

NEW YORK STATE DEPARTMENT OF TRANSPORTATION  
MATERIALS BUREAU ALBANY, NY 12232-0861

Materials Procedure No.: NY 03-001

## MATERIALS PROCEDURE

Issue Date: November 2003  
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SUBJECT: NON-NUCLEAR DENSITY GAUGE DATA COLLECTION FOR HOT MIX ASPHALT

APPROVED:

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Supersedes:  
Dated:

### I. SCOPE

This method describes the procedure for collecting non-nuclear density gauge readings, and determining the project target density (PTD) for Hot Mix Asphalt (HMA) specifications that require pavement density monitoring. The contractor is responsible for implementing the steps in this procedure, unless specified otherwise.

The non-nuclear density gauge shall be a Pavement Quality Indicator (PQI) Model 301 or later, a PaveTracker Model 1 or later, or other non-nuclear gauge(s) deemed equivalent by the Materials Bureau.

### II. GENERAL

Construct a test section to determine the project target density (PTD) in accordance with the standard specification except that a non-nuclear density gauge will replace the use of a nuclear density gauge. Obtain density readings during routine paving using a non-nuclear density gauge at sites **randomly** selected by the Engineer, in accordance with the specification. Record the density measurements on appropriate BR form listed in Table 1.

Table 1  
BR Forms for Daily Density Data Collection

Gauge	BR Form
Pavement Quality Indicator	BR 68 - In-Place Pavement Density Data - Sheet #1
	BR 69 - In-Place Pavement Density Data - Continuation Sheet
PaveTracker	BR 70 - In-Place Pavement Density Data - Sheet #1
	BR 71 - In-Place Pavement Density Data - Continuation Sheet

Continue recording density measurements on the appropriate BR form until the placement of material is completed or the placement is halted due to unsatisfactory density results. If placement is halted, the Engineer will order the construction of a new test section to determine a new PTD. Use a new BR form to record density readings corresponding to the new PTD.

Placements using 60 Series compaction method will require additional sets of pavement samples (4 cores per set) to verify the PTD, based on the number of production days as outlined in Table 2, Section VII of this procedure.

At the end of each production day, provide the Engineer with a copy of the BR form relating to that day's work.

### III. GAUGE SETUP

Definitions of words associated with the use of the non-nuclear density gauges:

Measurement = single density value.

Reading = average of all the measurements taken at one location.

Always operate the gauge in a density measuring mode. Prior to obtaining the required test section density readings, setup the gauge per manufacturer's recommendations or following the procedure below.

Take several measurements directly behind the paver on the uncompacted portion of the mat and average these measurements. Estimate the density of the uncompacted mat being placed by the paver. (This value will vary depending on several possible variables including the mix being placed, the type of paver, condition of the paver, etc.) Adjust the gauge based on the difference of the two values so that the gauge reads reasonably close to the estimated density. Follow the manufacturer's recommendations for making this adjustment.

**Example:** Mixture's Maximum Theoretical Density (MMTD) – 2.543  
Density of water – 1000 kg/m<sup>3</sup> (62.4 lbs/ft<sup>3</sup>)  
Estimate of % compaction achieved by the paver (%MMTD<sub>paver</sub>) - 82%

The average density of four (4) measurements taken behind the paver is equal to 2507 kg/m<sup>3</sup> (156.5 lbs/ft<sup>3</sup>)

The density being achieved by the paver is estimated as follows:  
MMTD\*Density of water\*Estimated Compaction being  
achieved by the paver  
 $2.543*1000*0.82 = 2085 \text{ kg/m}^3$   
 $(2.543*62.4*0.82 = 130.1 \text{ lbs/ft}^3)$

Difference between the average of the measurements and the estimated  
density being achieved by the paver is  
 $2507 \text{ kg/m}^3 - 2085 \text{ kg/m}^3 = 422 \text{ kg/m}^3$   
 $(156.5 \text{ pcf} - 130.1 \text{ pcf} = 26.4 \text{ lbs/ft}^3)$

**Therefore adjust the gauge so that it reads  $422 \text{ kg/m}^3$  ( $26.4 \text{ lbs/ft}^3$ )  
lower**

Record the new reference value for the PaveTracker, or the new offset for the PQI on  
the appropriate BR forms. These values cannot be changed after the beginning of the  
test section, unless a new test section is constructed.

