

*Evaluation of Pine Instrument Company  
Model AFG1A Superpave Gyratory Compactor*

Prepared for

Pine Instrument Company  
Grove City, PA

Prepared by

Robert B. McGennis, P.E.  
The South Central Superpave Center  
The University of Texas at Austin

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BACKGROUND

At the conclusion of the Strategic Highway Research Program, the FHWA Office of Technology applications developed a specification for the pooled fund purchase of Superpave gyratory compactors (SGC). The specification was largely based on the recommendations of SHRP researchers as well as on early FHWA experience with prototype units. In 1994, FHWA evaluated the first articles delivered by two manufacturers to meet this specification. These units were produced by Pine Instrument Company and Troxler Electronic Laboratories, Inc.

The FHWA's first article evaluation consisted primarily of comparing SGC test results among Pine, Troxler, and a modified Texas gyratory unit. The modified Texas unit was the prototype device that was used by SHRP researchers and was assumed to be the comparison standard. This evaluation showed that the Pine and Troxler compactors exhibited similar results as the modified Texas device. Overall, FHWA judged the compactors to be in conformance with the specification and thus, were suitable for the pooled fund purchase. Thirty units each of the Pine and Troxler compactors were procured as part of the first pooled fund purchase. In 1995, these units were placed in state DOT laboratories, FHWA facilities, and one in each of the five Superpave regional centers. Since then, a considerable number of the compactors have been purchased by state DOTs, industry, academia, and others.

Experience with the Pine and Troxler compactors has been good. Both devices have been upgraded in numerous ways. The most significant change to both compactors consisted of upgrade parts to allow the compaction angle to be more closely held at the desired value, 1.25°. A ruggedness experiment was conducted on the Superpave gyratory compaction procedure (AASHTO TP4). This experiment showed that the bulk specific gravity ( $G_{mb}$ ) of test specimens produced using the procedure was not unduly sensitive to tolerable operator variation. The FHWA conducted a study comparing the results of the two compactors using plant produced mixes. This study showed that the Pine and Troxler compactors were providing very similar test results. In general, the compactors were subjected to considerable scrutiny by the asphalt materials engineering community. The consensus appears to be overwhelming in favor of their use as a mix design tool.

Because of this positive experience, it soon became clear that the SGC would become the laboratory compactor of choice. Consequently, since 1995 several additional manufacturers have developed SGCs to meet the growing demand for such devices. While these units generally meet the broad requirements of the original FHWA SGC specification, their basic designs are somewhat different. Therefore, potential users of the new SGCs must ask the question, "Will I get the same test results from a new SGC as I would get from either the Pine or Troxler?"

To ensure a systematic means for answering this question, the FHWA developed a standard protocol for evaluation of SGCs. This protocol was reviewed by the FHWA Superpave Mixtures Expert Task Group (ETG) and changes were made based on this review. It is the intent of the

FHWA that this procedure will ultimately become an AASHTO standard. The protocol (Appendix B) remains in draft form as of April 1997 and it is likely that further changes will be made after it has been used.

This report describes the results of a compactor comparison experiment where the protocol was used. The experiment was conducted at the South Central Superpave Center (SCSC) at The University of Texas at Austin. It involved evaluation of a recently produced SGC from Pine Instrument Company. The objective of this report is to analyze and present data obtained using the FHWA ETG protocol for the purpose of comparing test results between the existing Pine SGC (Model No. AFGC125X) and the newly produced Pine SGC (Model AFG1A). For clarity of this report these two devices are simply referred to as “Old Pine” and “New Pine”.

## EXPERIMENTAL FEATURES

### Materials

The compactor evaluation utilized a full-factorial design with four asphalt mixtures and six specimens. The New Pine SGC was compared to the Old Pine SGC. A total of 48 specimens (4 mixes  $\times$  2 compactors  $\times$  6 replicates) were produced. Specimens were individually batched and stored in plastic bags prior to use. As required by the protocol, the four mixes were designed according to AASHTO PP28 and met all the Superpave requirements. The mixes are:

- Mix 1 - 12.5 mm coarse,
- Mix 2 - 19 mm coarse,
- Mix 3 - 19 mm fine, and
- Mix 4 - 25 mm coarse.

Coarse mixes have gradations below the Superpave restricted zone while the fine mix has a gradation above the restricted zone. The design asphalt content was selected at four percent air voids at the selected number of design gyrations using the Pine compactor. The Pine compactor was employed for this purpose because two of the mixes had previously been designed using that device for roadway projects in Texas. The asphalt binder met the requirements of PG 64-22.

