4.720 | 0.010 | SAMPLE 2- CORRECTION 3 | 4.680 | 4.720 | -0.040 |
| 315x-4 | SAMPLE 1-CORRECTION 3 | 4.670 | 4.710 | -0.040 | SAMPLE 1-CORRECTION 2 | 4.700 | 4.710 | -0.010 |
| 315x-6 | SAMPLE 3- CORRECTION 2 | 4.770 | 4.740 | 0.030 | SAMPLE 3- CORRECTION 1 | 4.790 | 4.740 | 0.050 |
| 415x-2 | SAMPLE 2- CORRECTION 1 | 5.470 | 5.410 | 0.060 | SAMPLE 2- CORRECTION 3 | 5.580 | 5.410 | 0.170 |
| 415x-3 | SAMPLE 1-CORRECTION 3 | 5.520 | 5.430 | 0.090 | SAMPLE 1-CORRECTION 2 | 5.370 | 5.430 | -0.060 |
| 415x-6 | SAMPLE 3- CORRECTION 2 | 5.240 | 5.390 | -0.150 | SAMPLE 3- CORRECTION 1 | 5.280 | 5.390 | -0.110 |
| 168x-1 | SAMPLE 2- CORRECTION 1 | 5.510 | 5.450 | 0.060 | SAMPLE 2- CORRECTION 3 | 5.500 | 5.450 | 0.050 |
| 168x-5 | SAMPLE 1-CORRECTION 3 | 5.440 | 5.450 | -0.010 | SAMPLE 1-CORRECTION 2 | 5.390 | 5.450 | -0.060 |
| 168x-6 | SAMPLE 3- CORRECTION 2 | 5.380 | 5.430 | -0.050 | SAMPLE 3- CORRECTION 1 | 5.440 | 5.430 | 0.010 |
| 239x-3 | SAMPLE 2- CORRECTION 1 | 5.190 | 5.110 | 0.080 | SAMPLE 2- CORRECTION 3 | 5.160 | 5.110 | 0.050 |
| 239x-4 | SAMPLE 1-CORRECTION 3 | 5.080 | 5.140 | -0.060 | SAMPLE 1-CORRECTION 2 | 5.060 | 5.140 | -0.080 |
| 239x-5 | SAMPLE 3- CORRECTION 2 | 5.120 | 5.140 | -0.020 | SAMPLE 3- CORRECTION 1 | 5.170 | 5.140 | 0.030 |
| 414x-2 | SAMPLE 2- CORRECTION 1 | 5.220 | 5.270 | -0.050 | SAMPLE 2- CORRECTION 3 | 5.150 | 5.270 | -0.120 |
| 414x-4 | SAMPLE 1-CORRECTION 3 | 5.200 | 5.270 | -0.070 | SAMPLE 1-CORRECTION 2 | 5.320 | 5.270 | 0.050 |
| 414x-6 | SAMPLE 3- CORRECTION 2 | 5.370 | 5.250 | 0.120 | SAMPLE 3- CORRECTION 1 | 5.320 | 5.250 | 0.070 |

| | Combination 1 | Combination 2 |
|---|---|---|
| MEAN | 0.000 | 0.000 |
| STD. DEV. | 0.081 | 0.085 |
| # OF SAMPLES | 42.000 | 44.000 |

**AVERAGE STD. DEV. = 0.083**

# Appendix F

## Summary of Asphalt Content Accuracy and Precision using a two-Specimen Correction for each Method of AC Measurement


FREQUENCY, 2 SPECIMEN CORR.
DETERMINED AC % - ACT. AC %
# OF OCCURENCES
0
2
4
6
8
10
12
14
16
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
PERCENT DIFF.
APPROX. 44 SPECIMENS
NCAT TEMP. COMPENSATED
EXTERNAL SCALE
NCAT NON-TEMP. COMP.

## 2 SPECIMEN CORRECTION

| PERCENT DIFF. RANGE | TEMP. COMPENSATED NCAT FREQUENCY | NON TEMP. COMPENSATED FREQUENCY | EXTERNAL FREQUENCY |
|---|---|---|---|
| -0.300 | 0.000 | 0.000 | 0.000 |
| -0.250 | 0.000 | 0.000 | 0.000 |
| -0.200 | 0.000 | 0.000 | 0.000 |
| -0.150 | 0.000 | 0.000 | 0.000 |
| -0.100 | 4.000 | 5.000 | 3.000 |
| -0.050 | 8.000 | 7.000 | 6.000 |
| -0.000 | 9.000 | 9.000 | 14.000 |
| 0.050 | 7.000 | 7.000 | 8.000 |
| 0.100 | 6.000 | 9.000 | 6.000 |
| 0.150 | 4.000 | 3.000 | 3.000 |
| 0.200 | 0.000 | 0.000 | 1.000 |
| 0.250 | 0.000 | 0.000 | 0.000 |
| | 1.000 | 1.000 | 0.000 |
| | 0.000 | 0.000 | 0.000 |
| | | 0.000 | |