#### IV. DETERMINING SAMPLE LOCATIONS

##### A. Random Sample Location Procedure

Random sampling is the process of selecting without intentionally or inadvertently  
favoring any particular sample. To determine the transverse sample locations for the  
daily density gauge testing, the Engineer will use one of the following procedures:

1. **The Materials Bureau computer program "LOCATE"**. This program has the  
capability of calculating the transverse locations for daily density gauge testing and  
the core locations required when a test section is placed. The program will provide  
two options:
  - a. **"GAUGE TEST LOCATIONS"** - This program will generate transverse  
locations for daily density gauge testing as required in the Superpave HMA  
specifications.
  - b. **"CORE LOCATIONS"** - This program will determine core location in  
accordance with the Specifications and Materials Procedure 96-04.

A copy of this program is available from the Director, Materials Bureau, upon  
request.

2. **The attached Random Number Tables.** For daily density gauge testing, approximate the distance in lane meters which the contractor will pave on that day. Divide the distance by 60 m and that will be the approximate random numbers required to calculate the transverse locations pertaining to that day. Select the required random numbers from the Random Number Tables. When selecting a set of random numbers, the Random Number Tables can be entered at any point but never the same point twice on a given contract. The random numbers can be selected by columns, rows, left to right, vertically, selecting alternating numbers, or any other desired pattern. Use imagination and good sense in selecting sets of random numbers. The following example demonstrates this process:

**Example Random Numbers**

	A	B	C	D	E	F	G	H	I	J
8	0.138	0.037	0.240	0.078	0.407	0.498	0.562	0.188	0.183	0.945
9	0.674	0.966	0.631	0.047	0.220	0.120	0.323	0.914	0.486	0.592
10	0.380	0.553	0.204	0.152	0.009	0.294	0.725	0.110	0.340	0.884
11	0.545	0.224	0.116	0.328	0.908	0.493	0.574	0.416	0.477	0.606
12	0.347	0.869	0.821	0.917	0.479	0.602	0.356	0.847	0.665	0.530

**Transverse (Y) Location At Every 60 m for Non-Nuclear Gauge Density Daily Testing.**

Y Coordinate = 0.294 x 3.6 m = 1.1 m

Y Coordinate = 0.725 x 3.6 m = 2.6 m

Y Coordinate = 0.110 x 3.6 m = 0.4 m\* (1.0 m)

\*Note: Since this position is within 0.6 m of a longitudinal joint, its position is adjusted by 0.6 m.

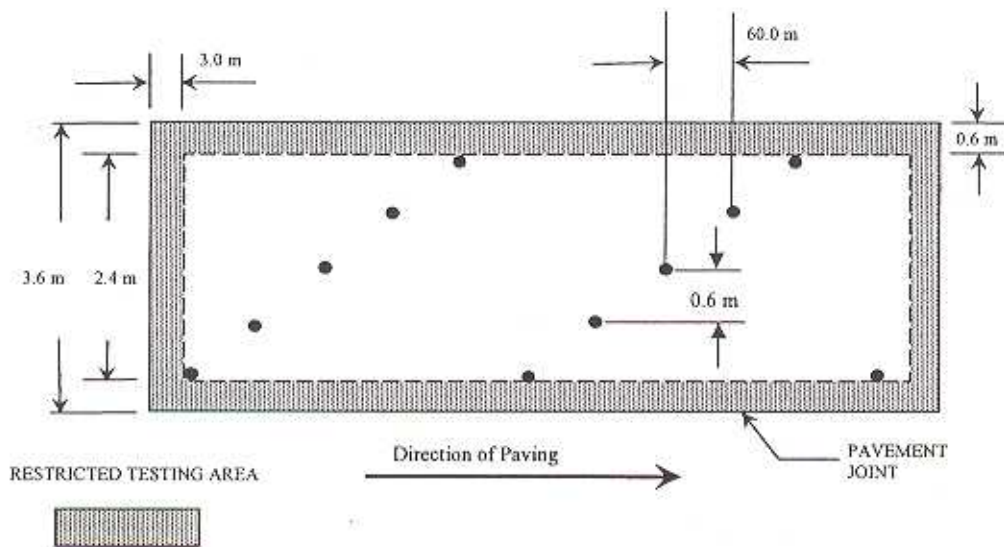
**B. ALTERNATE SAMPLE LOCATION PROCEDURE**

The following method may be substituted at the discretion of the Project Engineer.