Mix 1 (12.5 mm coarse) serves as the laboratory standard mix for the South Central Superpave Center. It is used for routine experimental purposes and training activities. A very similar mix was used to overlay a section of Bus. IH-35 in New Braunfels, Texas. It is composed of 90 percent crushed limestone and ten percent natural sand. The design asphalt binder content is 5.7 percent.

Mix 2 (19 mm coarse) was designed and used for an overlay of US 79 near Taylor, Texas. It is composed of 30 percent sandstone coarse aggregate and 70 percent crushed limestone. The design asphalt binder content is 4.8 percent.

Mix 3 (19 mm fine) is composed of the same materials as Mix 2 with different blend percentages to achieve a gradation above the Superpave restricted zone. The design asphalt binder content is 5.1 percent.

Mix 4 (25 mm coarse) is composed entirely of crushed limestone from the same source as Mix 1. An additional coarse aggregate from the same supplier was obtained to achieve the 25 mm maximum size. The design asphalt binder content is 4.3 percent.

Figures 1 through 3 show the gradations of the mixes. Table 1 shows mix design properties of the mixes.

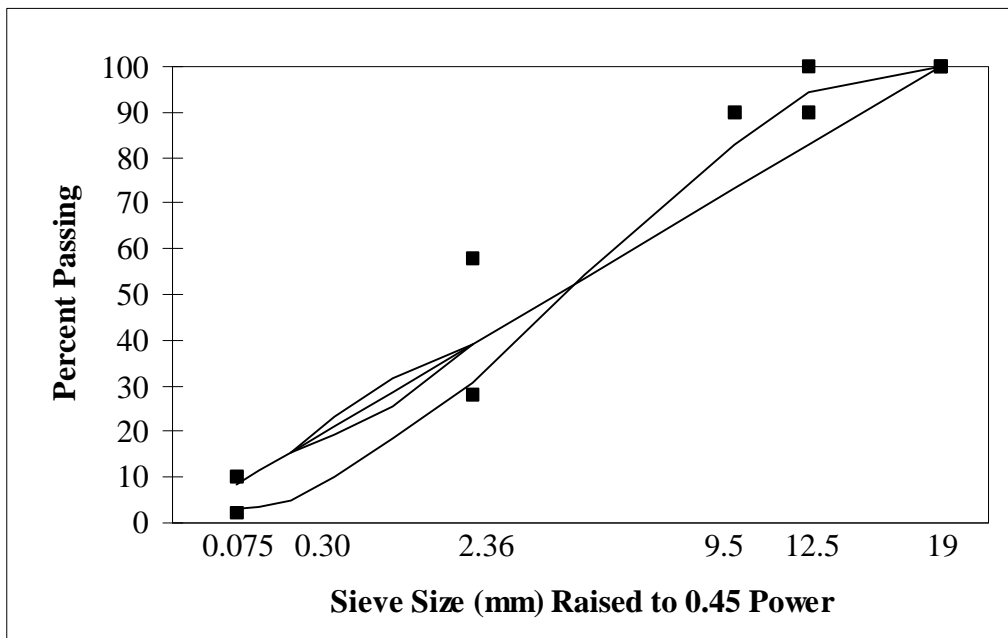


Figure 1. Gradation of Mix 1 (12.5 mm coarse)

