State Study No. 198

Transtech PQI 301 Pavement Quality Indicator Device Evaluation

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Prepared October 2010

Conducted By:

Research Division

Mississippi Department of Transportation

In Cooperation With:

Mississippi Department of Transportation, District One
Mississippi Department of Transportation, District Six
U.S. Department of Transportation
Federal Highway Administration

<table>
<tr><td>1.Report No.
FHWA/MS-DOT-RD-00-198</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2" rowspan="2">4. Title and Subtitle
Quality Verification of PQI 301 Asphalt Density Device</td><td colspan="2">5. Report Date
October 2010</td></tr>
<tr><td colspan="2">6. Performing Organization Code
MDOT Research Div 86-01</td></tr>
<tr><td colspan="2">7. Author(s)
Jordan Whittington, Matthew Strickland, and Paula Wiles</td><td colspan="2">8. Performing Organization Report No.
MS-DOT-RD-00-198</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address
Mississippi Department of Transportation
Research Division
P O Box 1850
Jackson MS 39215-1850</td><td colspan="2">10. Work Unit No. (TRAIS)</td></tr>
<tr><td colspan="2">11. Contract or Grant No.</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address
Federal Highway Administration and Mississippi Department of Transportation</td><td colspan="2">13. Type Report and Period Covered
Final Report</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code</td></tr>
<tr><td colspan="4">15. Supplementary Notes</td></tr>
<tr><td colspan="4">16. Abstract
The PQI 301 Asphalt Density device, developed by Transtech Systems, Inc., was evaluated by MDOT to determine if it could be used in lieu of the currently required nuclear density gauge. Nuclear density gauges require MDOT personnel to have a license, to be certified and wear a badge, and to be exposed to radiation. The PQI 301 was advertised as being easy and cost-effective to own, lightweight and easy to transport, as well as being quick and accurate. MDOT purchased two PQI 301 devices, one placed in the Gulfport Project Office and the other in the MDOT Materials Division. Both devices were used for comparison of results. During the study 236 density readings were taken with the PQI 301. However, difficulties in training, the lack of a standardized method of data collection and documentation, and lack of uniformity in data collection made data comparison between the PQI and the nuclear density gauge impossible. MDOT could seek further investigation into quality assurance, training, and standardized data collection methods if the agency wishes to implement the PQI 301 device.</td></tr>
<tr><td colspan="3">17. Key Words
PQI, Asphalt Density</td><td>18. Distribution Statement
Unclassified</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page)
Unclassified</td><td>21. No. of Pages
20</td><td>22. Price</td></tr>
</table>

Form DOT F 1700.7 (8-72)

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ACKNOWLEDGMENTS

The study reported herein was conducted by the Mississippi Department of Transportation (MDOT) under the sponsorship of the Federal Highway Administration, Mississippi Division Office. This work was accomplished under the supervision of Mr. James Watkins, State Research Engineer. This report was prepared by Mr. Matthew J. Strickland and Mr. Jordan Whittington, both formerly of the MDOT Research Division.

The author wishes to express his appreciation to the many people whose efforts contributed to the success of this study.

During the period of this study, the Executive Director of MDOT was Mr. Larry "Butch" Brown and the Deputy Executive Director / Chief Engineer was Mrs. Melinda McGrath.

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Introduction

Background

Under the current Mississippi (MDOT) specifications, field densities are required to ensure adequate compaction of each lift of Hot Mix Asphalt (HMA) construction. Achieving an adequate level of compaction in HMA is essential to ensure a pavement's long term durability. A denser layer of asphalt-aggregate mixture will achieve a higher level of structural stability and pavement strength. If this adequate level of compaction is not achieved, pavements can fall victim to early oxidation, cracking, rutting, raveling, and stripping (Blankenship).

According to the *Mississippi Department of Transportation's Field Manual for Hot Mix Asphalt (HMA)* it is acceptable to evaluate roadway density with either asphalt cores or a calibrated nuclear density gauge. The number of required density tests is determined by the daily production of asphalt in tons and also at the discretion of the Engineer. In order for a nuclear density gauge to be properly calibrated it must maintain an accurate gauge bias. This gauge bias is a relationship of density values obtained from cores taken in new construction lifts of HMA pavements and the values obtained from the nuclear density gauge. Either method of density determination is accepted to determine the payment schedule for compaction, although only densities determined from asphalt cores shall be used to determine the limits of a removal and replacement section.

Nuclear density gauges are currently used by the Mississippi Department of Transportation (MDOT) to determine the in-situ density of hot mix asphalt (HMA) layers. These Devices include a radioactive source which requires:

- MDOT must have a special license and follow regulatory controls
- Each user must be specially trained and certified
- Each user must wear a badge which is periodically tested to ensure that the employee has not been exposed to an excessive amount of radiation
- Designated special storage areas

The 6th District will purchase a PQI 301 Pavement Quality Indicator. This device is advertised to provide accurate density measurements of HMA while eliminating every negative aspect of the use of the nuclear density gauge. The Gulfport Project Office will use this device in conjunction with the nuclear density gauge on upcoming projects to provide comparison test results. These results will be evaluated to determine if the PQI 301 can be used in lieu of the nuclear density gauge.

Objectives

Using asphalt cores to determine the density of HMA pavements is a more accurate technique to determine a pavement's density than using a nuclear gauge but does has drawbacks. For instance, although repairing the hole left by the extraction of a core is not terribly difficult but many people are not keen on the idea of destructive testing to a brand new pavement. A nuclear density gauge is not as accurate as the core density method but it does offer the advantages of being more portable, less time consuming to obtain results and it is not destructive to the pavement. Nuclear density gauges, like the core density method, are not without drawbacks. They contain a radioactive source which requires that MDOT have a special license authorizing their possession and all operators of the nuclear density gauge must be specially trained and certified. In addition, the nuclear density gauge operator must wear a badge that monitors radiation exposure to ensure that radiation levels remain acceptable. Lastly, the nuclear gauge itself must be transported and stored in an approved container.