**Transverse (Y) Location At Every 60 m for Density Gauge Daily Testing.** The first transverse offset will be 0.6 m from the right edge of paving. Further transverse offsets will be 0.6 m greater than the previous offset. At no time shall the transverse offset be closer than 0.6 m to the left edge of paving. When the transverse offsets have reached the limits of the paving width, repeat the process.

Example: A 3.6 m lane is being placed. The first longitudinal test location is at 60 m from the start of paving. Using the above process, the locations for Non-Nuclear density gauge testing would be located as shown in Figure 3.

FIGURE 1 – ALTERNATE SAMPLE LOCATIONS



Test Number	Longitudinal Location	Transverse Offset
1	60 m	0.6 m
2	120 m	1.2 m
3	180 m	1.8 m
4	240 m	2.4 m
5	300 m	3.0 m
6	360 m	0.6 m
7	420 m	1.2 m

## V. COLLECTING, RECORDING AND CALCULATING NON-NUCLEAR DENSITY GAUGE DATA

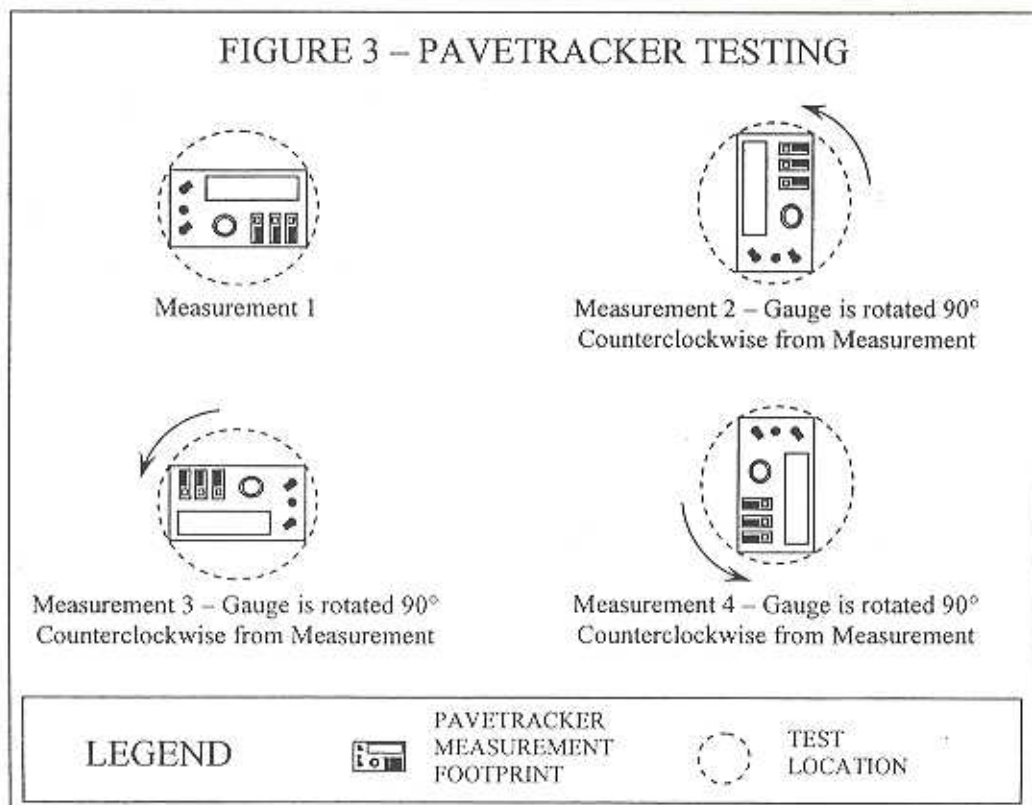
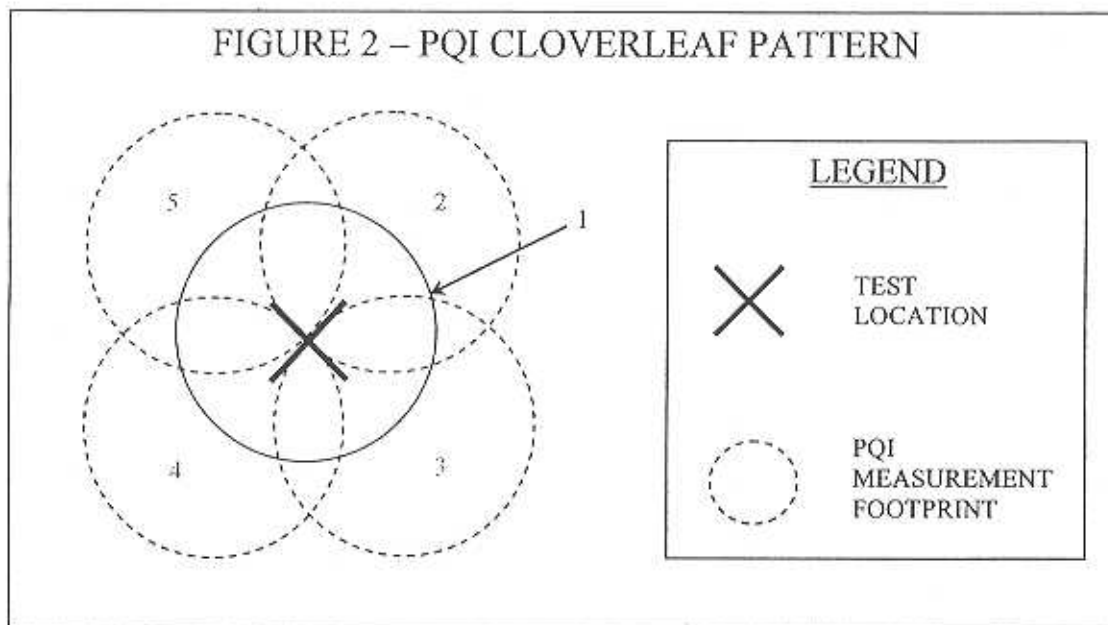
### A. Routine Daily Density Data