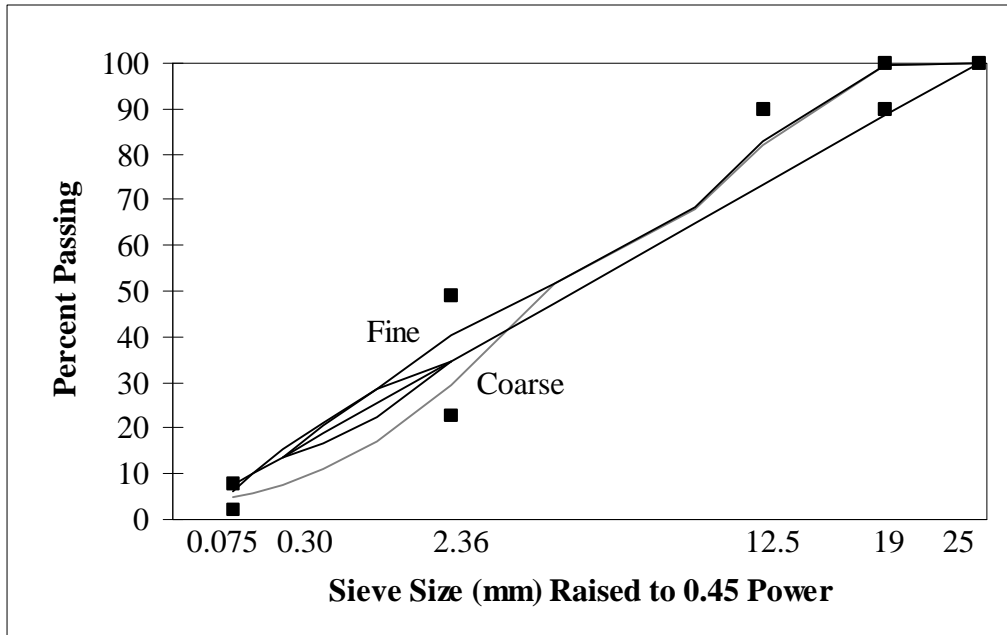


Figure 2. Gradations of Mixes 2 and 3 (19 mm coarse and fine)

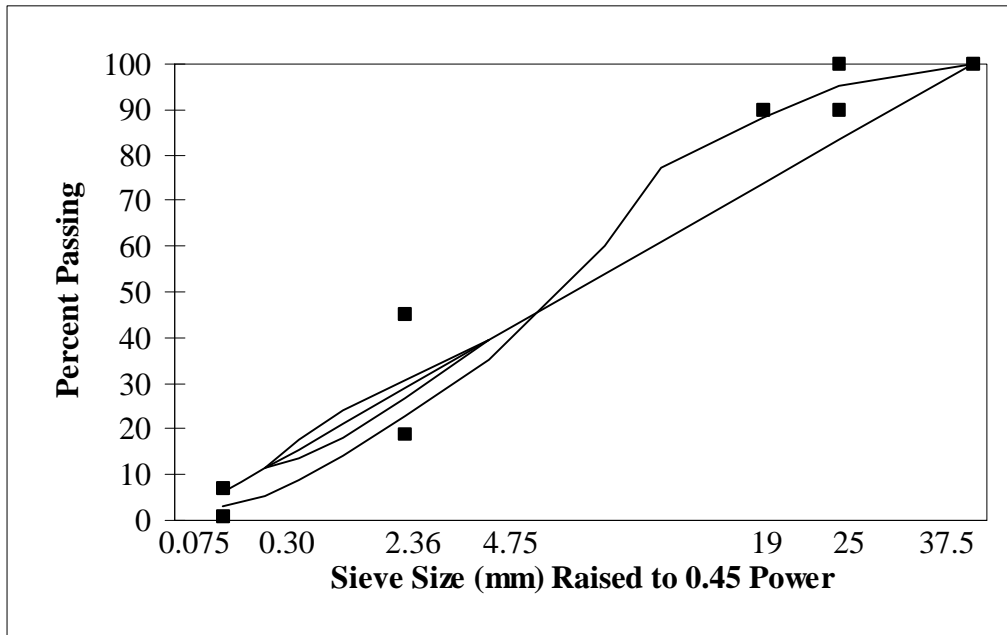


Figure 3. Gradations of Mix 4 (25 mm coarse)

Table 1. Mix Design Properties of the Mixes

Parameter	Mixture			
	1	2	3	4
Binder Content, %	5.7	4.8	5.1	4.1
Air Void Content, %	4.0	4.0	4.0	4.0
VMA, %	15.0	13.5	14.1	13.2
VFA, %	73.2	70.5	71.6	69.7
% $G_{mm}$ @ $N_{ini}$	84.6	84.0	86.9	84.4
% $G_{mm}$ @ $N_{design}$	96.0	96.0	96.0	96.0
% $G_{mm}$ @ $N_{max}$	97.6	97.6	97.1	97.4
Compaction Slope	10.0	10.6	9.1	11.6
Dust Proportion	0.6	1.0	1.2	0.8

Mixes 1, 2, and 4:  $N_{ini} = 8$ ,  $N_{des} = 109$ ,  $N_{max} = 174$   
Mix 3:  $N_{ini} = 7$ ,  $N_{des} = 86$ ,  $N_{max} = 134$

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## EXPERIMENTAL FEATURES

### Mixing and Compaction

As required by the protocol, a single operator was used throughout the experiment for the compaction process. Working closely with the compaction operator, a different operator was used for mixing. A mixing and compaction cycle of 15 minutes was used. That is, there was a constant 15-minute interval between mixing of specimens and likewise, a constant interval of 15 minutes between compaction of specimens. A short term aging period of four hours was used. Each day 12 specimens were produced. The experiment was conducted over a period of 4 days.

Oven temperatures were verified prior to the experiment and daily throughout the mixing and compaction process. A calibrated thermocouple with digital readout was employed. The mixing temperature was 150° C. To reduce variability due to operator manipulation of mixes, the compaction temperature was fixed at 135° C, which was the same as the short term aging temperature.