# 2 SAMPLE CORRECTION

EXTERNAL SCALE

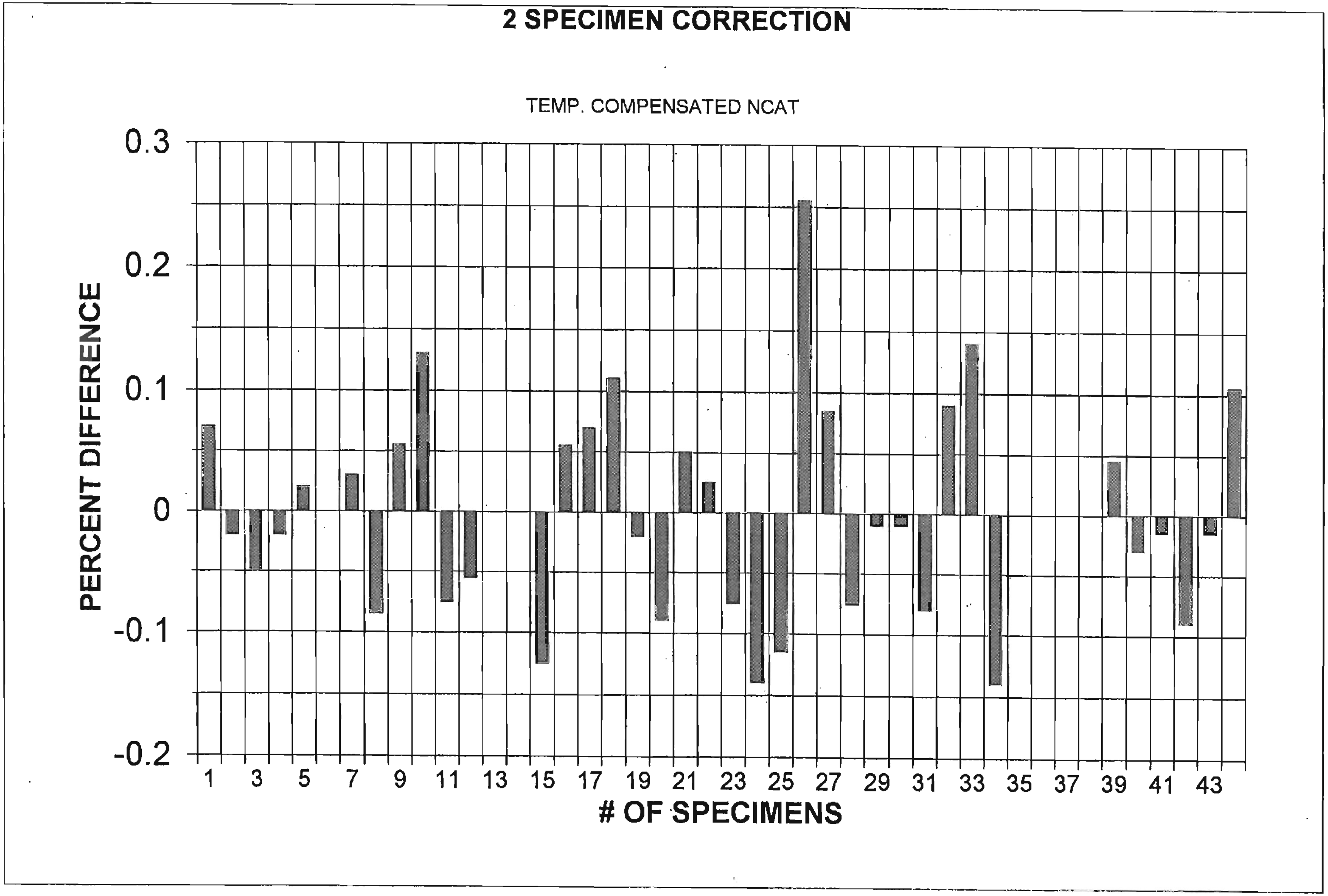
| | | | ACT. AC % | CORR. - ACT. AC % |
|---|---|---|---|---|
| 137X-2 | SAMPLE 2-CORR.(1,3) | 5.570 | 5.510 | 0.060 |
| 137X-3 | SAMPLE 1-CORR.(2,3) | 5.480 | 5.510 | -0.030 |
| 137X-5 | SAMPLE 3-CORR.(1,2) | 5.500 | 5.530 | -0.030 |
| 94x-6 | SAMPLE 2-CORR.(1,3) | 5.210 | 5.250 | -0.040 |
| 94x-5 | SAMPLE 1-CORR.(2,3) | 5.350 | 5.290 | 0.060 |
| 94x-3 | SAMPLE 3-CORR.(1,2) | 5.230 | 5.250 | -0.020 |
| 152x-5 | SAMPLE 2-CORR.(1,3) | 5.895 | 5.800 | 0.095 |
| 152x-2 | SAMPLE 1-CORR.(2,3) | 5.845 | 5.820 | 0.025 |
| 152x-3 | SAMPLE 3-CORR.(1,2) | 5.630 | 5.750 | -0.120 |
| 160x-1 | SAMPLE 2-CORR.(1,3) | 5.425 | 5.380 | 0.045 |
| 160x-2 | SAMPLE 1-CORR.(2,3) | 5.420 | 5.430 | -0.010 |
| 160x-5 | SAMPLE 3-CORR.(1,2) | 5.365 | 5.400 | -0.035 |
| 261x-3 | | | | 0.000 |
| 261x-5 | | | | 0.000 |
| 177X-4 | SAMPLE 2-CORR.(1,3) | 6.100 | 6.180 | -0.080 |
| 177X-1 | SAMPLE 1-CORR.(2,3) | 6.295 | 6.210 | 0.085 |
| 177X-6 | SAMPLE 3-CORR.(1,2) | 6.185 | 6.190 | -0.005 |
| 443X-4 | SAMPLE 2-CORR.(1,3) | 5.215 | 5.260 | -0.045 |
| 443X-6 | SAMPLE 1-CORR.(2,3) | 5.360 | 5.250 | 0.110 |
| 443X-2 | SAMPLE 3-CORR.(1,2) | 5.135 | 5.200 | -0.065 |
| 166X-6 | SAMPLE 2-CORR.(1,3) | 5.205 | 5.210 | -0.005 |
| 166X-2 | SAMPLE 1-CORR.(2,3) | 5.215 | 5.200 | 0.015 |
| 166X-4 | SAMPLE 3-CORR.(1,2) | 5.190 | 5.200 | -0.010 |
| 184x-3 | SAMPLE 2-CORR.(1,3) | 6.940 | 7.050 | -0.110 |
| 184x-2 | SAMPLE 1-CORR.(2,3) | 6.975 | 7.060 | -0.085 |
| 184x4 | SAMPLE 3-CORR.(1,2) | 7.225 | 7.030 | 0.195 |
| 417x-2 | SAMPLE 2-CORR.(1,3) | 5.460 | 5.330 | 0.130 |
| 417x-3 | SAMPLE 1-CORR.(2,3) | 5.335 | 5.380 | -0.045 |
| 417x5 | SAMPLE 3-CORR.(1,2) | 5.245 | 5.330 | -0.085 |
| 315x-1 | SAMPLE 2-CORR.(1,3) | 4.705 | 4.720 | -0.015 |
| 315x-4 | SAMPLE 1-CORR.(2,3) | 4.685 | 4.710 | -0.025 |
| 315x-6 | SAMPLE 3-CORR.(1,2) | 4.780 | 4.740 | 0.040 |
| 415x-2 | SAMPLE 2-CORR.(1,3) | 5.525 | 5.410 | 0.115 |
| 415x-3 | SAMPLE 1-CORR.(2,3) | 5.445 | 5.430 | 0.015 |
| 415x-6 | SAMPLE 3-CORR.(1,2) | 5.260 | 5.390 | -0.130 |
| 168x-1 | SAMPLE 2-CORR.(1,3) | 5.505 | 5.450 | |
| 168x-5 | SAMPLE 1-CORR.(2,3) | 5.415 | 5.450 | |
| 168x-6 | SAMPLE 3-CORR.(1,2) | 5.410 | 5.430 | |
| 239x-3 | SAMPLE 2-CORR.(1,3) | 5.175 | 5.110 | 0.065 |
| 239x-4 | SAMPLE 1-CORR.(2,3) | 5.070 | 5.140 | -0.070 |
| 239x-5 | SAMPLE 3-CORR.(1,2) | 5.145 | 5.140 | 0.005 |
| 414x-2 | SAMPLE 2-CORR.(1,3) | 5.185 | 5.270 | -0.085 |
| 414x-4 | SAMPLE 1-CORR.(2,3) | 5.260 | 5.270 | -0.010 |
| 414x-6 | SAMPLE 3-CORR.(1,2) | 5.345 | 5.250 | 0.095 |