Complete the following information on the appropriate BR form(s) for the gauge being used:

- Region: Enter the Region where the contract is located.
- Starting Date: Enter the paving starting date.
- Contract #: Enter the contract number.
- Route #: Enter the route number on which the contract is located.
- Project Target Density: Enter the PTD that was determined from the test section.
- Min. average (Single Reading): ***PTD x 0.96***
- Max. average (Single Reading): ***PTD x 1.03***
- Min. average (Moving Avg.): ***PTD x 0.98***
- Reference Value (BR 70 and 71): Enter the PaveTracker Reference Value that will be used. *(NOTE: This value may only be changed when a new Test Section is ordered.)*
- Gauge Offset (BR 68 and 69): Enter the PQI's Offset value to be used. *(NOTE: This value may only be changed when a new Test Section is ordered.)*

Take density gauge measurements, at each test location selected by the Engineer, in accordance with the specification and Figure 2 or Figure 3 as appropriate. Use a lumber crayon or other marking implement that is easily visible and will not be removed by the construction operations, to outline and label the footprint of the density gauge, for all

measurements at each location. Enter these measurements in the appropriate columns. Determine the average of the measurements and enter the result in the average reading column as appropriate. Check the result value against the minimum and maximum requirement for a single reading. If two consecutive readings are less than the minimum value or greater than the maximum value, stop the placement of material and notify the Engineer immediately.



After the 10<sup>th</sup> reading, also calculate the moving average of the last 10 readings by taking the average of the last 10 "Average PQI Density" or "Average PaveTracker Density" values. Enter this value in the "Average of Last 10" column corresponding to each test. Check the resultant value against the requirement for the "Minimum Moving Average." If the moving average is less than the required minimum value, stop the placement of material and notify the Engineer immediately. The moving average will continue on subsequent paving days, and will only be reestablished when the Engineer orders a new test section or a new PTD.

The Engineer or the Engineer's representative will regularly witness readings at a minimum of five locations per day. The Engineer or the Engineer's representative will compare the average reading of the required density gauge measurements taken against the minimum and maximum average density requirements for a single reading, and the "Moving Average of the Last 10" against the "Minimum Average of the Last 10", and initial the appropriate BR form indicating that the specification requirements have been fulfilled. If the specification requirements have not been fulfilled, the Engineer or the Engineer's representative will stop the placement of material and direct a new test section to be constructed.

At the end of each production day, provide the Engineer with a copy of that day's appropriate BR form(s). The Engineer or the Engineer's representative will review and check the calculations at various test locations, to assure the calculations are being performed properly and that the information is being recorded correctly. The reviewer will scan the BR form(s) to assure the moving average of 10 is always 98% of the PTD or above, and that there are no two consecutive test locations with densities lower than 96% of the PTD or greater than 103% of the PTD. The reviewer will also scan the "offset" and "station" columns to ensure that the density of the entire mat, exclusive of the outside 0.6 meters was monitored and the test locations were taken every 60 meters. The stations listed on the BR form(s) should support that density readings were taken at a spacing of 60 meters.

