Test Method N01: Compacted density of soil and crushed rock

1 Source

This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This method sets out the procedure for the determination of the compacted density of soils and crushed rock materials using a nuclear surface moisture-density gauge in the direct transmission mode. Insitu dry density is determined from measured values of wet density and moisture content.

For wet density measurement, an adjustment is made to the standard blocks wet density for all materials used in pavements (for example, unbound materials such as quarry materials or natural gravels, insitu stabilised materials or plant-mixed stabilised materials) and for all other stabilised materials. For nuclear gauge moisture content measurement, an adjustment is made to the standard blocks moisture content as determined from comparative nuclear gauge and oven drying moisture content results.

Where it is not practical to use a nuclear gauge to measure insitu moisture content, the standard oven drying method or a subsidiary method can be used. The use of a subsidiary method is conditional on a correlation established with the oven drying method in accordance with Test Method AS 1289.2.3.1.

3 Apparatus

The following apparatus is required:

3.1 Nuclear gauge of an approved make and model as listed in Section 1, Subsection 6 of the Nuclear Gauge Testing Manual and capable of the following:
   a) direct transmission measurement in 25 mm increments from 50 mm to 300 mm
   b) uncertainty of the predicted density at the depth used for the test not exceeding 0.06 t/m³, and
   c) uncertainty of the predicted water content not exceeding 0.07 t/m³.

3.2 Reference block, as supplied by the manufacturer with the nuclear gauge and traceable to the nuclear gauge.

3.3 Drill, a rotary hammer drill or a drill rod and hammer capable of forming a hole at least 16 mm in diameter.

3.4 Guideplate, a flat metal template at least the same size as the base of the nuclear gauge, with a hole in one end for the drill rod.

3.5 Fines, dry fine sand or dry native fines passing a 0.600 mm test sieve.

4 Calibration and biasing

4.1 Standard blocks calibration

Calibrate the nuclear gauge on standard blocks at least once every two years for both wet density measurement and moisture content measurement as detailed in AS 1289.5.8.4 (Note 11.1). For wet density measurement, obtain a separate calibration for each test depth.
4.2 Material moisture bias

4.2.1 Where the insitu moisture content of a material is to be measured using a nuclear gauge, determine a moisture bias for the particular nuclear gauge and material source (and, if applicable, material type and subtype) as detailed in Test Method N02 (Note 11.2). This bias is to be re-determined whenever any of the following apply:

a) the depth of the layer being tested changes by more than 50 mm

b) the insitu moisture content has changed by more than 2 percent from the average value at the time the moisture bias was determined, or

c) there is a change in the source rock or the source of any fine component.

4.2.2 In addition to the requirements of Step 4.2.1, check the moisture bias in accordance with Test Method N02 as follows:

a) following the compaction of every 10,000 tonnes of material (such that the check is within the lot that contains the last of the 10,000 tonnes), or

b) if the moisture bias has not been used with the nuclear gauge for two months or more.

4.3 Material wet density bias

4.3.1 Determine a wet density bias for the particular nuclear gauge, material source (and, if applicable, material type and subtype) and test depth as detailed in Test Method N03 (Note 11.2). This bias is to be re-determined whenever any of the following apply:

a) whenever any MDD is reassigned as detailed in Materials Testing Manual Test Method Q144A, or

b) there is a change in the source rock or the source of any fine component.

4.3.2 In addition to the requirements of Step 4.3.1, check the wet density bias in accordance with Test Method N03 as follows:

a) following the compaction of every 10,000 tonnes of material (such that the check is within the lot that contains the last of the 10,000 tonnes), or

b) if the wet density bias has not been used with the nuclear gauge for two months or more.

5 Operational checks

To ensure that the nuclear gauge is operating normally, checks are to be undertaken routinely or following repair as follows:

5.1 Standard count check (frequency: each day of use)

5.1.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.4).

5.1.2 Take a standard count in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and
c) density standard count and moisture standard count values are recorded (Notes 11.5 and 11.6).

5.1.3 Calculate the average of the previous four recorded and accepted density standard counts and the average of the previous four recorded and accepted moisture standard counts.

5.1.4 Calculate the limits for density and moisture as follows and record:

\[ L = \overline{SC} - 2 \sqrt{\frac{SC}{PS}} \]
\[ U = \overline{SC} + 2 \sqrt{\frac{SC}{PS}} \]

where \( \overline{SC} \) = average density standard count (DS) or average moisture standard count (MS)

\( L \) = lower limit for density (\( L_\rho \)) or moisture (\( L_\omega \))

\( U \) = limit for density (\( U_\rho \)) or moisture (\( U_\omega \))

\( PS \) = nuclear gauge prescale factor (Refer to Table 1)

5.1.5 If the recorded standard count values lie within the range \( L_\rho \) to \( U_\rho \) for density and \( L_\omega \) to \( U_\omega \) for moisture, the density or moisture standard count is accepted and the nuclear gauge may be used for testing.

5.1.6 If the recorded standard count value lies outside the range \( L_\rho \) to \( U_\rho \) for density or \( L_\omega \) to \( U_\omega \) for moisture, repeat Steps 5.1.2 to 5.1.5. If either standard count is again outside the appropriate range, remove the nuclear gauge from service and have it repaired by a licensed service agent (Notes 11.6 and 11.7).

5.2 Gauge function check – statistical performance (frequency: monthly)

5.2.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.4).