Determination of bulk specific gravity ( $G_{mb}$ ) was accomplished according to AASHTO T166, Method A. Calibration of the balance used for this activity was verified before and after the experiment.

### Equipment Checks and Calibration

Immediately, prior to the experiment, the new Pine compactor was thoroughly checked on-site by a Pine Instrument Company representative to ensure it was in proper working order. The operator was thoroughly briefed in proper methods of verification of calibration.

In an effort to explain testing variation as much as possible, verification of calibration items was accomplished before the experiment commenced and before each day's compaction activities for both compactors. Calibration items were: compaction angle, compaction pressure, height measurement, and rotational speed. Appendix A shows the data from the daily calibration checks.

### Experimental Design

The sequence of testing is not specified in the FHWA ETG protocol. Thus, it was necessary to develop an experimental design that would meet the ultimate goals of the protocol. A randomized test sequence was used. This ensured that systematic, unnoticed errors in the experiment would be randomly distributed among all the data. Table 2 shows the randomized test sequence.

Table 2. Randomized Test Sequence

Day	Mix	Randomized Order of Specimen Mixing and Compaction											
		1	2	3	4	5	6	7	8	9	10	11	12
1	1	OP	NP	NP	OP	NP	OP	OP	NP	NP	NP	OP	OP
2	2	OP	OP	NP	OP	NP	OP	NP	NP	OP	NP	OP	NP
3	3	NP	NP	OP	OP	NP	NP	OP	OP	OP	NP	OP	NP
4	4	NP	OP	OP	NP	OP	NP	NP	NP	OP	OP	NP	OP

For each cell in Table 2, three response variables are collected and analyzed:

- $G_{mb}$  at  $N_{initial}$
- $G_{mb}$  at  $N_{design}$
- $G_{mb}$  at  $N_{maximum}$

The  $G_{mb}$  at  $N_{max}$  was a measured value. The other response variables were computed by the following equation:

$$G_{mb} \text{ at } x \text{ gyrations} = (h_{max}/h_x) \times G_{mb} \text{ at } N_{max}$$

where,  $h_{max}$  = specimen height at  $N_{max}$  and  $h_x$  = specimen height at  $x$  gyrations.

Comparisons were conducted according to the FHWA ETG protocol. For a given mix, the average and standard deviation in  $G_{mb}$  for both compactors were computed. The protocol states that any “candidate” compactor (new Pine) with an average  $G_{mb}$  more than 0.010 different than the “evaluated SGC” (old Pine) will not be considered “comparable.” The FHWA ETG protocol also requires that the variation in  $G_{mb}$  be analyzed, but the evaluation is more qualitative. According to the protocol, the standard deviations are observed and should be “comparable.”

## EXPERIMENTAL RESULTS

The experiment proceeded according to plan. In addition, the compactors remained within calibration.

Tables 3 through 6 show the  $G_{mb}$  data formatted in the manner required by the FHWA ETG protocol. Tables 7 and 8 are the required summary tables. The comparison is made according to the following specification:

Null Hypothesis: For a given mix, the  $G_{mb}$  of a candidate compactor is the same as the  $G_{mb}$  of an evaluated compactor.

Alternate Hypothesis: For a given mix, the  $G_{mb}$  of a candidate compactor is not the same as the  $G_{mb}$  of an evaluated compactor.

Criteria: Reject null hypothesis and accept alternate hypothesis if  $|G_{mb}(\text{evaluated}) - G_{mb}(\text{candidate})| \geq 0.010$

Table 3. Bulk Specific Gravity Data for Mix 1 (12.5 mm coarse)

Spec	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$	
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine
1	2.027	2.028	2.297	2.297	2.334	2.338
2	2.039	2.037	2.308	2.305	2.345	2.342
3	2.034	2.037	2.302	2.306	2.339	2.343
4	2.035	2.037	2.304	2.307	2.341	2.344
5	2.038	2.038	2.305	2.304	2.344	2.343
6	2.042	2.035	2.311	2.302	2.348	2.339
Avg	2.036	2.035	2.305	2.304	2.342	2.342
SD	0.005	0.004	0.005	0.004	0.005	0.002

Table 4. Bulk Specific Gravity Data for Mix 2 (19 mm coarse)

