

State of Nevada
Department of Transportation
Materials Division

METHOD OF TEST FOR RELATIVE COMPACTION
OF PLANTMIX BITUMINOUS BASE AND SURFACE
USING A NUCLEAR DENSITY GAUGE

SCOPE

This test is designed to measure the degree of compaction of plantmix base and surface mat and joint density, using a nuclear density testing device. Results should be obtained during the compaction process while the mix is still hot, allowing time for additional compactive effort, if required.

Control of compaction is first obtained by determining a target density in accordance with the project specifications. Test sections are then constructed and tests are performed. The density values achieved are then compared to the project specifications. Using established acceptance criteria, the compaction in the test section is accepted or rejected.

A. APPARATUS

1. Nuclear density gauge, Troxler Model 4640, 4640-B or 3450.
2. Reference standard shall be provided with each gauge for checking the gauge operation and to provide a stable condition for a reproducible count rate.

B. STANDARDIZATION OF NUCLEAR GAUGE

1. Troxler Model 4640: To be run every six months or at the beginning of a new contract. Troxler Model 4640-B & 3450: To be run daily or at the start of each shift.
2. Place the standard on compacted soil, plantmix or concrete pavement at least 3 m (10 ft.) away from any large object and at least 20 m (66 ft.) from any other nuclear gauge.
3. Place the gauge on the reference standard, apply power to the unit and wait the required time period for all circuits to stabilize. (Refer to operator's manual for turn on and warm up procedures).
4. After warm up period, standardize the gauge as per the manufacturer's instructions.

5. To validate the operation of the Troxler Model 4640 gauge on a daily basis, set the thickness at 25 mm (1 in.) and the count time at 4 minutes. Place the magnesium standard block on a smooth surface with a density of 1600 kg/m^3 (100 pcf) or greater such as concrete or compacted plantmix. Be sure the block does not “rock” on the surface and there is not another gauge within 20 m (66 ft.). Center the gauge on the magnesium standard block. To establish a reference when you first receive the gauge, place the source in the measure position, take five four-minute readings and average for a reference value. Then the daily validation reading should be $\pm 30 \text{ kg/m}^3$ (± 2.0 pcf) of the reference value. On the 4640-B and 3450 no daily validation is required; the standard count is the validation.
6. If the reading is outside tolerance limits, check to see that the magnesium standard block does not rock, no other gauges are in the area and thickness is set at 25 mm (1 in.) then retake the reading. If an acceptable reading cannot be obtained in repeated attempts, contact the appropriate District Progress Tester.

C. TESTING “TEST SECTIONS” AND COMPUTING PERCENT COMPACTION

1. General – after a target density is determined (Test Method Nev. T324, Test Method Nev. T337 or Test Method Nev. T750) and programmed into the nuclear gauge, material is placed and compacted in test sections. After completion of the desired roller coverages, but before the mix has cooled, a series of density tests are taken at locations according to the following.
2. Location of test sites
 - a. In order to assure that material throughout the entire test section is effectively represented by testing, divide the test section into five (5) subsections of equal length. A minimum of two tests will be taken for each subsection, a mat density and a joint density. Refer to project specifications for the size of the test sections. The exact station and distance in from the edge of the pad at which the mat density test will be taken, is determined from the table of random numbers by multiplying a random number times the length of the subsection, then rounded to the nearest 10 m (25 ft.), for the test site station and another random number times the width of the pad, rounded to the nearest 0.5 m (1 ft.) for the distance in from the edge. Use one column of random numbers for the station and the other for the distance from the edge from any random number block for each test section. The second test of the subsection will be on the joint at the same station that the first test was taken, if the mat was inlaid, perform tests on each joint. Joint density tests will not be required on unconfined edges. The table of random numbers is given in Figure 1.

- b. Random numbers are always used in a series of ten (10), five (5) from column A and five (5) from column B. Any block may be used as long as a different block is selected for each new “test section”.