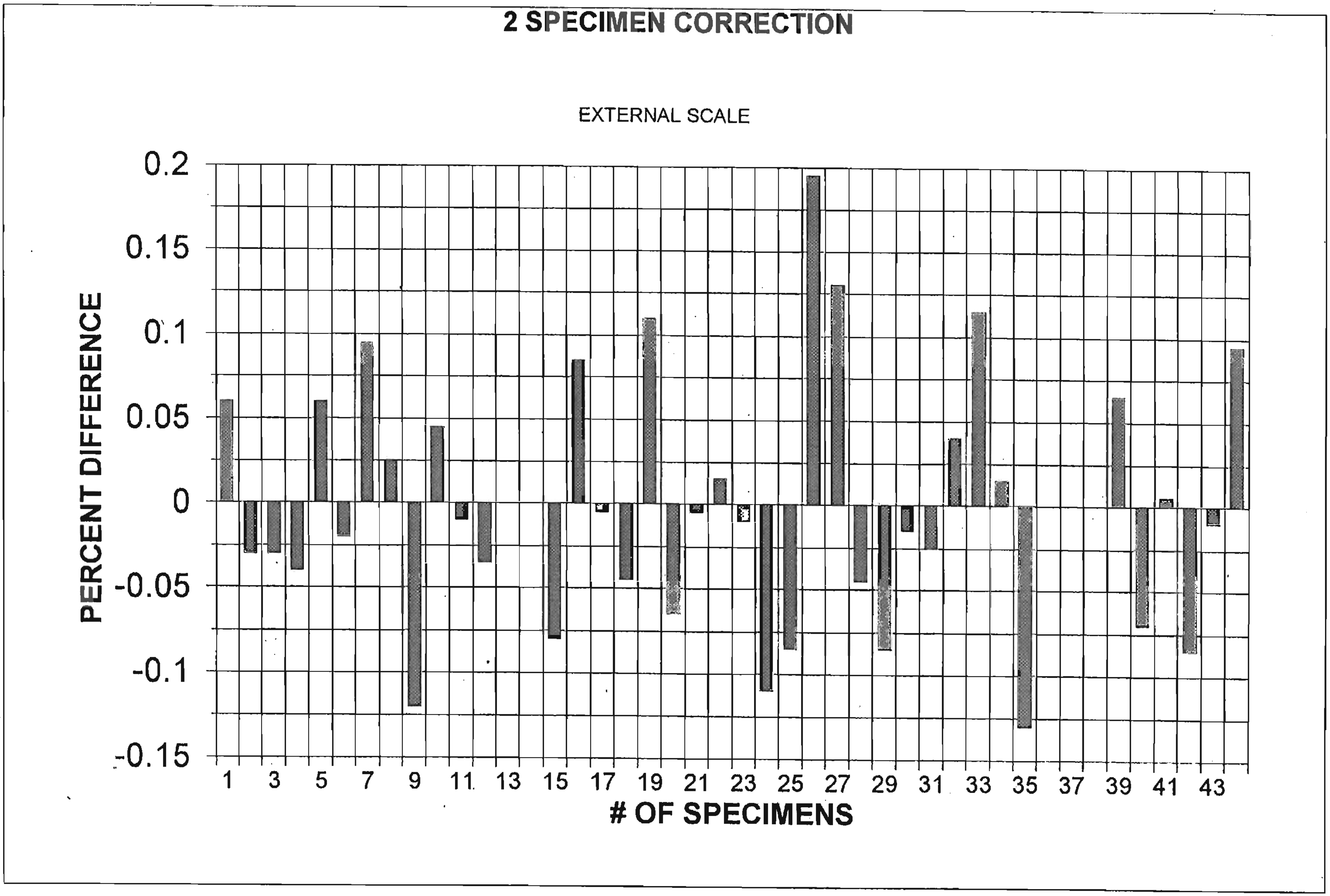
| | |
|---|---|
| MEAN | 0.000 |
| STD. DEV. | 0.073 |
| # OF CASES | 41.000 |