Spec	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$	
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine
1	2.054	2.057	2.349	2.342	2.385	2.378
2	2.060	2.054	2.351	2.342	2.387	2.378
3	2.066	2.071	2.361	2.356	2.397	2.390
4	2.060	2.068	2.363	2.359	2.397	2.392
5	2.045	2.051	2.339	2.342	2.377	2.380
6	2.069	2.068	2.366	2.367	2.399	2.394
Avg	2.059	2.062	2.355	2.351	2.390	2.385
SD	0.008	0.008	0.010	0.011	0.009	0.007

Table 5. Bulk Specific Gravity Data for Mix 3 (19 mm fine)

Spec	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$	
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine
1	2.180	2.184	2.390	2.396	2.404	2.408
2	2.163	2.171	2.384	2.389	2.400	2.406
3	2.140	2.172	2.376	2.388	2.394	2.402
4	2.175	2.174	2.390	2.383	2.404	2.397
5	2.169	2.174	2.390	2.391	2.402	2.408
6	2.168	2.176	2.391	2.390	2.403	2.402
Avg	2.165	2.175	2.387	2.389	2.401	2.404
SD	0.016	0.005	0.006	0.004	0.004	0.004

Table 6. Bulk Specific Gravity Data for Mix 4 (25 mm coarse)

Spec	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$	
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine
1	2.031	2.057	2.304	2.337	2.339	2.371
2	2.054	2.048	2.339	2.335	2.371	2.369
3	2.047	2.062	2.328	2.334	2.360	2.370
4	2.036	2.046	2.321	2.321	2.357	2.359
5	2.038	2.047	2.319	2.330	2.357	2.366
6	2.052	2.048	2.334	2.327	2.370	2.363
Avg	2.043	2.051	2.324	2.330	2.359	2.366
SD	0.009	0.006	0.012	0.006	0.012	0.005

Table 7. Average  $G_{mb}$  Values

Mix	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$	
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine
1	2.036	2.035	2.305	2.304	2.342	2.342
2	2.059	2.062	2.355	2.351	2.390	2.385
3	2.165	2.175	2.387	2.389	2.401	2.404
4	2.043	2.051	2.324	2.330	2.359	2.366

Table 8. Standard Deviation of  $G_{mb}$  Values

Mix	$G_{mb}$ @ $N_{initial}$		$G_{mb}$ @ $N_{design}$		$G_{mb}$ @ $N_{maximum}$		Mix
	New Pine	Old Pine	New Pine	Old Pine	New Pine	Old Pine	Average
1	0.005	0.004	0.005	0.004	0.005	0.002	0.004
2	0.008	0.008	0.010	0.011	0.009	0.007	0.009
3	0.016	0.005	0.006	0.004	0.004	0.004	0.007
4	0.009	0.006	0.012	0.006	0.012	0.005	0.008
Compactor Average	0.010	0.006	0.008	0.006	0.007	0.005	0.007

Table 9 shows the differences in  $G_{mb}$  values. The numbers are old Pine  $G_{mb}$  minus new Pine  $G_{mb}$ . Shaded cells indicate differences that equal or exceed the discriminating value of 0.010.

Table 9. Difference in  $G_{mb}$  Between New and Old Pine Compactors

Mix	$G_{mb}$ @ $N_{initial}$	$G_{mb}$ @ $N_{design}$	$G_{mb}$ @ $N_{maximum}$
1	-0.001	-0.002	0.000
2	0.003	-0.003	-0.005
3	0.010	0.003	0.003
4	0.008	0.006	0.007
Average	0.006	0.004	0.004

Note: Averages based on absolute value of difference.

Observing the summary comparison in Table 9, it is obvious that the practically all of the comparisons of  $G_{mb}$  meet the FHWA ETG protocol test for comparability. The average differences in the new and old and Pine compactors are 0.006, 0.004, and 0.004 at  $N_{initial}$ ,  $N_{design}$ , and  $N_{maximum}$ , respectively. Overall, 11 out of 12 (92 percent) total comparisons have a difference in  $G_{mb}$  of less than 0.010. One comparison, for Mix 3, showed a difference in  $G_{mb}$  equal to 0.010 at  $N_{initial}$ . The trend is for the new Pine compactor to exhibit a slightly smaller  $G_{mb}$  than the old Pine compactor. This is evidenced by the mostly positive values in Table 9.

In observing the standard deviation values in Table 8, there appears to be a slight difference according to compactor. The new Pine compactor produced  $G_{mb}$  values that were slightly more variable when compared to the old Pine compactor. The old Pine standard deviation values were very consistent at about 0.006. New Pine standard deviation values ranged from 0.005 to 0.010. No definite cause can be assigned to this variability. A possible cause may involve the proficiency of the operator. The operator conducting the compaction has considerable experience with the old Pine compactor and very little with the new Pine compactor. Prior to conducting the experiment, the operator had compacted approximately 10 specimens using the new Pine unit and several hundred using an old Pine unit.