D. DENSITY TESTING – NORMAL MODE

1. Place the gauge on the surface of the plantmix, choosing a smooth flat surface with a minimum of air voids for best results. Check for rocking by placing each hand on opposite corners of the base. Enter one (1) minute count time and depth of paving into the gauge.
2. Place the source rod in the “**Measure**” position and press the “**Start**” key. At the end of the count time, density and percent voids or percent maximum density will be displayed.
3. Repeat the above procedures for each required count.

E. IN PLACE MAT DENSITY MEASUREMENTS

1. Program the target density into the gauge.
2. At each predetermined test site, place the gauge on the hot pad for normal mode, select the proper depth and time interval, put the probe in the “**Measure**” position and begin the test count.
3. Take four (4) one-minute density readings, rotating the gauge 90 degrees about its center after each reading. Entering the “**T-4**” or “**Averaging**” mode before starting will direct the gauge to average each set of four (4) one minute readings.
4. Do not leave the gauge on the hot plantmix surface any longer than absolutely necessary to take the four (4) one minute counts. Long term exposure to high temperature can reduce the service life of the components and temporarily affect the accuracy of the gauge.
5. Record each one minute density reading, and the average of the four (4) on NDOT form 040-017.
6. The average of the four (4) density readings will constitute one test site density.

F. IN PLACE JOINT DENSITY MEASUREMENTS

1. Place the gauge on the mat directly adjacent and parallel to the joint line. Align one edge of the gauge along the top of the mat seam. The gauge should be firmly seated on the new mat and located as close to the joint as possible without

extending any part of the gauge beyond the seam. Put the probe in the “Measure” position and begin the test count.

2. Take two (2) one minute density readings on the joint, rotating the gauge 180 degrees about its center after each reading. Enter the “T-2” or “Averaging” mode if only one side of the mat will be measured. If the mat has been inlaid, it will require joint measurements on each side. Enter “T-4” if joints will be measured on each side of the mat.
3. Record each one minute density reading and the average of the two (2) or four (4) readings on NDOT form 040-017.
4. The average of the readings for the individual joint, or the average of both joint readings, if two joints were measured within the subsection, will constitute one test site density.

G. CORRELATION WITH DRILLED CORES

1. Mark under the center of the gauge each of the five (5) test sites to be correlated.
2. Take cores of the pavement after mat has cooled enough to allow drilling without distortion or cracking of the cores.
3. Determine the density of the cores as per Test Method Nev. T336.
4. If the drilled core density minus the corresponding nuclear reading is not uniform throughout the five (5) sites, cores shall be re-drilled at some or all of the sites and new nuclear readings taken to ascertain a good correlation between the densities.
5. The average of five (5) drilled cores will be correlated with the average of the five (5) nuclear densities taken in the same location as follows:
 - a. If the difference between the two averages is not greater than +/- 1% of the average core density, the nuclear gauge readings shall be used without correction. (i.e. correction factor = 1.00)
 - b. If the difference between the two averages exceeds the tolerance in (a) above, a correction factor for use of the nuclear gauge shall be determined as follows:

(1) Correction Factor =

$$\frac{\text{Average of the five (5) core densities}}{\text{Average of the five (5) nuclear densities}}$$

- (2) The correction factor is then multiplied times the nuclear site densities for future tests until another correlation is run.

H. COMPUTING PERCENT COMPACTION

1. Percent compaction of an individual test site:

- a. Compaction percent =

$$\frac{(\text{Average Test Site Density}) \times (\text{Correction Factor})}{\text{Target Density}}$$

- b. Record the percent compaction to the nearest whole percent.
2. To obtain the mean percent compaction of a “test section” average the (5) corrected test site densities from the five (5) test locations and compute the mean “test section” compaction as follows:

- a. Mean Percent Relative Compaction =

$$\frac{\text{Mean Test Section Density}}{\text{Target Density}}$$

- b. Record to the nearest whole percent.
3. Target density is obtained from the Test Method Nev. T324, Test Method Nev. T337 or Test Method Nev. T750.
 4. Refer to project specifications for minimum and maximum density requirements.
 5. Record the test values on form NDOT 040-017.