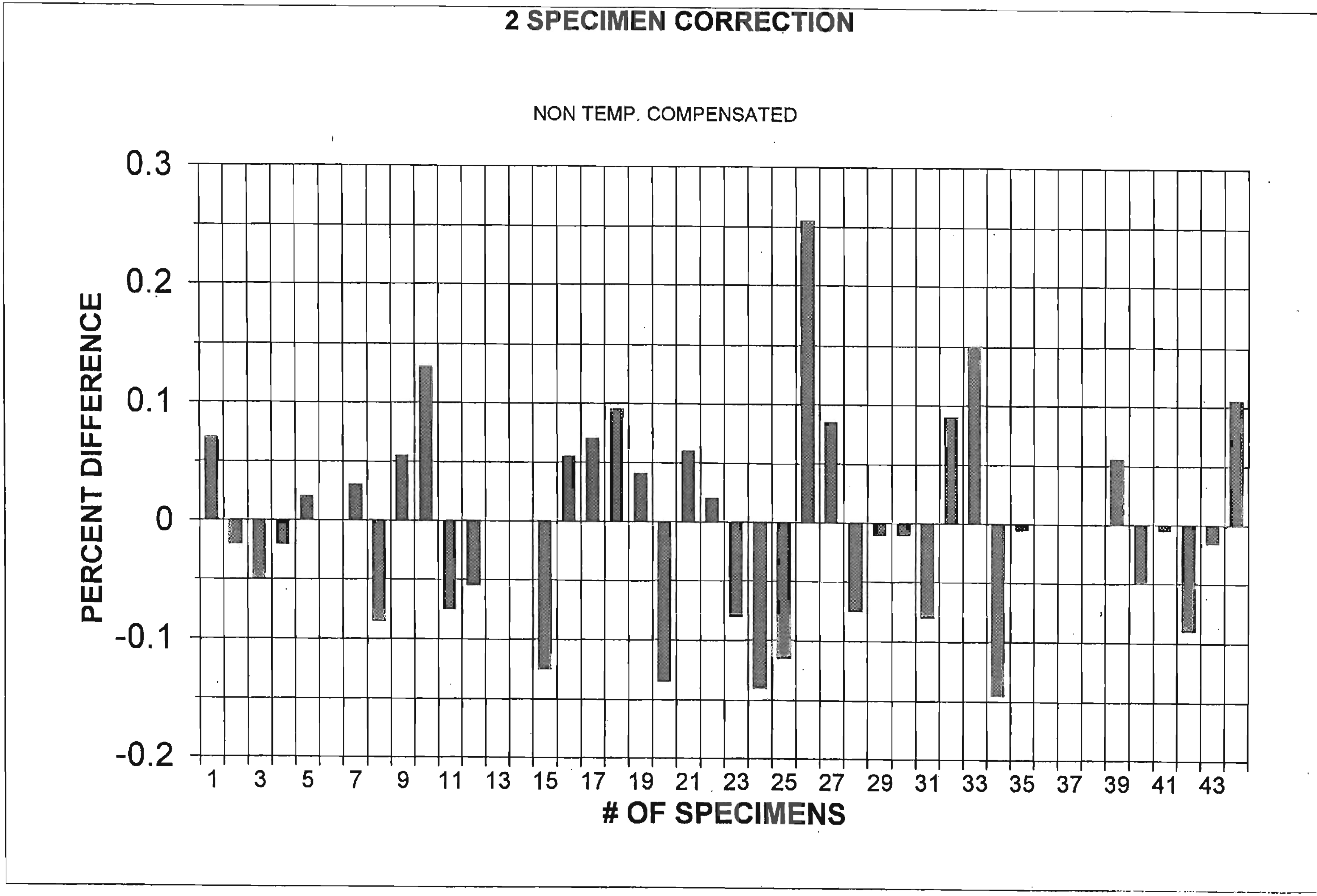
## 2 SAMPLE CORRECTION

| TEMP. COMPENSATED NCAT | | | ACT AC% | CORR.-ACT. AC% |
|---|---|---|---|---|
| 137X-2 | SAMPLE 2-CORR.(1,3) | 5.580 | 5.510 | 0.070 |
| 137X-3 | SAMPLE 1-CORR.(2,3) | 5.490 | 5.510 | -0.020 |
| 137X-5 | SAMPLE 3-CORR.(1,2) | 5.480 | 5.530 | -0.050 |
| 94x-6 | SAMPLE 2-CORR.(1,3) | 5.230 | 5.250 | -0.020 |
| 94x-5 | SAMPLE 1-CORR.(2,3) | 5.310 | 5.290 | 0.020 |
| 94x-3 | SAMPLE 3-CORR.(1,2) | 5.250 | 5.250 | 0.000 |
| 152x-5 | SAMPLE 2-CORR.(1,3) | 5.830 | 5.800 | 0.030 |
| 152x-2 | SAMPLE 1-CORR.(2,3) | 5.735 | 5.820 | -0.085 |
| 152x-3 | SAMPLE 3-CORR.(1,2) | 5.805 | 5.750 | 0.055 |
| 160x-1 | SAMPLE 2-CORR.(1,3) | 5.510 | 5.380 | 0.130 |
| 160x-2 | SAMPLE 1-CORR.(2,3) | 5.355 | 5.430 | -0.075 |
| 160x-5 | SAMPLE 3-CORR.(1,2) | 5.345 | 5.400 | -0.055 |
| 261x-3 | | | | |
| 261x-5 | | | | |
| 177X-4 | SAMPLE 2-CORR.(1,3) | 6.055 | 6.180 | -0.125 |
| 177X-1 | SAMPLE 1-CORR.(2,3) | 6.265 | 6.210 | 0.055 |
| 177X-6 | SAMPLE 3-CORR.(1,2) | 6.260 | 6.190 | 0.070 |
| 443X-4 | SAMPLE 2-CORR.(1,3) | 5.370 | 5.260 | 0.110 |
| 443X-6 | SAMPLE 1-CORR.(2,3) | 5.230 | 5.250 | -0.020 |
| 443X-2 | SAMPLE 3-CORR.(1,2) | 5.110 | 5.200 | -0.090 |
| 166X-6 | SAMPLE 2-CORR.(1,3) | 5.260 | 5.210 | 0.050 |
| 166X-2 | SAMPLE 1-CORR.(2,3) | 5.225 | 5.200 | 0.025 |
| 166X-4 | SAMPLE 3-CORR.(1,2) | 5.125 | 5.200 | -0.075 |
| 184x-3 | SAMPLE 2-CORR.(1,3) | 6.910 | 7.050 | -0.140 |
| 184x-2 | SAMPLE 1-CORR.(2,3) | 6.945 | 7.060 | -0.115 |
| 184x4 | SAMPLE 3-CORR.(1,2) | 7.285 | 7.030 | 0.255 |
| 417x-2 | SAMPLE 2-CORR.(1,3) | 5.415 | 5.330 | 0.085 |
| 417x-3 | SAMPLE 1-CORR.(2,3) | 5.305 | 5.380 | -0.075 |
| 417x5 | SAMPLE 3-CORR.(1,2) | 5.320 | 5.330 | -0.010 |
| 315x-1 | SAMPLE 2-CORR.(1,3) | 4.710 | 4.720 | -0.010 |
| 315x-4 | SAMPLE 1-CORR.(2,3) | 4.630 | 4.710 | -0.080 |
| 315x-6 | SAMPLE 3-CORR.(1,2) | 4.830 | 4.740 | 0.090 |
| 415x-2 | SAMPLE 2-CORR.(1,3) | 5.550 | 5.410 | 0.140 |
| 415x-3 | SAMPLE 1-CORR.(2,3) | 5.290 | 5.430 | -0.140 |
| 415x-6 | SAMPLE 3-CORR.(1,2) | 5.390 | 5.390 | 0.000 |
| 168x-1 | SAMPLE 2-CORR.(1,3) | 5.420 | 5.450 | |
| 168x-5 | SAMPLE 1-CORR.(2,3) | 0.015 | 5.450 | |
| 168x-6 | SAMPLE 3-CORR.(1,2) | 5.445 | 5.430 | |
| 239x-3 | SAMPLE 2-CORR.(1,3) | 5.155 | 5.110 | 0.045 |
| 239x-4 | SAMPLE 1-CORR.(2,3) | 5.110 | 5.140 | -0.030 |
| 239x-5 | SAMPLE 3-CORR.(1,2) | 5.125 | 5.140 | -0.015 |
| 414x-2 | SAMPLE 2-CORR.(1,3) | 5.180 | 5.270 | -0.090 |
| 414x-4 | SAMPLE 1-CORR.(2,3) | 5.255 | 5.270 | -0.015 |
| 414x-6 | SAMPLE 3-CORR.(1,2) | 5.355 | 5.250 | 0.105 |

| | |
|---|---|
| MEAN | 0.000 |
| STD. DEV. | 0.087 → Same value |
| # OF CASES | 39.000 |

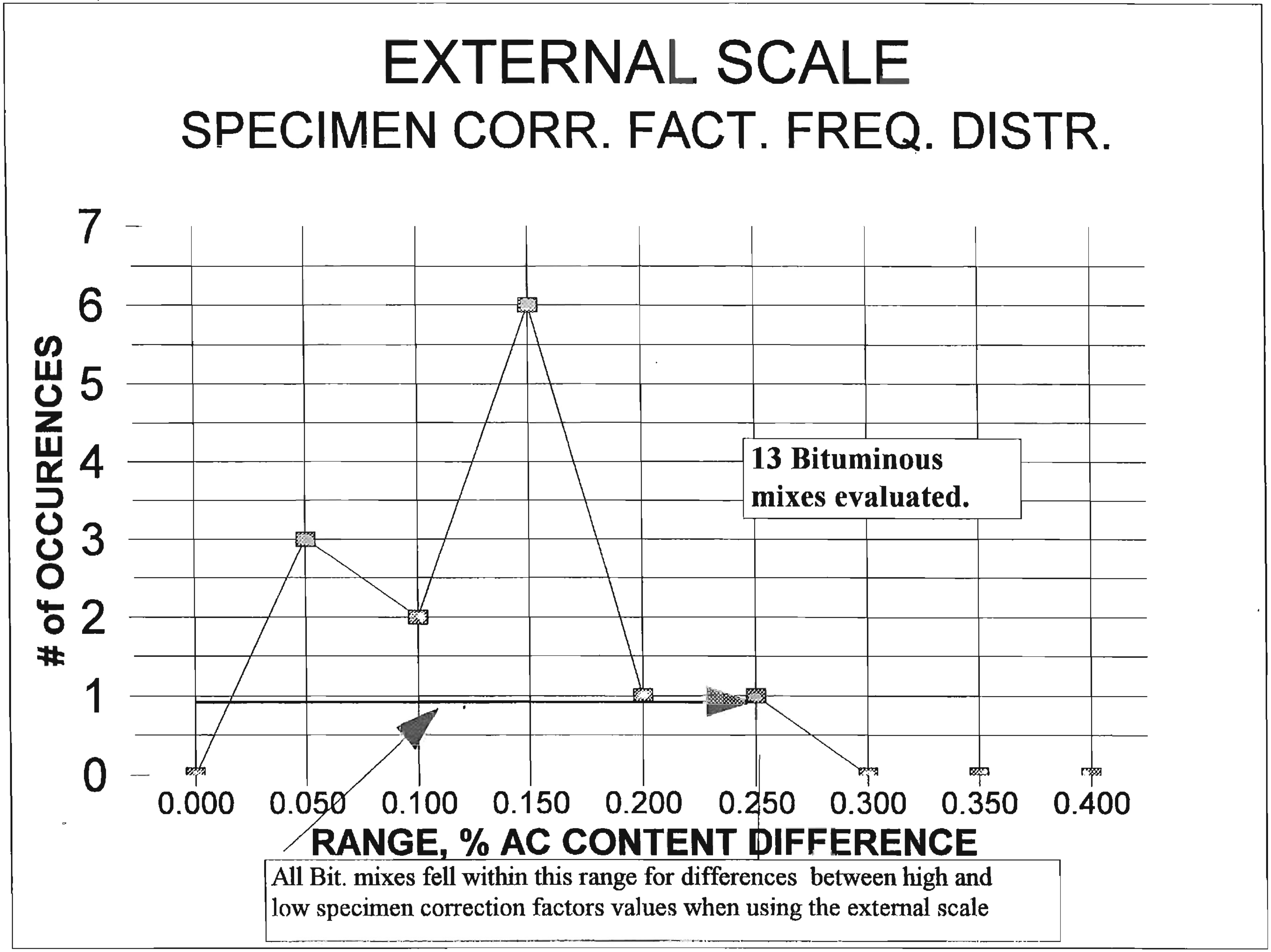

2 SPECIMEN CORRECTION
TEMP. COMPENSATED NCAT
PERCENT DIFFERENCE
0.3
0.2
0.1
0
-0.1
-0.2
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
# OF SPECIMENS