In an effort to provide a highly portable, accurate, and easy to use method of collecting pavement densities; Transtech Systems, Inc. developed the Pavement Quality Indicator (PQI) 301. This meter uses an electromagnetic field to obtain pavement densities versus the radioactive source of the nuclear density gauge. This lack of a nuclear source allows Transtech Inc. to advertise the PQI 301 as being:

- Easy and cost-effective to own and operate
- Lightweight and easy to transport
- Non-nuclear source means no licensing, service fees, or safety concerns
- Quick, accurate density measurement of HMA mats

The objective of this study is to test the validity of the claims made by Transtech Inc. as well as the potential benefit to the Mississippi Department of Transportation of implementing the PQI 301 non-nuclear density gauge in its field testing of in place HMA.

Scope

For this study, a PQI 301 non-nuclear density gauge was loaned to the Gulfport Project Office to test the initial usefulness of the device. After a discussion of the initial data, it was determined that further testing was needed to provide a conclusive statement in relation to the PQI 301 device. Two PQI 301 devices were purchased by the Mississippi Department of Transportation for further investigation. One device was placed with the Gulfport Project Office while the other was placed with the MDOT Materials Division to rotate throughout other Mississippi Department of Transportation districts. These two devices were to be used in conjunction with asphalt cores and nuclear density gauges on MDOT projects to provide comparison test results. The results gathered from this comparison testing will then be used to determine whether or not the PQI 301 device can be used as an acceptable substitute to the nuclear density gauge.

Testing and Results

Summary of Testing

Since the purpose of this study is to obtain a comparison between the density measured by the PQI 301 and the density given by both the nuclear gauge and asphalt cores, the PQI 301 will be used in field density measurements of newly constructed HMA pavements by MDOT personnel. Both the Gulfport Project Office and the District 1 Materials Lab were given a PQI 301 non-nuclear device to use at their discretion for comparative testing of new asphalt pavements. Each staff will implement the use of the non-nuclear device as well as the standard nuclear density gauge in their quality assurance testing program.

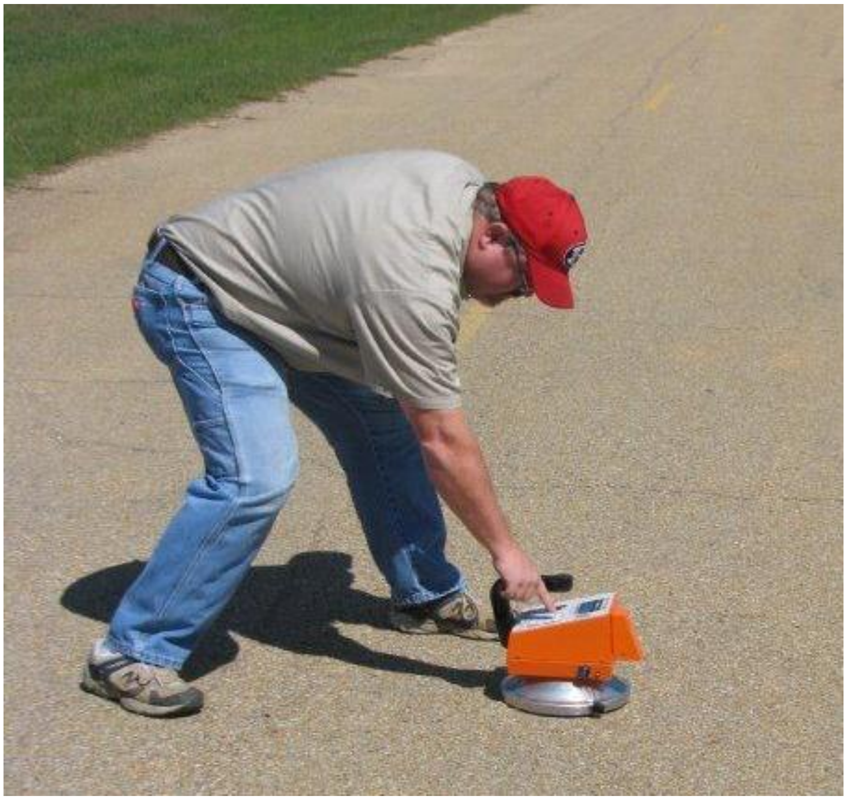

Figure 1. MDOT's District 1 Arthur Parham with the PQI Device

The density measured by the PQI 301 will be taken and recorded as well as the value obtained by either an asphalt core, nuclear density gauge, or both. The results from these field experiments will be recorded for several different kinds of HMA pavements. From these results an analysis will be performed to determine the accuracy, repeatability, and feasibility offered by the PQI 301 device.

Difficulties in Testing

With the absence of a radioactive source there are several inherit features of the PQI 301 that make using it advantageous to the standard nuclear density gauge. For instance, it is much easier to transport and store than the traditional nuclear density gauge. However, since the PQI 301 non-nuclear device is a new type of technology there will also be difficulties associated with implementing the technology.

The first and largest difficulty associated with the testing of the PQI 301 device was the absence of a standardized method of data collection and documentation. Since the majority of MDOT personnel responsible for the field inspection of newly constructed asphalt pavements have been properly trained and are experienced with the use of nuclear gauges they are comfortable with the data collection and documentation procedure that goes along with it. Since there is no MDOT specification available pertaining to the use of non-nuclear density gauges, the data collection and documentation process varied from person to person responsible for testing.