#### **B. Density Data Collection at Core Locations**

When cores are required by the specification, or ordered by the Engineer, BR 66 (for use with the PaveTracker) or BR 67 (for use with the PQI) must be completed and packaged with the cores as outlined in Materials Procedure 96-04, "Hot Mix Asphalt Statistical Pavement Density Determination."

Prior to drilling of pavement cores, take density gauge readings at each of the core locations in the presence of the Engineer or the Engineer's representative. Take the appropriate density gauge measurements at each of the core locations. Enter the results on the BR form. Determine the average of the measurements and enter those results on the BR form. The Engineer or the Engineer's representative will witness the density readings, check the calculations for accuracy, and initial the form prior to packaging with the cores.

## VI. DETERMINING PROJECT TARGET DENSITY (PTD)

This section describes the determination of the Project Target Density.

### A. 60 Series Compaction Specification

The Regional Materials Engineer will determine and submit, within one business day of receipt of the cores and loose mix samples, the PTD to the Project Engineer as follows:

1. Calculate the average of the density gauge measurements taken at each core location to determine a density gauge reading for each location. This information should be delivered with the pavement cores.
2. Determine A, the average of the density gauge readings determined above.

**Note:** An inconsistent density gauge reading may be omitted at the discretion of the Regional Materials Engineer.

1. Determine B, the average of the four core densities.
2. Determine C, 94.5% of mixture's maximum theoretical density (Rice density).
3. Determine D, the difference between the averages calculated above, i.e., A - B.

**Project Target Density (PTD) = C + D**

<b>Example:</b> Rice	=	2600.0 kg/m <sup>3</sup>		
A	=	2325.0 kg/m <sup>3</sup>		
B	=	2400.0 kg/m <sup>3</sup>		
C	=	2600.0 × 0.945	=	2457.0 kg/m <sup>3</sup>
D	=	2325.0 - 2400.0	=	-75.0 kg/m <sup>3</sup>
PTD	=	2457.0 + (-75.0)	=	2382.0 kg/m <sup>3</sup>

#### Interim PTD

If the Contractor elects Option 2 of the 60 Series Standard Specifications, an interim PTD must be established by the Contractor. This interim PTD will be used until the actual PTD is determined. As a minimum, the Contractor should determine the interim PTD as 94.5% of the MMTD. Once the actual PTD is determined by the Regional Materials Engineer, the Engineer will review and determine whether the readings taken with the interim PTD are acceptable based on the actual PTD. If the readings taken using the interim PTD are not acceptable, the Engineer will determine four (4) additional random core locations as described in MP 96-04. Prior to drilling of the pavement cores take density gauge readings at each core location in accordance with section III. B. of this procedure.

#### B. 70 Series Compaction Specification

Construct a Test Section and determine the PTD in accordance with §402, Hot Mix Asphalt Pavements, except replace the nuclear density gauge with a non-nuclear density gauge.

### VII. PAVEMENT DENSITY SAMPLES

Pavement Density Samples will be taken in accordance with §402-3.08, *Pavement Density Samples*, Materials Procedure 96-04, and the following:

Projects that require the 60 Series compaction method are required to take additional sets of cores based on Table 2 below to verify the PTD. The Engineer will randomly select the four core locations in accordance with §402-3.08, *Pavement Density Samples*, and Materials Procedure 96-04. Instead of BR form 109 use BR form 66 or BR form 67, to record the measurements made by the PaveTracker or the PQI, respectively.

Table 2  
Additional Pavement Samples

Production Days	Required Pavement Samples
2 or Less	Standard Specification Requirements Only
3 – 5	Standard Specification Requirements + 1 Additional Pavement Sample Set
More than 5	Standard Specification Requirements + 2 Additional Pavement Sample Sets

The Engineer may require additional pavement core samples for daily density verification from the previously placed HMA. The requirement of these samples shall be based on the following situations. The material placed under these situations will be subject to payment adjustment.

- Insufficient number of density readings recorded, either at a specific location or at the required frequency.
- Paving without a non-nuclear density gauge on site.
- Paving completed after the only calibrated non-nuclear density gauge on site breaks down.
- Gauge readings do not accurately represent the HMA density.