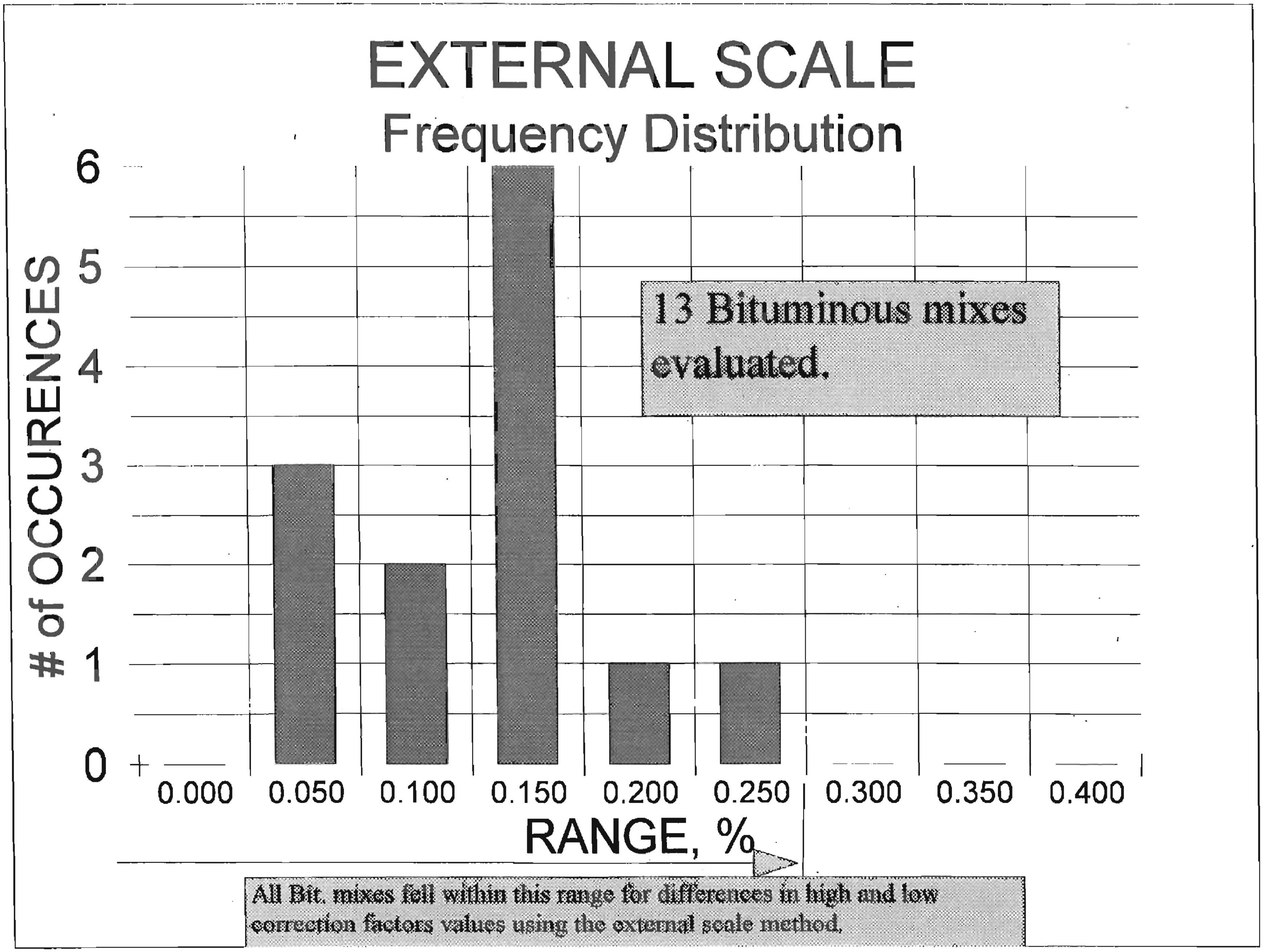

2 SPECIMEN CORRECTION
EXTERNAL SCALE
PERCENT DIFFERENCE
0.2
0.15
0.1
0.05
0
-0.05
-0.1
-0.15
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
43
# OF SPECIMENS


2 SPECIMEN CORRECTION
NON TEMP. COMPENSATED
PERCENT DIFFERENCE
0.3
0.2
0.1
0
-0.1
-0.2
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43
# OF SPECIMENS

# APPENDIX G

## Range of Specimen Correction Factors for each Bituminous Mixture


EXTERNAL SCALE
SPECIMEN CORR. FACT. FREQ. DISTR.
# of OCCURENCES
0
1
2
3
4
5
6
7
0.000
0.050
0.100
0.150
0.200
0.250
0.300
0.350
0.400
RANGE, % AC CONTENT DIFFERENCE
13 Bituminous mixes evaluated.
All Bit. mixes fell within this range for differences between high and low specimen correction factors values when using the external scale


EXTERNAL SCALE
Frequency Distribution
# of OCCURENCES
0
1
2
3
4
5
6
0.000
0.050
0.100
0.150
0.200
0.250
0.300
0.350
0.400
RANGE, %
13 Bituminous mixes evaluated.
All Bit. mixes fell within this range for differences in high and low correction factors values using the external scale method.