The second problem encountered in testing was the process of collecting data uniform enough for comparison. In order to make valid arguments in research it is essential that data be collected in a manner consistent enough to eliminate guess work and the need for assumptions. Near the end of data collection the method by which moisture was monitored at the time of testing was altered and the change of collection parameters was not documented. Without knowing exactly what setting was changed and how it affected the density reported by the PQI device it is impossible to relate this data with the previous data collected. This accidental reconfiguration of the PQI device invalidated nearly thirty points of data from the information gathered during testing.

It should also be mentioned that personnel changes within MDOT's Research Division during the course of this study also made the coordination of uniform data collection and documentation difficult. This staff transition also impeded the transfer of knowledge previously acquired in the study. Despite all of the difficulties encountered during testing it is the hope of all parties involved that this study still produces a recommendation that will be helpful in decision of the future implementation of the PQI 301 device.

Results and Discussion

Results Obtained from Testing

Throughout the experimental program portion of this research study there were 236 total density readings taken with the two PQI 301 non-nuclear devices. As mentioned previously in this report nearly 28 of the readings were deemed invalid because of a complication resulting from a modification in the moisture data collection method. All readings were the result of the combined efforts of MDOT District 1 Materials Division and District 6 personnel. All density measurements collected with the non-nuclear device were also accompanied by a nuclear gauge density, an asphalt core density, or both. Without a specified method of data collection, many of the density readings were also accompanied with different points of data including time of collection, project location, type of asphalt mat being tested, and the ambient humidity during the density measurement.

Data Collection

As mentioned in the previous section, there was not an established method of data collection used for this study. This lack of a definitive method of data collection created several difficulties when attempting to analyze the data. First, the method in which the data was collected and documented was left at the discretion of the personnel responsible for the field testing. For this reason much of the data collected lacks the uniformity needed to make direct comparisons between sets of data. As mentioned in the previous paragraph, 28 of the readings collected for this study were deemed unusable after the method of monitoring moisture at the time of testing was altered without documentation. This brought the total number of applicable density readings to 208. Of these 208 readings only 83 readings were reported with a documented gauge bias for both the nuclear and non-nuclear devices. Although the nuclear density gauge is used by MDOT for quality acceptance, for the purposes of this study it is believed that the correlation of the density reading reported by the PQI device would be most valid when compared to the value obtained from asphalt cores tested in the lab. Of the 83 readings which contained a documented gauge bias for both devices, only six were supported with density values obtained from asphalt cores. According to the PQI 301 Operator's Handbook it is imperative that a calibration be performed for each type of asphalt mat the device is used on in order to ensure accurate density values are reported. Of the data sets that were collected there were none which documented the proposed layer thickness of pavement being tested and very few listed what aggregate size the pavement contained. Lastly, the environment in which each density reading was collecting was not adequately documented for every case in this study. In order to adequately characterize the effects of environmental and pavement factors as to the consistency of the PQI device it is necessary that these conditions be recorded for each reading as well as the calibrated bias, type of pavement, and the density obtained in the lab from cores. For these reasons it seems inappropriate to conduct a statistical analysis of the data gathered to draw conclusions as to the accuracy and repeatability of the PQI 301 device.

Limitations of the PQI Device

While the PQI 301 device does eliminate the radioactive source present in traditional density gauges it lacks the versatility offered by the nuclear gauges already in use by the Mississippi Department of Transportation. The nuclear gauges currently in use by MDOT are not only used for the density testing of newly constructed asphalt pavements but they also return usable density readings for compacted soil layers of excavations and embankments. The PQI 301 devices used for the testing portion of this study are not designed by their manufacturer to give accurate densities for soil layers. With this limitation, implementation of the PQI 301 non-nuclear device would only reduce, not eliminate, the need for the nuclear density gauge. While this would reduce the exposure of employees to radiation from density testing, it would not eliminate this exposure completely nor would it eliminate the need for employees to obtain training with the nuclear device, licensing of technicians, or monitoring of radiation exposure associated with the nuclear density gauge. This is important to note since the implementation of the non-nuclear gauge would not mean a complete replacement of the nuclear technology already in place.

Conclusions and Recommendations

Conclusions

A review of the results obtained in the testing portion of this study concludes that a statistical analysis is not a valid technique given the variability in documentation of the data.

Much of the data received from testing personnel reported a non-nuclear density yet lacked the environmental and procedural documentation to make direct comparisons between data sets and justifiable conclusions with regard to the implementation of the PQI 301 non-nuclear device.

It is also evident from examining the data submitted that a strategic test procedure should be developed as well as a uniform method of data collection. This would minimize the amount of variability in results and allow involved parties to make more effective decisions using the density data obtained from field personnel.

Recommendations for PQI 301

Based on the results of this study, it is recommended that further investigation of the PQI 301 device be conducted if the Mississippi Department of Transportation further seeks its implementation into the quality assurance program of newly constructed asphalt pavements. From the testing program utilized for portions of this study it has become evident that several variables need be monitored and documented in order to gather comparable data. These variables should include but are not limited to:

- Time elapsed since compaction
- Proposed asphalt lift thickness
- Asphalt type being tested
- Underlying asphalt layer material type
- Ambient Temp
- Pavement Temp
- Ambient Moisture (humidity)
- Density of asphalt by nuclear gauge (including bias used)
- Density of asphalt by non-nuclear gauge (including bias used)
- Calibration method used for non-nuclear gauge
- Density of asphalt determined by lab core method

Also, in order to conduct a valid statistical analysis it is recommended that efforts be made to collect significant data on asphalt pavements with similar aggregate blends and varying lift thicknesses as well as pavements with similar lift thicknesses and varying aggregate blends in order to test the effects of lift thickness and aggregate type on densities reported by the PQI non-nuclear device.