Even with the discriminating value of 0.010, the FHWA ETG protocol does not state the extent to which two compactors need to be “comparable” to be judged substantially the same. One method to make this judgment is to compare the Pine and Troxler compactors. A previous compactor comparison experiment was conducted between those two compactors. The same four mixes were used to conduct that experiment. Table 10 shows a summary of this comparison in the same format as Table 9.

Table 10. Difference in  $G_{mb}$  Between Troxler and Pine Compactors

Mix	$G_{mb}$ @ $N_{initial}$	$G_{mb}$ @ $N_{design}$	$G_{mb}$ @ $N_{maximum}$
1	0.009	0.026	0.028
2	-0.001	0.008	0.006
3	0.004	0.005	0.003
4	-0.015	-0.001	0.005
Average	0.007	0.010	0.011

In this comparison, the Pine and Troxler compactors are “comparable” 9 out of 12 times (75 percent). Evidently, the new Pine compactor compares with the old Pine at a better rate than the Troxler compactor.

## CONCLUSIONS

Using the discriminating value of 0.010 for  $G_{mb}$  in the FHWA ETG protocol, the new Pine compactor compared 11 out of 12 times in terms of  $G_{mb}$  at the three levels of gyrations of interest. The new Pine compactor exhibited slightly more variability in  $G_{mb}$  values than the Pine compactor. Both units remained in calibration throughout the experiment.

## Appendix A - Summary of Calibration Verification

Summary of Daily Calibration Verification

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Old Pine Compactor				
Date	Height, mm (152.4)	Pressure, kPa (76.3-77.1 and 320.1-326.6) <sup>a</sup>	Speed, rpm (30)	Angle, deg (1.23 - 1.25)
11/20	152.38	77.7 - 324.6	30	1.24
11/21	152.37	77.8 - 324.2	30	1.25
11/22	152.37	77.6 - 325.0	30	1.25
11/23	152.38	77.8 - 324.8	30	1.26
<sup>a</sup> numbers are dial gauge readings				

New Pine Compactor				
Date	Height (ok)	Pressure, kPa (108.1-114.8 and 228.4-242.5) <sup>a</sup>	Speed, rpm (30)	Angle, deg (1.23 - 1.25)
11/20	152.36	111.3 - 235.2	30	1.25
11/21	152.36	111.2 - 235.6	30	1.25
11/22	152.41	111.1 - 234.9	30	1.25
11/23	152.41	111.2 - 236.0	30	1.25
<sup>a</sup> numbers are dial gauge readings				

## Appendix B - Standard Protocol for the Evaluation of Superpave Gyratory Compactors

## Protocol for Evaluation of Superpave Gyratory Compactors

*Draft April 18, 1997*

The Superpave Gyratory Compactor (*SGC*) creates a cylindrical specimen from loose, hot mix asphalt through a gyratory (*kneading*) effort. The components inducing the gyratory effort are: angle of gyration, consolidation pressure, and speed of gyration. The SGC compaction procedure is described in AASHTO TP 4, “Method for Preparing and Determining the Density of Hot Mix Asphalt (*HMA*) Specimens by Means of the SHRP Gyratory Compactor.”

Two models of SGCs were purchased and evaluated by the Federal Highway Administration (*FHWA*) in a “pooled” fund purchase for the State highway agencies: Pine Instruments Company, 101 Industrial Drive, Grove City, Pennsylvania 16127, model number AFGC125X; and Troxler Electronic Laboratories, Inc., 3008 Cornwallis Road, P.O. Box 12057, Research Triangle Park, North Carolina 27709, model number 4140.

The evaluated units conformed to the equipment requirements in AASHTO TP 4. In addition, these units provide comparable results to the SHRP prototype SGC. The following protocol is suggested for all manufacturers of new SGCs. This protocol is intended to provide a uniform process to verify that the candidate SGC meets the operational requirements outlined in AASHTO TP 4 and that the candidate SGC can provide comparable compaction results to the two models of SGC evaluated in the FHWA “pooled fund” purchase.

**1**     **Protocol for Evaluation:** A gyratory compactor, herein referred to as the candidate gyratory, shall be fabricated in compliance with the operating characteristics defined in AASHTO TP 4. In addition, the candidate gyratory should be evaluated through a volumetric comparison to a previously evaluated SGC. The volumetric comparison should be performed by one of the laboratories listed in § 1.01.