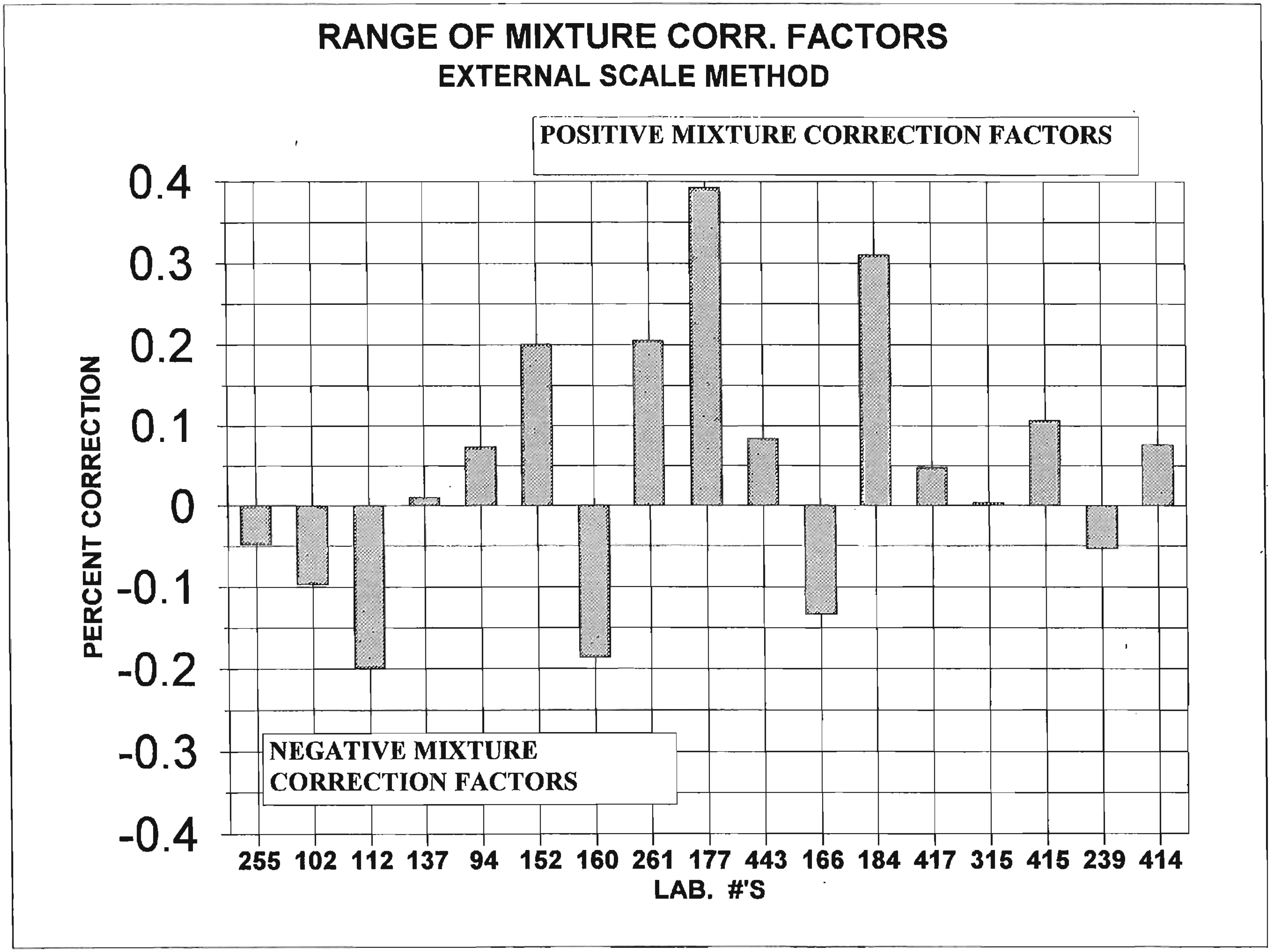
| | ncat DIFF. (C-A) | ncat range | ext DIFF. (c-b) | ext. range |
|---|---|---|---|---|
| **137X-2** | 0.000 | | -0.050 | |
| **137X-3** | 0.060 | | 0.010 | |
| **137X-5** | 0.080 | 0.080 | 0.010 | 0.060 |
| | | | | |
| **94x-6** | -0.040 | | -0.140 | |
| **94x-5** | 0.000 | | -0.060 | |
| **94x-3** | 0.040 | 0.080 | -0.020 | 0.120 |
| | | | | |
| **152x-5** | -0.180 | | -0.250 | |
| **152x-2** | -0.150 | | -0.230 | |
| **152x-3** | -0.100 | 0.080 | -0.120 | 0.130 |
| | | | | |
| **160x-1** | 0.180 | | 0.160 | |
| **160x-2** | 0.250 | | 0.190 | |
| **160x-5** | 0.270 | 0.090 | 0.210 | 0.050 |
| | | | | |
| **177X-4** | -0.390 | | -0.470 | |
| **177X-1** | -0.380 | | -0.390 | |
| **177X-6** | -0.230 | 0.160 | -0.320 | 0.150 |
| | | | | |
| **443X-4** | -0.090 | | -0.150 | |
| **443X-6** | 0.010 | | -0.060 | |
| **443X-2** | 0.050 | 0.140 | -0.040 | 0.110 |
| | | | | |
| **166X-6** | 0.190 | | 0.130 | |
| **166X-2** | 0.220 | | 0.130 | |
| **166X-4** | 0.280 | 0.090 | 0.140 | 0.010 |
| | | | | |
| **184x-3** | -0.410 | | -0.440 | |
| **184x-2** | -0.170 | | -0.260 | |
| **184x4** | -0.140 | 0.270 | -0.230 | 0.210 |
| | | | | |
| **417x-2** | -0.040 | | -0.100 | |
| **417x-3** | -0.010 | | -0.050 | |
| **417x5** | 0.000 | 0.040 | 0.010 | 0.110 |
| | | | | |
| **315x-1** | 0.050 | | -0.030 | |
| **315x-4** | 0.110 | | 0.000 | |
| **315x-6** | 0.170 | 0.120 | 0.020 | 0.050 |
| | | | | |
| **415x-2** | -0.090 | | -0.130 | |
| **415x-3** | -0.010 | | -0.170 | |
| **415x-6** | 0.070 | 0.160 | -0.020 | 0.110 |
| | | | | |
| **239x-3** | 0.050 | | 0.030 | |
| **239x-4** | 0.060 | | 0.050 | |
| **239x-5** | 0.070 | 0.020 | 0.080 | 0.050 |
| | | | | |
| **414x-2** | -0.080 | | -0.140 | |
| **414x-4** | 0.000 | | -0.070 | |
| **414x-6** | 0.050 | 0.130 | -0.020 | 0.120 |
| | | | External | |
| | | | mean | 0.098 |
| | | | std. dev. | 0.053 |