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Appendix A--Results Gathered with PQI 301 Devices

		Nuclear				Non-Nuclear				Core		Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O									
Date	Station #	Gauge	Bias	Corr Rdg	Pay	Gauge	Bias	Corr Rdg	Pay	Density	Pay															
3/9/2007	9+541	145.7	2.9	148.6	1	145.3	0.5	145.8	1			2.8			2.8									1	1	
	9+725	143.7	2.9	146.6	2	146.5	0.5	147.0	2			-0.4			0.4									2	2	
	9+801	142.1	2.9	145.0	3	144.6	0.5	145.1	3			-0.1			0.1									3	3	
	9+997	144.1	2.9	147.0	4	146.5	0.5	147.0	4			0.0			0									4	4	
	9+557	144.5	2.9	147.4	5	144.6	0.5	145.1	5			2.3			2.3									5	5	
	9+710	146.8	2.9	149.7	6	145.3	0.5	145.8	6			3.9			3.9									6	6	
	9+874	144.2	2.9	147.1	7	146.0	0.5	146.5	7			0.6			0.6									7	7	
	9+933	146.8	2.9	149.7	8	145.8	0.5	146.3	8			3.4			3.4									8	8	
3/22/2007	5+246	137.1	2.9	140.0	9	145.7	0.5	146.2	9			-6.2			6.2									9	9	
	5+683	144.0	2.9	146.9	10	148.3	0.5	148.8	10			-1.9			1.9									10	10	
	5+908	143.0	2.9	145.9	11	146.9	0.5	147.4	11			-1.5			1.5									11	11	
	6+164	144.4	2.9	147.3	12	149.0	0.5	149.5	12			-2.2			2.2									12	12	
	6+548	142.3	2.9	145.2	13	146.1	0.5	146.6	13			-1.4			1.4									13	13	
	6+632	139.8	2.9	142.7	14	142.8	0.5	143.3	14			-0.6			0.6									14	14	
	6+746	145.4	2.9	148.3	15	146.4	0.5	146.9	15			1.4			1.4									15	15	
	7+116	146.4	2.9	149.3	16	146.3	0.5	146.8	16			2.5			2.5									16	16	
	7+363	147.1	2.9	150.0	17	148.4	0.5	148.9	17			1.1			1.1									17	17	
	7+594	142.7	2.9	145.6	18	148.0	0.5	148.5	18			-2.9			2.9									18	18	
3/28/2007	7+788	142.4	2.9	145.3	19	146.4	0.5	146.9	19			-1.6			1.6									19	19	
	7+807	145.1	2.9	148.0	20	148.1	0.5	148.6	20			-0.6			0.6									20	20	
	8+212	140.8	2.9	143.7	21	141.1	0.5	141.6	21			2.1			2.1									21	21	
	8+346	140.0	2.9	142.9	22	146.5	0.5	147.0	22			-4.1			4.1									22	22	
	8+451	142.8	2.9	145.7	23	143.7	0.5	144.2	23			1.5			1.5									23	23	
	8+698	145.7	2.9	148.6	24	147.8	0.5	148.3	24			0.3			0.3									24	24	
	5+388	144.0	2.9	146.9	25	148.2	0.5	148.7	25			-1.8			1.8									25	25	
	5+710	142.8	2.9	145.7	26	147.9	0.5	148.4	26			-2.7			2.7									26	26	
	5+809	141.2	2.9	144.1	27	146.1	0.5	146.6	27			-2.5			2.5									27	27	
	5+937	139.2	2.9	142.1	28	147.2	0.5	147.7	28			-5.6			5.6									28	28	
3/29/2007	6+483	143.7	2.9	146.6	29	148.4	0.5	148.9	29			-2.3			2.3									29	29	
	6+622	146.6	2.9	149.5	30	148.2	0.5	148.7	30			0.8			0.8									30	30	
	6+792	144.0	2.9	146.9	31	146.5	0.5	147.0	31			-0.1			0.1									31	31	
	6+943	146.5	2.9	149.4	32	148.1	0.5	148.6	32			0.8			0.8									32	32	
	7+413	144.5	2.9	147.4	33	148.2	0.5	148.7	33			-1.3			1.3									33	33	
	7+680	142.9	2.9	145.8	34	146.9	0.5	147.4	34			-1.6			1.6									34	34	
	7+748	139.1	2.9	142.0	35	147.5	0.5	148.0	35			-6.0			6									35	35	
	7+821	142.0	2.9	144.9	36	148.6	0.5	149.1	36			-4.2			4.2									36	36	
4/3/2007	8+301	137.1	2.9	140.0	37	147.8	0.5	148.3	37			-8.3			8.3									37	37	
	8+359	140.9	2.9	143.8	38	146.5	0.5	147.0	38			-3.2			3.2									38	38	
	8+495	142.2	2.9	145.1	39	149.0	0.5	149.5	39			-4.4			4.4									39	39	
	8+542	141.5	2.9	144.4	40	148.2	0.5	148.7	40			-4.3			4.3									40	40	
4/6/2007	9+363	142.3	2.9	145.2	41	148.2	0.5	148.7	41			-3.5			3.5									41	41	
	9+624	145.2	2.9	148.1	42	150.1	0.5	150.6	42			-2.5			2.5									42	42	
	9+818	144.5	2.9	147.4	43	145.1	0.5	145.6	43			1.8			1.8									43	43	
	9+893	145.1	2.9	148.0	44	148.7	0.5	149.2	44			-1.2			1.2									44	44	
	10+016	147.0	2.9	149.9	45	149.7	0.5	150.2	45			-0.3			0.3									45	45	
	10+188	144.0	2.9	146.9	46	148.1	0.5	148.6	46			-1.7			1.7									46	46	
	10+369	144.2	2.9	147.1	47	147.1	0.5	147.6	47			-0.5			0.5									47	47	
	10+402	146.6	2.9	149.5	48	148.6	0.5	149.1	48			0.4			0.4									48	48	