1.1     **Laboratories:** The following is the list of recommended laboratories for the volumetric comparison, herein referred to as the evaluation laboratory:

1.1.1   **Superpave Regional Centers (*SRC*):**

- a. Northeast SRC: Penn State University, State College, Pennsylvania
- b. Southeast SRC: Auburn University, Auburn, Alabama
- c. North-Central SRC: Purdue University, West Lafayette, Indiana
- d. South-Central SRC: University of Texas, Austin, Texas
- e. West Coast SRC: University of Nevada at Reno, Reno, Nevada

SHRP Research Originating Laboratory: Asphalt Institute, Lexington, Kentucky

- 1.2 **Volumetric Comparison:** Volumetric comparison should be conducted employing a minimum of four (4) evaluation mixtures as described in § 1.03. The evaluation mixtures should satisfy the Superpave volumetric requirements.
  - 1.2.1 A single operator should be used throughout the evaluation, herein referred to as the operator.
  - 1.2.2 The candidate compactor is to be compared to one of the SGCs previously evaluated. If more than one previously evaluated SGC is available at the evaluation laboratory, it is recommended they be employed in the evaluation.
  - 1.2.3 Prior to compaction, the operator shall perform, on all compactors included in the evaluation, the manufacturer's calibration procedures to ensure the angle of gyration, consolidation pressure, speed of gyration, and height measurement conform to AASHTO TP 4 and the manufacturer's machine tolerances. A summary of the calibration results, including date and time, should be provided in the final report, as described in § 1.05.
  - 1.2.4 Adequate amounts of each evaluation mixture shall be prepared to yield six (6) gyrotory specimens per compactor and two (2) maximum specific gravity specimens (*Rice*,  $G_{mm}$  ).
  - 1.2.5 Split samples of each of the evaluation mixtures will be compacted in the candidate compactor and previously evaluated SGC(s), according to AASHTO TP 4. Six (6) gyrotory specimens per evaluation mixture shall be compacted for each compactor.

Specimens are compacted to the maximum number of gyrations ( $N_{max}$ ) as described in § 1.03. Specimen height is recorded at each gyration and should be provided in the final report, as described in § 1.05. The specimens are extruded. The bulk specific gravity ( $G_{mb}$ ) of each specimen is determined according to AASHTO T 166. Bulk specific gravity at  $N_{des}$  and  $N_{ini}$  are calculated for each specimen and data reported on Table 1.

Determine the average of the bulk specific gravities at  $N_{max}$  of each set of six (6) specimens. No individual specimens bulk specific gravity at  $N_{max}$  should deviate from its average of all six specimens in the group by more than 0.020. If the bulk specific gravity of any one specimen is not within 0.020 of its group average, the specimens should be discarded. A notation of this should be made in the final report. Checks to assure compactor operation and specimen preparation is occurring properly should be taken. A new batch of mixture to produce six specimens for each of the subjected compactors should be prepared and the above procedure should be repeated. If the deviation of any specimen of this new set again exceeds the group average for either compactor another set will not be prepared. At the discretion of the evaluation laboratory and the manufacturer, a decision will be made whether to continue testing on that mixture. A note to this effect will be made in the final report.

1.2.6 Two (2) split samples of each of the evaluation mixtures shall be used to determine the maximum specific gravity of the mixtures ( $R_{ice}$ ,  $G_{mm}$ ), according to AASHTO T 209. The supplemental dry-back procedure of AASHTO T 209 is recommended.

1.2.7 The evaluation mixtures need to have a minimum of one percent (1.0 %) air voids at the maximum number of gyrations to be used in the evaluation.

1.2.8 Tables 1, 2, and 3 should be used to compile the data.

**Table 1: Summary of Bulk Specific Gravities ( $G_{mb}$ )**

<b>Mix No. 1</b>						
Specimen	Candidate Compactor, (A)			"Evaluated" Compactor, (B)		
	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$
1						
2						
3						
4						
5						
6						
Avg.						

<b>Mix No. 2</b>						
Specimen	Candidate Compactor, (A)			"Evaluated" Compactor, (B)		
	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$
1						
2						
3						
4						
5						
6						
Avg.						

<b>Mix No. 3</b>		
	Candidate Compactor, (A)	"Evaluated" Compactor, (B)

Specimen	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$
1						
2						
3						
4						
5						
6						
Avg.						

<b>Mix No. 4</b>						
Specimen	Candidate Compactor, (A)			“Evaluated” Compactor, (B)		
	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$	$G_{mb}$ @ $N_{ini}$	$G_{mb}$ @ $N_{des}$	$G_{mb}$ @ $N_{max}$
1						
2						
3						
4						
5						
6						
Avg.						