# APPENDIX H

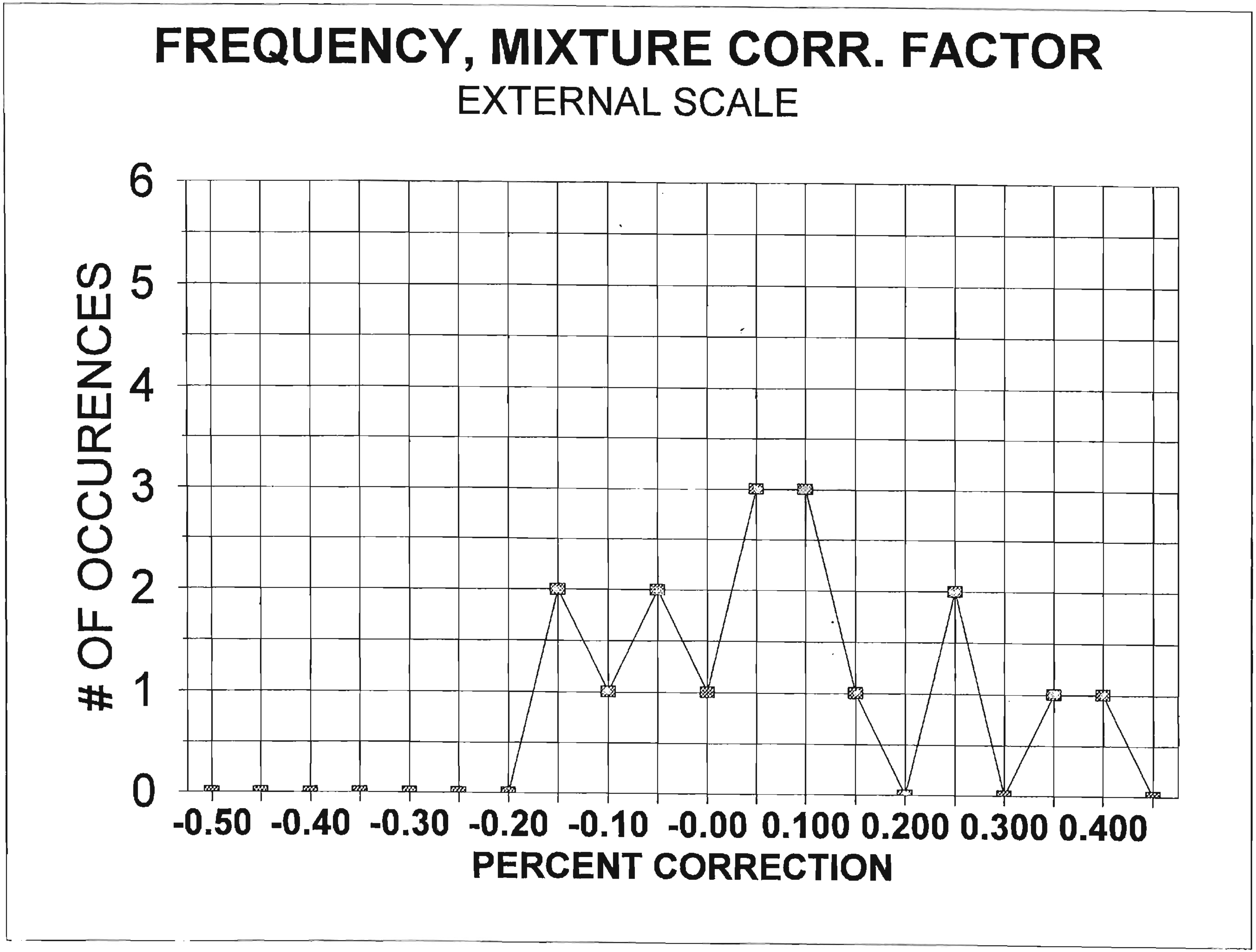
**Range of Positive and Negative Mixture Correction Factors.**