		Nuclear				Non-Nuclear				Core		Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O									
Date	Station #	Gauge	Bias	Corr Rdg	Pay	Gauge	Bias	Corr Rdg	Pay	Density	Pay															
4/9/2007	10+963	147.2	2.9	150.1	49	149.5		149.5	49	146.4		0.6	-3.1	-3.7	0.6	3.1	3.7							49		
	11+138	146.1	2.9	149.0	50	148.1		148.1	50	143.6		0.9	-4.5	-5.4	0.9	4.5	5.4							50		
	11+281	141.2	2.9	144.1	51	148.0		148.0	51	142.8	90%	-3.9	-5.2	-1.3	3.9	5.2	1.3							51		
	11+427	145.4	2.9	148.3	52	147.9		147.9	52	144.6		0.4	-3.3	-3.7	0.4	3.3	3.7							52		
4/10/2007	11+865	144.7	2.9	147.6	53	147.6		147.6	53			0.0			0									53		
	12+215	145.3	2.9	148.2	54	151.8		151.8	54			-3.6			3.6									54		
4/11/2007	9+464	139.3	2.9	142.2	55	147.7	-0.1	147.6	55	147.9		-5.4	0.3	5.7	5.4	0.3	5.7							55	49	1
	9+612	143.3	2.9	146.2	56	148.7	-0.1	148.6	56	147.3		-2.4	-1.3	1.1	2.4	1.3	1.1							56	50	2
	9+891	141.7	2.9	144.6	57	147.6	-0.1	147.5	57	147.4		-2.9	-0.1	2.8	2.9	0.1	2.8							57	51	3
	10+091	144.0	2.9	146.9	58	148.0	-0.1	147.9	58	145.3		-1.0	-2.6	-1.6	1	2.6	1.6							58	52	4
	10+312	140.9	2.9	143.8	59	147.3	-0.1	147.2	59			-3.4			3.4									59	53	
	10+475	143.8	2.9	146.7	60	149.0	-0.1	148.9	60			-2.2			2.2									60	54	
4/13/2007	10+976	139.4	2.6	142.0	61	149.0	-0.1	148.9	61			-6.9			6.9									61	55	
	11+138	142.2	2.6	144.8	62	150.1	-0.1	150.0	62			-5.2			5.2									62	56	
	11+393	142.5	2.6	145.1	63	148.2	-0.1	148.1	63			-3.0			3									63	57	
	11+531	145.4	2.6	148.0	64	149.7	-0.1	149.6	64			-1.6			1.6									64	58	
	11+763	138.4	2.6	141.0	65	149.2	-0.1	149.1	65			-8.1			8.1									65	59	
	11+779	147.5	2.6	150.1	66	148.7	-0.1	148.6	66			1.5			1.5									66	60	
	12+119	139.5	2.6	142.1	67	147.3	-0.1	147.2	67	143.1		-5.1	-4.1	1.0	5.1	4.1	1							67	61	5
	12+232	139.9	2.6	142.5	68	148.7	-0.1	148.6	68	142.4		-6.1	-6.2	-0.1	6.1	6.2	0.1							68	62	6
4/14/2007	12+941	148.9	2.6	151.5	69	148.0	-0.1	147.9	69			3.6			3.6									69	63	
	13+014	146.1	2.6	148.7	70	145.7	-0.1	145.6	70			3.1			3.1									70	64	
	13+171	143.2	2.6	145.8	71	145.5	-0.1	145.4	71			0.4			0.4									71	65	
	13+227	142.4	2.6	145.0	72	145.7	-0.1	145.6	72			-0.6			0.6									72	66	
	13+424	144.3	2.6	146.9	73	145.2	-0.1	145.1	73			1.8			1.8									73	67	
	13+502	142.9	2.6	145.5	74	143.1	-0.1	143.0	74			2.5			2.5									74	68	
4/17/2007	13+787	142.5	2.6	145.1	75	143.2	-0.1	143.1	75			2.0			2									75	69	
	14+046	143.3	2.6	145.9	76	144.5	-0.1	144.4	76			1.5			1.5									76	70	
	14+268	143.7	2.6	146.3	77	148.2	-0.1	148.1	77			-1.8			1.8									77	71	
	14+423	144.7	2.6	147.3	78	146.5	-0.1	146.4	78			0.9			0.9									78	72	
	14+516	141.8	2.6	144.4	79	142.8	-0.1	142.7	79			1.7			1.7									79	73	
	14+747	142.5	2.6	145.1	80	146.1	-0.1	146.0	80			-0.9			0.9									80	74	
	15+140	144.2	2.6	146.8	81	145.5	-0.1	145.4	81			1.4			1.4									81	75	
	15+249	142.4	2.6	145.0	82	145.6	-0.1	145.5	82			-0.5			0.5									82	76	
	15+525	144.4	2.6	147.0	83	145.5	-0.1	145.4	83			1.6			1.6									83	77	
	15+771	142.2	2.6	144.8	84	145.0	-0.1	144.9	84			-0.1			0.1									84	78	
4/20/2007	16+409	147.4	2.6	150.0	85	146.1	-0.1	146.0	85			4.0			4									85	79	
	16+556	144.0	2.6	146.6	86	143.7	-0.1	143.6	86			3.0			3									86	80	
	16+740	145.6	2.6	148.2	87	143.7	-0.1	143.6	87			4.6			4.6									87	81	
	16+814	144.3	2.6	146.9	88	146.5	-0.1	146.4	88			0.5			0.5									88	82	
	17+207	143.7	2.6	146.3	89	145.7	-0.1	145.6	89			0.7			0.7									89	83	