**Table 2: Summary of Bulk Specific Gravities ( $G_{mb}$ ) Standard Deviations**

Mix No.	Candidate Compactor, (A)			“Evaluated” Compactor, (B)		
	Std Dev of $G_{mb}$ @ $N_{ini}$	Std Dev of $G_{mb}$ @ $N_{des}$	Std Dev of $G_{mb}$ @ $N_{max}$	Std Dev of $G_{mb}$ @ $N_{ini}$	Std Dev of $G_{mb}$ @ $N_{des}$	Std Dev of $G_{mb}$ @ $N_{max}$
1						
2						
3						
4						

**Table 3: Summary of Average Bulk Specific Gravities ( $G_{mb}$ )**

	Candidate Compactor,	“Evaluated” Compactor,	Difference,
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Mix No.	(A)			(B)			(A - B)		
	$G_{mb}$ at $N_{ini}$	$G_{mb}$ at $N_{des}$	$G_{mb}$ at $N_{max}$	$G_{mb}$ at $N_{ini}$	$G_{mb}$ at $N_{des}$	$G_{mb}$ at $N_{max}$	$G_{mb}$ at $N_{ini}$	$G_{mb}$ at $N_{des}$	$G_{mb}$ at $N_{max}$
1									
2									
3									
4									

1.2.9 The standard deviations of  $G_{mb}$  for the candidate compactor and the SGC(s) at  $N_{ini}$ ,  $N_{des}$ , and  $N_{max}$  are to be reported on Table 2 and should be comparable. If candidate compactor results are repeatedly greater this should be commented on in the final report.

1.2.10 The difference in  $G_{mb}$  from the candidate compactor, average of all 6 specimens, to the previously “evaluated” SGC(s), average of all 6 specimens, at  $N_{ini}$ ,  $N_{des}$ , and  $N_{max}$  (as reported in Table 3) should be less than 0.01 to be considered comparable.

1.3 **Evaluation Mixtures:** Evaluation mixtures should be designed according to AASHTO PP 28 and MP 2. Two of the evaluation mixtures shall have 19.0 millimeter (*mm*) nominal maximum size blends, referred to as 19 mm mixtures. One of the 19 mm mixtures should be on the coarse side of the restricted zone, (*coarse 19 mm mixture*). The coarse 19 mm mixture should be designed for a traffic level greater than 10 million equivalent single axle loadings (ESALs) at an  $N_{des}$  of 109. The other 19 mm mixture should be on the fine side of the restricted zone, (*fine 19 mm mixture*). The fine 19 mm mixture should be designed for a traffic level greater than 1 million ESALs at an  $N_{des}$  of 86.

1.3.1 The additional evaluation mixtures should be designed according to AASHTO PP 28 and MP 2. It is recommended a 12.5 mm and a 25.0 mm nominal maximum size blend mixtures be employed. Each of these mixes should be designed for properties commensurate with a traffic loading of greater than 10 million ESALs at an  $N_{des}$  of 109.

1.4 **Review:** An evaluation of the above data should be reviewed by a minimum of one of the other evaluation laboratories, as given in § 1.01. All reviewer comments should be included in the final evaluation report, as given in § 1.05.

1.5 **Reporting:** A final report should include the following:

- a. An executive summary of evaluation findings,
- b. Tables 1, 2, and 3 from § 1.02.08,
- c. A summary of the evaluation mixtures’ designs, and
- d. A summary of the calibrations performed on each unit.

The final report should include all reviewer comments.

- 1.6 **Distribution**: In addition to providing the manufacturer a copy of the final report, a copy of the final report will be supplied to all evaluation laboratories, § 1.01, and the FHWA Office of Technology Applications. This will help to ensure proper retesting, should any be required. The copies of the report are to be held in confidence by all recipients and results not to be divulged without the manufacturers permission.

Prior to commencement of testing under this protocol, the evaluation lab will ensure that the manufacturer is made aware of the above intended final report distribution, and his agreement obtained.

- 1.6.1 **Future Evaluations**: If a candidate compactor is found not to compare to the previously “evaluated” SGC(s), future evaluations should not be performed by any of the evaluation laboratories unless the manufacturer modifies the unit.
- 1.6.2 The evaluation is only valid for the model tested. If the manufacturer elects to modify the unit, a new evaluation is necessary. If these tests are performed on a “proto-type” candidate compactor, they should be repeated on an actual production model prior to utilization by agencies of that model.
- 1.6.3 **Evaluation Cost**: All costs associated with the evaluation are the responsibility of the manufacturer of the candidate compactor. Costs for the evaluation are at the discretion of the evaluation laboratory. Costs should include compensation for any reviewing laboratories, § 1.04.