**Mean and Standard Deviation of Mixture Correction Factors**

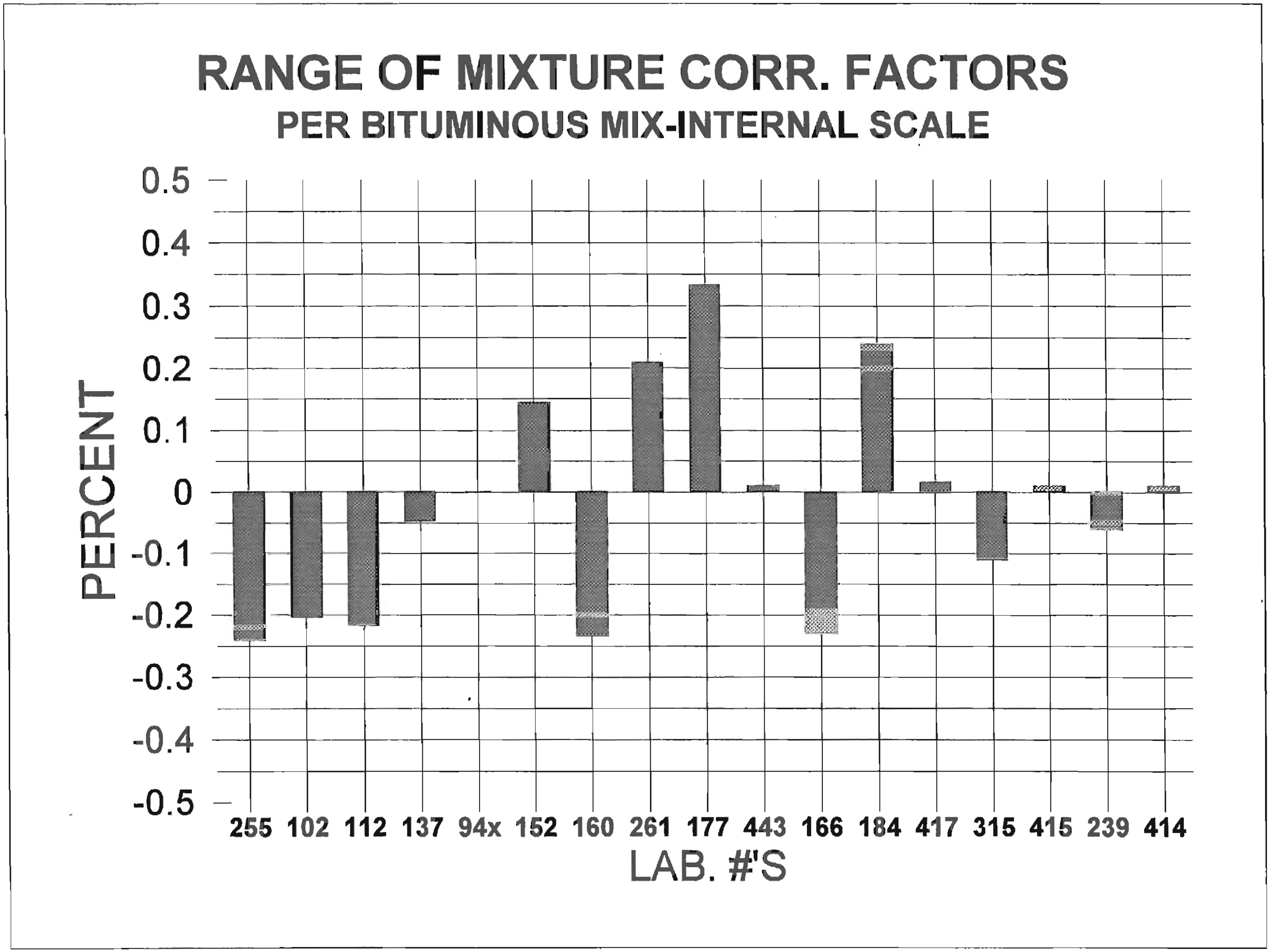
**used in this study**

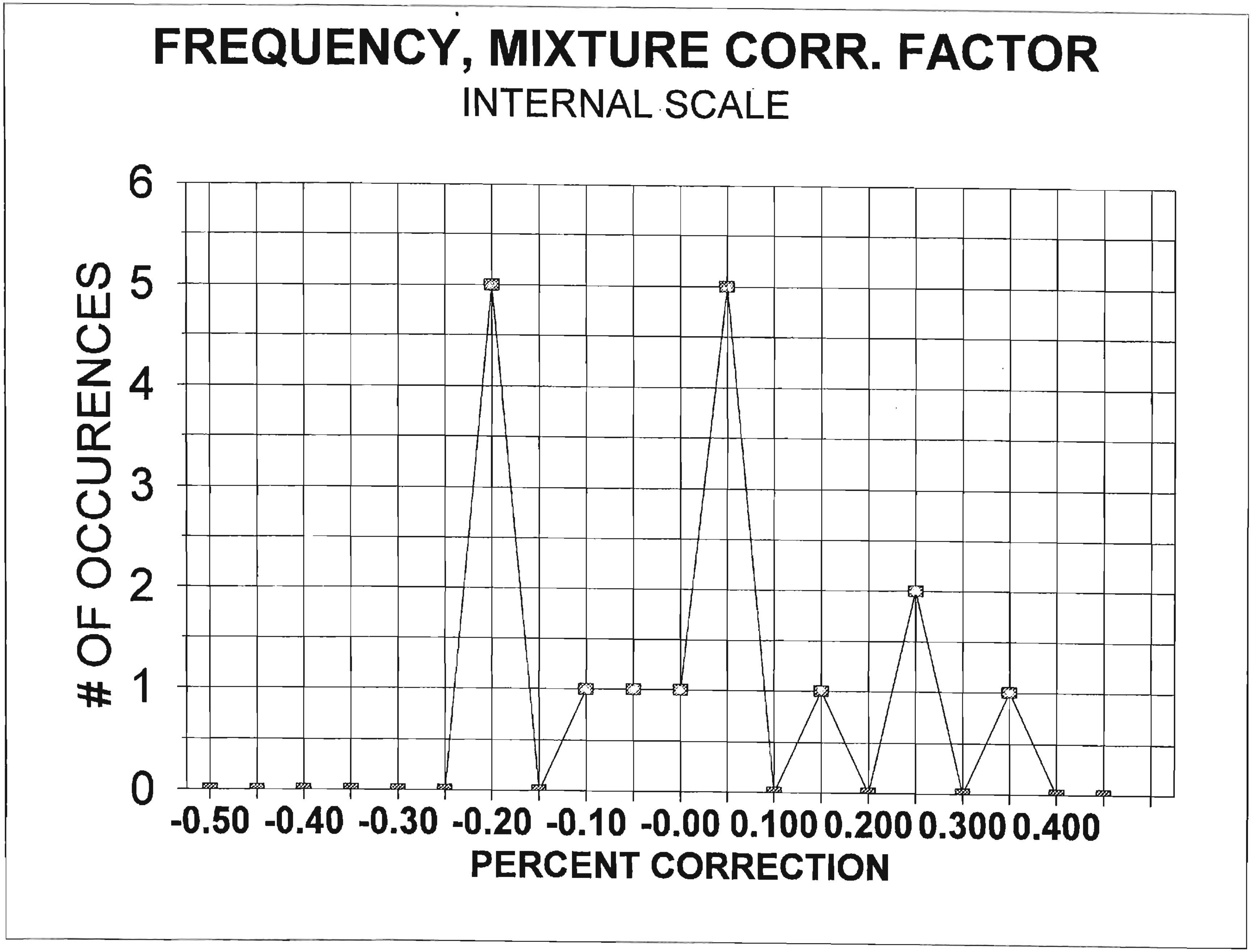


RANGE OF MIXTURE CORR. FACTORS
EXTERNAL SCALE METHOD
POSITIVE MIXTURE CORRECTION FACTORS
NEGATIVE MIXTURE CORRECTION FACTORS
PERCENT CORRECTION
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
255 102 112 137 94 152 160 261 177 443 166 184 417 315 415 239 414
LAB. #'S



FREQUENCY, MIXTURE CORR. FACTOR
EXTERNAL SCALE
# OF OCCURENCES
0
1
2
3
4
5
6
-0.50 -0.40 -0.30 -0.20 -0.10 -0.00 0.100 0.200 0.300 0.400
PERCENT CORRECTION


RANGE OF MIXTURE CORR. FACTORS
PER BITUMINOUS MIX-INTERNAL SCALE
PERCENT
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
255 102 112 137 94x 152 160 261 177 443 166 184 417 315 415 239 414
LAB. #'S


FREQUENCY, MIXTURE CORR. FACTOR
INTERNAL SCALE
# OF OCCURENCES
6
5
4
3
2
1
0
-0.50 -0.40 -0.30 -0.20 -0.10 -0.00 0.100 0.200 0.300 0.400
PERCENT CORRECTION

## CORRECTION FACTORS, AVERAGE

| LAB. # | INTERNAL | RANGE | FREQUENCY | EXTERNAL | RANGE | FREQUENCY |
|---|---|---|---|---|---|---|
| 255X-3 | -0.240 | -0.500 | 0.000 | -0.047 | -0.500 | 0.000 |
| 102X-3 | -0.203 | -0.450 | 0.000 | -0.097 | -0.450 | 0.000 |
| 112X-4 | -0.217 | -0.400 | 0.000 | -0.200 | -0.400 | 0.000 |
| 137X-5 | -0.047 | -0.350 | 0.000 | 0.010 | -0.350 | 0.000 |
| 94x-3 | 0.000 | -0.300 | 0.000 | 0.073 | -0.300 | 0.000 |
| 152x-3 | 0.143 | -0.250 | 0.000 | 0.200 | -0.250 | 0.000 |
| 160x-5 | -0.233 | -0.200 | 5.000 | -0.187 | -0.200 | 0.000 |
| 261x-5 | 0.210 | -0.150 | 0.000 | 0.205 | -0.150 | 2.000 |
| 177X-6 | 0.333 | -0.100 | 1.000 | 0.393 | -0.100 | 1.000 |
| 443X-2 | 0.010 | -0.050 | 1.000 | 0.083 | -0.050 | 2.000 |
| 166X-4 | -0.230 | -0.000 | 1.000 | -0.133 | -0.000 | 1.000 |
| 184x4 | 0.240 | 0.050 | 5.000 | 0.310 | 0.050 | 3.000 |
| 417x5 | 0.017 | 0.100 | 0.000 | 0.047 | 0.100 | 3.000 |
| 315x-6 | -0.110 | 0.150 | 1.000 | 0.003 | 0.150 | 1.000 |
| 415x-6 | 0.010 | 0.200 | 0.000 | 0.107 | 0.200 | 0.000 |
| 239x-5 | -0.060 | 0.250 | 2.000 | -0.053 | 0.250 | 2.000 |
| 414x-6 | 0.010 | 0.300 | 0.000 | 0.077 | 0.300 | 0.000 |
| | | 0.350 | 1.000 | | 0.350 | 1.000 |
| | | 0.400 | 0.000 | | 0.400 | 1.000 |
| | | | 0.000 | | | 0.000 |

MIXTURE CORRECTION FACTORS

| LAB # | INTERNAL | EXTERNAL |
|---|---|---|
| **255** | -0.240 | -0.047 |
| **102** | -0.203 | -0.097 |
| **112** | -0.217 | -0.200 |
| **137** | -0.047 | 0.010 |
| **94** | 0.000 | 0.073 |
| **152** | 0.143 | 0.200 |
| **160** | -0.233 | -0.187 |
| **261** | 0.210 | 0.205 |
| **177** | 0.333 | 0.393 |
| **443** | 0.010 | 0.083 |
| **166** | -0.230 | -0.133 |
| **184** | 0.240 | 0.310 |
| **417** | 0.017 | 0.047 |
| **315** | -0.110 | 0.003 |
| **415** | 0.010 | 0.107 |
| **239** | -0.060 | -0.053 |
| **414** | 0.010 | 0.077 |
| | N= | 17.000 |
| | mean | 0.047 |
| | std. dev. | 0.165 |

| ***Column 1*** | |
|---|---|
| Mean | 0.047 |
| Standard Error | 0.040 |
| Median | 0.047 |
| Mode | NA |
| Standard Deviation | 0.165 |
| Variance | 0.027 |
| Kurtosis | -0.108 |
| Skewness | 0.466 |
| Range | 0.593 |
| Minimum | -0.200 |
| Maximum | 0.393 |
| Sum | 0.792 |
| Count | 17.000 |
| Confidence Level(0.9! | 0.078 |