		Nuclear				Non-Nuclear				Core		Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O									
Date	Station #	Gauge	Bias	Corr Rdg	Pay	Gauge	Bias	Corr Rdg	Pay	Density	Pay															
4/25/2007	12+934	146.1	2.4	148.5	90					147.3				-1.2			1.2									
	13+065	140.2	2.4	142.6	91					141.1	90%			-1.5			1.5									
	13+292	141.5	2.4	143.9	92					144.5				0.6			0.6									
	13+559	144.0	2.4	146.4	93					145.7				-0.7			0.7									
4/26/2007	13+461	146.2	2.4	148.6	94	145.5		145.5	90			3.1			3.1									90		
	13+637	146.7	2.4	149.1	95	145.6		145.6	91			3.5			3.5									91		
	12+947	144.4	2.4	146.8	96	145.1		145.1	92			1.7			1.7									92		
	13+203	143.5	2.4	145.9	97	144.5		144.5	93			1.4			1.4									93		
	11+566	144.6	2.4	147.0	98	143.9		143.9	94			3.1			3.1									94		
	11+799	144.4	2.4	146.8	99	145.0		145.0	95			1.8			1.8									95		
	12+083	144.3	2.4	146.7	100	145.3		145.3	96			1.4			1.4									96		
	12+306	144.4	2.4	146.8	101	144.5		144.5	97			2.3			2.3									97		
4/30/2007	9+448	142.2	2.4	144.6	102	144.3		144.3	98			0.3			0.3									98		
	9+698	144.4	2.4	146.8	103	145.8		145.8	99			1.0			1									99		
	9+984	147.5	2.4	149.9	104	146.7		146.7	100			3.2			3.2									100		
4/30/2007	10+048	146.2	2.4	148.6	105	146.4		146.4	101			2.2			2.2									101		
	10+329	142.2	2.4	144.6	106	144.7		144.7	102			-0.1			0.1									102		
	10+578	143.8	2.4	146.2	107	146.4		146.4	103			-0.2			0.2									103		
	10+896	146.4	2.4	148.8	108	146.9		146.9	104			1.9			1.9									104		
	11+022	144.9	2.4	147.3	109	146.7		146.7	105			0.6			0.6									105		
	11+230	147.8	2.4	150.2	110	147.0		147.0	106			3.2			3.2									106		
	11+400	144.9	2.4	147.3	111	145.2		145.2	107			2.1			2.1									107		
5/2/2007	9+801	140.3	2.4	142.7	112	140.8		140.8	108			1.9			1.9									108		
	9+843	141.4	2.4	143.8	113	143.7		143.7	109			0.1			0.1									109		
	9+911	140.0	2.4	142.4	114	144.2		144.2	110			-1.8			1.8									110		
	9+957	141.1	2.4	143.5	115	143.2		143.2	111			0.3			0.3									111		
5/3/2007	9+962	144.2	2.4	146.6	116	145.7		145.7	112			0.9			0.9									112		
	9+978	143.4	2.4	145.8	117	144.6		144.6	113			1.2			1.2									113		
5/7/2007	11+522	144.8	2.4	147.2	118	Not Used				146.5				-0.7			0.7									
	11+288	142.2	2.4	144.6	119	Not Used				144.5				-0.1			0.1									
	11+050	142.3	2.4	144.7	120	Not Used				143.6				-1.1			1.1									
	10+893	142.4	2.4	144.8	121	Not Used				144.5				-0.3			0.3									
	2+591	144.0	2.4	146.4	122	Not Used				143.3				-3.1			3.1									
	2+470	145.0	2.4	147.4	123	Not Used				146.2				-1.2			1.2									
	2+406	144.7	2.4	147.1	124	Not Used				145.6				-1.5			1.5									
	2+325	144.4	2.4	146.8	125	Not Used				145.1				-1.7			1.7									
5/8/2007	2+567	145.2	2.4	147.6	126	147.8		147.8	114			-0.2			0.2									114		
	2+491	142.7	2.4	145.1	127	145.3		145.3	115			-0.2			0.2									115		

		Nuclear				Non-Nuclear				Core		Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O									
Date	Station #	Gauge	Bias	Corr Rdg	Pay	Gauge	Bias	Corr Rdg	Pay	Density	Pay															
5/9/2007	9+827	138.3	2.4	140.7	128	146.3		146.3	116	144.7		-5.6	-1.6	4.0	5.6	1.6	4							116		
	9+927	137.8	2.4	140.2	129	145.1		145.1	117	143.5		-4.9	-1.6	3.3	4.9	1.6	3.3							117		
	10+312	140.1	2.4	142.5	130	144.3		144.3	118	143.9		-1.8	-0.4	1.4	1.8	0.4	1.4							118		
5/11/2007	9+214	143.0	2.4	145.4	131	146.9		146.9	119			-1.5			1.5									119		
	8+971	141.3	2.4	143.7	132	144.6		144.6	120			-0.9			0.9									120		
	8+257	141.4	2.4	143.8	133	145.6		145.6	121			-1.8			1.8									121		
	8+737	139.4	2.4	141.8	134	144.6		144.6	122			-2.8			2.8									122		
	7+576	142.0	2.4	144.4	135	144.9		144.9	123			-0.5			0.5									123		
	7+886	144.8	2.4	147.2	136	147.9		147.9	124			-0.7			0.7									124		
	6+949	134.9	2.4	137.3	137	144.5		144.5	125	140.4		-7.2	-4.1	3.1	7.2	4.1	3.1							125		
	7+351	142.5	2.4	144.9	138	144.7		144.7	126	144.1		0.2	-0.6	-0.8	0.2	0.6	0.8							126		
	6+219	142.0	2.4	144.4	139	145.2		145.2	127			-0.8			0.8									127		
	6+549	139.6	2.4	142.0	140	143.6		143.6	128			-1.6			1.6									128		
	6+601	141.8	2.4	144.2	141	142.7		142.7	129			1.5			1.5									129		
	5+721	144.6	2.4	147.0	142	145.2		145.2	130			1.8			1.8									130		
5/15/2007	2+834	146.4	2.4	148.8	143	147.5		147.5	131			1.3			1.3									131		
	2+957	145.3	2.4	147.7	144	147.0		147.0	132			0.7			0.7									132		
	3+137	145.9	2.4	148.3	145	145.2		145.2	133			3.1			3.1									133		
	3+202	145.0	2.4	147.4	146	145.1		145.1	134			2.3			2.3									134		
5/16/2007	2+917	144.2	2.4	146.6	147	146.3		146.3	135			0.3			0.3									135		
	3+033	137.5	2.4	139.9	148	141.6		141.6	136			-1.7			1.7									136		
	3+107	143.0	2.4	145.4	149	145.2		145.2	137			0.2			0.2									137		
	3+252	143.6	2.4	146.0	150	147.7		147.7	138			-1.7			1.7									138		
6/29/2007	16+862	143.4	2.8	146.2	151	144.4		144.4	139			1.8			1.8									139		
	16+877	146.2	2.8	149.0	152	145.6		145.6	140			3.4			3.4									140		