I. RETESTING PROCEDURES

1. If an individual test either on the mat or on a joint does not meet the required minimum specification for compaction, additional rolling will be required. After re-rolling, take a retest by testing at a single location chosen at random within the same subsection.
2. If the mean test section compaction for the mat does not meet the required minimum specifications, additional rolling will be required on the entire test section. After re-rolling, take a series of five (5) retests using the same random procedure for selection of test sites as previously described, except that a different block shall be selected from the table of random numbers for the retests.

3. If the mean joint compaction does not meet the required minimum specifications, additional rolling will be required on the full length of the longitudinal joints within the test section. After re-rolling, take a series of five (5) retests using the same random procedure using a different random number block for selection of the joint test sites as previously described.

NOTE: Any additional rolling should not be performed if the temperature at mid-depth of the lift is below 82°C (180° F).

**TABLE OF
RANDOM NUMBERS**

Test Method Nev. T335F

A	B	A	B	A	B	A	B	A	B					
1	.576	.730	2	.430	.754	3	.271	.870	4	.732	.721	5	.998	.239
	.892	.948		.858	.025		.935	.114		.153	.508		.749	.291
	.669	.726		.501	.402		.231	.305		.009	.420		.517	.858
	.609	.482		.809	.140		.396	.025		.937	.310		.253	.761
	.971	.824		.902	.470		.997	.392		.892	.957		.640	.463
6	.053	.899	7	.554	.627	8	.427	.760	9	.470	.040	10	.904	.993
	.810	.159		.225	.163		.549	.405		.285	.542		.231	.919
	.081	.277		.035	.039		.860	.507		.081	.538		.986	.501
	.982	.468		.334	.921		.690	.806		.879	.414		.106	.031
	.095	.801		.576	.417		.251	.884		.522	.235		.398	.222
11	.509	.025	12	.794	.850	13	.917	.887	14	.751	.608	15	.698	.683
	.371	.059		.164	.838		.289	.169		.569	.977		.796	.996
	.165	.996		.356	.375		.654	.939		.815	.592		.348	.743
	.477	.535		.337	.155		.767	.187		.579	.787		.358	.595
	.788	.101		.434	.638		.021	.894		.324	.871		.698	.539
16	.566	.815	17	.622	.548	18	.947	.169	19	.317	.472	20	.864	.466
	.901	.342		.873	.964		.942	.985		.123	.086		.335	.212
	.470	.682		.412	.064		.150	.962		.925	.355		.909	.019
	.068	.242		.667	.356		.195	.313		.396	.460		.740	.247
	.874	.420		.127	.284		.448	.215		.833	.652		.601	.326
21	.897	.877	22	.209	.862	23	.428	.117	24	.100	.259	25	.425	.284
	.875	.969		.109	.843		.759	.239		.890	.317		.428	.802
	.190	.696		.757	.283		.666	.491		.523	.665		.919	.146
	.341	.688		.587	.908		.865	.333		.928	.404		.892	.696
	.846	.355		.831	.218		.945	.364		.673	.305		.195	.887
26	.882	.227	27	.552	.077	28	.454	.731	29	.716	.265	30	.058	.075
	.464	.658		.629	.269		.069	.998		.917	.217		.220	.659
	.123	.791		.503	.447		.659	.463		.994	.307		.631	.422
	.116	.120		.721	.137		.263	.176		.798	.879		.432	.391
	.836	.206		.914	.574		.870	.390		.104	.755		.082	.939
31	.636	.195	32	.614	.486	33	.629	.663	34	.619	.007	35	.296	.456
	.630	.673		.665	.666		.399	.592		.441	.649		.270	.612
	.804	.112		.331	.606		.551	.928		.830	.841		.602	.183
	.360	.193		.181	.399		.564	.772		.890	.062		.919	.875
	.183	.651		.157	.150		.800	.875		.205	.446		.648	.685

Figure 1