The Engineer may also require additional pavement samples to verify PTD used on the project for the following situations. The material placed under these situations will not be subject to payment adjustment.

- When the contract includes multiple paving locations.
- Changes in condition of existing pavement being overlaid.
- Excessive plant mix variations.
- When accuracy of the non-nuclear density gauge is in question.

When pavement samples are required, take cores, non-nuclear density readings at each core location, and loose mix samples in accordance with §402-3.08 and deliver them to the Regional Materials Laboratory. The Regional Materials Engineer will establish a new PTD based on the pavement core samples, if different from the original PTD.

**Random Numbers**

	A	B	C	D	E	F	G	H	I	J
1	0.140	0.034	0.242	0.074	0.415	0.483	0.594	0.376	0.558	0.195
2	0.174	0.961	0.636	0.041	0.227	0.105	0.354	0.852	0.855	0.853
3	0.857	0.850	0.858	0.846	0.867	0.830	0.904	0.505	0.302	0.708
4	0.147	0.016	0.276	0.760	0.789	0.731	0.098	0.364	0.832	0.900
5	0.513	0.287	0.740	0.084	0.396	0.521	0.272	0.766	0.778	0.753
6	0.807	0.696	0.168	0.973	0.613	0.333	0.893	0.522	0.265	0.783
7	0.747	0.066	0.432	0.450	0.659	0.995	0.570	0.424	0.462	0.636
8	0.041	0.232	0.099	0.364	0.831	0.901	0.508	0.298	0.718	0.125
9	0.314	0.935	0.444	0.672	0.966	0.628	0.057	0.196	0.169	0.972
10	0.619	0.326	0.912	0.485	0.590	0.379	0.551	0.207	0.150	0.013
11	0.287	0.740	0.078	0.402	0.509	0.295	0.724	0.116	0.327	0.909
12	0.492	0.580	0.399	0.511	0.292	0.726	0.111	0.341	0.880	0.552
13	0.209	0.141	0.027	0.260	0.790	0.730	0.103	0.357	0.850	0.860
14	0.841	0.879	0.556	0.200	0.163	0.985	0.591	0.379	0.556	0.201
15	0.162	0.984	0.590	0.379	0.551	0.206	0.151	0.008	0.293	0.723
16	0.114	0.332	0.900	0.514	0.286	0.741	0.078	0.408	0.492	0.575
17	0.410	0.489	0.582	0.395	0.525	0.264	0.780	0.752	0.804	0.704
18	0.155	1.000	0.564	0.436	0.436	0.436	0.437	0.440	0.679	0.955
19	0.653	0.003	0.307	0.695	0.174	0.966	0.631	0.052	0.209	0.141
20	0.032	0.249	0.062	0.189	0.184	0.940	0.679	0.952	0.655	0.003
21	0.304	0.702	0.159	0.992	0.580	0.403	0.506	0.297	0.720	0.123
22	0.313	0.933	0.447	0.670	0.970	0.620	0.323	0.914	0.481	0.597
23	0.368	0.827	0.906	0.502	0.310	0.694	0.173	0.965	0.634	0.045
24	0.218	0.127	0.060	0.194	0.171	0.971	0.622	0.315	0.929	0.455
25	0.649	0.012	0.286	0.738	0.087	0.389	0.532	0.245	0.070	0.425
26	0.460	0.640	0.034	0.242	0.079	0.404	0.505	0.303	0.703	0.158
27	0.998	0.563	0.433	0.447	0.670	0.974	0.616	0.328	0.908	0.498
28	0.568	0.427	0.460	0.640	0.033	0.248	0.063	0.433	0.444	0.674
29	0.961	0.642	0.026	0.260	0.789	0.736	0.091	0.380	0.552	0.209
30	0.141	0.027	0.259	0.792	0.729	0.102	0.360	0.842	0.875	0.559
31	0.191	0.181	0.951	0.662	0.990	0.584	0.396	0.520	0.269	0.776
32	0.757	0.799	0.710	0.143	0.023	0.267	0.780	0.750	0.064	0.436
33	0.438	0.684	0.942	0.675	0.963	0.634	0.042	0.229	0.102	0.356
34	0.847	0.869	0.826	0.911	0.491	0.577	0.405	0.503	0.304	0.706
35	0.148	0.017	0.279	0.755	0.803	0.704	0.152	0.005	0.300	0.713