Date	Station #	Nuclear Gauge	Nuclear Bias	Nuclear Corr Rdg	Nuclear Pay	Non-Nuclear Gauge	Non-Nuclear Bias	Non-Nuclear Corr Rdg	Non-Nuclear Pay	Core Density	Core Pay	Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O	
7/9/2007	16+843	147.2	1.0	148.2	153	149.7		149.7	141			-1.5			1.5			141
	16+904	144.8	1.0	145.8	154	145.2		145.2	142			0.6			0.6			142
7/11/2007	4+152	148.3	2.4	150.7	155	149.1		149.1	143			1.6			1.6			143
	4+160	145.4	2.4	147.8	156	147.6		147.6	144			0.2			0.2			144
7/25/2007	12+879	144.4		144.4	157	131.0		131.0	145	147.3		13.4	16.3	2.9	13.4	16.3	2.9	145
	13+117	149.6		149.6	158	136.1		136.1	146	146.8		13.5	10.7	-2.8	13.5	10.7	2.8	146
	13+397	144.0		144.0	159	132.8		132.8	147	144.1		11.2	11.3	0.1	11.2	11.3	0.1	147
	13+621	148.6		148.6	160	131.9		131.9	148	148.3		16.7	16.4	-0.3	16.7	16.4	0.3	148
7/26/2007	12+943	146.8		146.8	161	129.2		129.2	149	146.0		17.6	16.8	-0.8	17.6	16.8	0.8	149
	13+171	148.0		148.0	162	129.9		129.9	150	148.2		18.1	18.3	0.2	18.1	18.3	0.2	150
	13+311	147.4		147.4	163	129.1		129.1	151	150.1		18.3	21.0	2.7	18.3	21	2.7	151
	13+538	145.9		145.9	164	128.5		128.5	152	144.5		17.4	16.0	-1.4	17.4	16	1.4	152
8/13/2007	6+843	145.0		145.0	165	129.9		129.9	153	143.4	90%	15.1	13.5	-1.6	15.1	13.5	1.6	153
	7+428	142.6		142.6	166	128.1		128.1	154	144.3		14.5	16.2	1.7	14.5	16.2	1.7	154
	8+503	143.7		143.7	167	130.8		130.8	155	144.3		12.9	13.5	0.6	12.9	13.5	0.6	155
	5+594	143.1		143.1	168	128.2		128.2	156	144.3		14.9	16.1	1.2	14.9	16.1	1.2	156
	6+023	146.3		146.3	169	129.9		129.9	157	147.4		16.4	17.5	1.1	16.4	17.5	1.1	157
8/14/2007	6+852	146.5		146.5	170	130.3		130.3	158	143.2	90%	16.2	12.9	-3.3	16.2	12.9	3.3	158
	7+487	145.7		145.7	171	131.0		131.0	159	145.3		14.7	14.3	-0.4	14.7	14.3	0.4	159
	8+226	147.4		147.4	172	131.0		131.0	160	145.0		16.4	14.0	-2.4	16.4	14	2.4	160
	8+803	143.1		143.1	173	127.5		127.5	161	143.0	90%	15.6	15.5	-0.1	15.6	15.5	0.1	161
8/15/2007	6+509	145.0		145.0	174	129.4		129.4	162	145.1		15.6	15.7	0.1	15.6	15.7	0.1	162
	6+749	147.2		147.2	175	130.2		130.2	163	144.7		17.0	14.5	-2.5	17	14.5	2.5	163
	7+461	145.5		145.5	176	129.6		129.6	164	142.0	90%	15.9	12.4	-3.5	15.9	12.4	3.5	164
	7+822	146.8		146.8	177	130.1		130.1	165	146.1		16.7	16.0	-0.7	16.7	16	0.7	165
	8+441	147.2		147.2	178	131.5		131.5	166	147.9		15.7	16.4	0.7	15.7	16.4	0.7	166
8/23/2007	5+392	147.7		147.7	179	129.9		129.9	167	146.3		17.8	16.4	-1.4	17.8	16.4	1.4	167
	5+517	147.1		147.1	180	129.8		129.8	168	145.0		17.3	15.2	-2.1	17.3	15.2	2.1	168
	5+688	145.7		145.7	181	130.5		130.5	169	146.7		15.2	16.2	1.0	15.2	16.2	1	169
	6+004	147.3		147.3	182	130.4		130.4	170	145.9		16.9	15.5	-1.4	16.9	15.5	1.4	170

Initial Results Summary

	Nuclear	Non-Nuclear	Asphalt Core
No. of Readings	220	208	91
Avg. Density (lb/ft³)	145.6	141.2	143.9
Standard Deviation of Density	3.0	8.5	3.1

Comparative Test Results

Compared Methods	Core/Nuclear Gauge	Core/Non-Nuclear Gauge	Nuclear/Non-Nuclear Gauge
No. of Readings	91	79	208
Average Difference	1.8	12.1	6.1
Standard Deviation of Difference	1.5	5.7	6.6

		Nuclear				Non-Nuclear				Core		Nuclear Minus Non-Nuclear	Core Minus Non-Nuclear	Core Minus Nuclear	Absolute M	Absolute N	Absolute O									
Date	Station #	Gauge	Bias	Corr Rdg	Pay	Gauge	Bias	Corr Rdg	Pay	Density	Pay															
District 6		149.2		149.2	183	134.2		134.2	171	147.6		15.0	13.4	-1.6	15	13.4	1.6							171		
		147.8		147.8	184	130.5		130.5	172	142.5		17.3	12.0	-5.3	17.3	12	5.3							172		
		149.5		149.5	185	133.2		133.2	173	146.9		16.3	13.7	-2.6	16.3	13.7	2.6							173		
		145.2		145.2	186	131.4		131.4	174	142.3		13.8	10.9	-2.9	13.8	10.9	2.9							174		
		148.5		148.5	187	133.6		133.6	175	144.9		14.9	11.3	-3.6	14.9	11.3	3.6							175		
		149.4		149.4	188	135.0		135.0	176	143.0		14.4	8.0	-6.4	14.4	8	6.4							176		
		148.9		148.9	189	133.7		133.7	177	141.4		15.2	7.7	-7.5	15.2	7.7	7.5							177		
		144.8		144.8	190	128.4		128.4	178	141.3		16.4	12.9	-3.5	16.4	12.9	3.5							178		
		144.5		144.5	191	123.9		123.9	179	142.7		20.6	18.8	-1.8	20.6	18.8	1.8							179		
		143.8		143.8	192	123.7		123.7	180	140.4		20.1	16.7	-3.4	20.1	16.7	3.4							180		
		143.3		143.3	193	123.7		123.7	181	142.1		19.6	18.4	-1.2	19.6	18.4	1.2							181		
		144.5		144.5	194	123.8		123.8	182	141.7		20.7	17.9	-2.8	20.7	17.9	2.8							182		
		142.9		142.9	195	123.2		123.2	183	141.3		19.7	18.1	-1.6	19.7	18.1	1.6							183		
		142.1		142.1	196	123.4		123.4	184	142.8		18.7	19.4	0.7	18.7	19.4	0.7							184		
		143.7		143.7	197	126.1		126.1	185	144.6		17.6	18.5	0.9	17.6	18.5	0.9							185		
		140.9		140.9	198	126.0		126.0	186	143.1		14.9	17.1	2.2	14.9	17.1	2.2							186		
		140.3		140.3	199	124.8		124.8	187	141.3		15.5	16.5	1.0	15.5	16.5	1							187		
		148.5		148.5	200	136.5		136.5	188	147.4		12.0	10.9	-1.1	12	10.9	1.1							188		
		145.8		145.8	201	133.1		133.1	189	143.8		12.7	10.7	-2.0	12.7	10.7	2							189		
		146.2		146.2	202	134.3		134.3	190	143.8		11.9	9.5	-2.4	11.9	9.5	2.4							190		
		147.9		147.9	203	137.7		137.7	191	144.8		10.2	7.1	-3.1	10.2	7.1	3.1							191		
		148.6		148.6	204	136.5		136.5	192	149.2		12.1	12.7	0.6	12.1	12.7	0.6							192		
		143.2		143.2	205	120.7		120.7	193	141.5		22.5	20.8	-1.7	22.5	20.8	1.7							193		
		140.8		140.8	206	119.8		119.8	194	138.3		21.0	18.5	-2.5	21	18.5	2.5							194		
		141.5		141.5	207	119.8		119.8	195	140.8		21.7	21.0	-0.7	21.7	21	0.7							195		
		144.3		144.3	208	121.1		121.1	196	142.1		23.2	21.0	-2.2	23.2	21	2.2							196		
		141.5		141.5	209	129.9		129.9	197	144.6		11.6	14.7	3.1	11.6	14.7	3.1							197		
		145.7		145.7	210	134.7		134.7	198	146.1		11.0	11.4	0.4	11	11.4	0.4							198		
		143.0		143.0	211	133.8		133.8	199	144.0		9.2	10.2	1.0	9.2	10.2	1							199		
		148.3		148.3	212	135.0		135.0	200	148.9		13.3	13.9	0.6	13.3	13.9	0.6							200		
District 1		137.1		137.1	213	128.6		128.6	201	137.2		8.5	8.6	0.1	8.5	8.6	0.1							201		
		136.0		136.0	214	127.9		127.9	202	135.7		8.1	7.8	-0.3	8.1	7.8	0.3							202		
		137.6		137.6	215	129.4		129.4	203	137.9		8.2	8.5	0.3	8.2	8.5	0.3							203		
		138.3		138.3	216	130.3		130.3	204	137.8		8.0	7.5	-0.5	8	7.5	0.5							204		
		136.4		136.4	217	123.3		123.3	205	136.3		13.1	13.0	-0.1	13.1	13	0.1							205		
		136.8		136.8	218	123.9		123.9	206	136.2		12.9	12.3	-0.6	12.9	12.3	0.6							206		
		135.5		135.5	219	124.7		124.7	207	137.2		10.8	12.5	1.7	10.8	12.5	1.7							207		
		136.3		136.3	220	124.0		124.0	208	138.2		12.3	14.2	1.9	12.3	14.2	1.9							208		
Average		143.7	2.6	145.6		141.1	0.2	141.2		143.9		4.4	11.1	-0.7												
Standard Deviation		3.0	0.3	3.0		8.4	0.3	8.5		3.1		7.8	7.5	2.2												
PQI Average		143.9	2.7	144.4		132.6	-0.1	132.6		143.7		11.8	11.1	-0.7	6.1	12.1	1.8									
PQI Standard Deviation		3.9	0.2	3.7		8.1	0.0	8.1		3.2		7.9	7.5	2.4	6.6	5.7	1.5									