5.2.2 Take at least 16 density and moisture counts in accordance with the appropriate statistical count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block
b) the source rod handle is correctly located in the shielded position, and
c) density and moisture count values are recorded (Notes 11.5 and 11.8).

5.2.3 Calculate the mean and standard deviation of the density counts and moisture counts.
5.2.4 Calculate the density ratio and moisture ratio using the following formula and record the values in the nuclear gauge logbook:

\[ r = \frac{s}{\sqrt{C}} \]

where

- \( r \) = density ratio (\( r_\rho \)) or moisture ratio (\( r_w \))
- \( s \) = standard deviation of the density or moisture counts
- \( \sqrt{C} \) = mean density count (\( \overline{C}_\rho \)) or mean moisture count (\( \overline{C}_w \))

5.2.5 If the density ratio and moisture ratio lie within the limits given in Table 2, the nuclear gauge is verified to be operating normally and may be used for testing.

5.2.6 If either the density ratio or the moisture ratio, lie outside the relevant limits given in Table 2, repeat Steps 5.2.2 to 5.2.5. If either ratio is again outside the limits, remove the nuclear gauge from service and have it repaired by a licensed service agent.

5.3 Density system consistency check (frequency: monthly)
Perform a density system consistency check in accordance with Section 2, Clause 1.2 of the Nuclear Gauge Testing Manual.

6 Configuration
On each day of use, configure the nuclear gauge before testing any material by undertaking a standard count and setting or checking test parameters for the particular material (and, if applicable, material type and subtype) as follows:

6.1 Standard count
6.1.1 Remove the nuclear gauge and reference block from the transport case and place the reference block on the surface of the particular material (and, if applicable, material type and subtype) under test (Note 11.9).

6.1.2 Take a standard count in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:
   a) the nuclear gauge is correctly located on the reference block
   b) the source rod handle is correctly located in the shielded position, and
   c) density and moisture standard count values are recorded with the test data and, where the functionality exists, stored in the nuclear gauge microprocessor.

6.2 Test parameters
Check or set user definable test parameters in accordance with the appropriate test parameters operating instruction detailed in Section 4: Operating Instructions: Testing – Soils of the Nuclear Gauge Testing Manual (Note 11.10).
7 Test site selection and preparation

Determine test locations and prepare each test site as follows:

7.1 Use Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Materials Testing Manual Test Method Q050 to determine each test location.

7.2 At a designated test location, use the guideplate to define a test site that is flat and free from depressions (Note 11.11). The guideplate may be used to trim the surface of some materials, provided the surface is not de-densified by such action.

7.3 Sweep all loose material from the test site and sprinkle fine sand or native fines on the surface. Move the guideplate over the surface until the voids are just filled, ensuring that the sand or fines does not form an added layer.

7.4 Place the guideplate on the test site and drill a hole at least 50 mm beyond the specified measurement depth (Note 11.12). Where the measurement depth is not stipulated in the appropriate specification, select a depth in keeping with the following criteria:

a) the measurement depth for pavement layers is 15 mm to 39 mm less than the nominal layer thickness up to the maximum direct transmission measurement depth of 300 mm (Note 11.12), or

b) the measurement depth for other stabilised layers is 0 mm to 24 mm less than the nominal depth of the layer up to the maximum direct transmission measurement depth of 300 mm.

7.5 Remove the guideplate and repair the prepared test area using some additional sand or fines if required.

7.6 Use the guideplate to mark the test area to allow the placement of the nuclear gauge over the test site and to align the source rod to the hole (Note 11.13).

8 Testing

Testing shall be performed as follows:

8.1 Place the nuclear gauge on the marked test site, lower to source rod into the formed hole and move the source rod to the required measurement depth.

8.2 Ease the source rod against the hole wall by moving the nuclear gauge in the direction of the source rod handle.

8.3 Confirm the firm seating of the nuclear gauge on the test area by rotating the nuclear gauge several degrees left or right if required (Note 11.14). Maintain contact between the source rod and the formed hole.

8.4 Take a 1-minute count in accordance with the appropriate measurement operating instruction detailed in Section 4: Operating Instructions: Testing – Soils of the Nuclear Gauge Testing Manual. Record relevant density and moisture test data while meeting the requirements of Table 3.

8.5 Rotate the nuclear gauge through 90° ensuring that the test site is not disturbed. Repeat Steps 8.2 to 8.4 and then move the source rod to the shielded position (Note 11.11).

8.6 Compare the dry density values from the two orientations. If the difference exceeds 0.075 t/m³, examine and further prepare the test site as necessary and repeat Steps 8.1 to 8.5.
8.7 If the dry density difference again exceeds 0.075 t/m³, abandon the test site and select a new site immediately adjacent.

8.8 Where the insitu moisture content is to be measured using the standard oven drying method or a subsidiary method, obtain a moisture content sample as detailed in Materials Testing Manual Test Method Q061.

8.9 Determine the oven dry moisture content of the sample obtained as detailed in Materials Testing Manual Test Method AS 1289.2.1.1 or one of the subsidiary Test Methods AS 1289.2.1.4 or AS 1289.2.1.6 for which a relationship with Test Method AS 1289.2.1.1 has been established as detailed in Test Method AS 1289.2.3.1.

9 Calculations

Calculations shall be as follows:

9.1 Nuclear gauge density and moisture measurement

9.1.1 Determine the compacted dry density for the test site by averaging the dry density values obtained at the 0° and 90° orientations.

9.1.2 Where any relevant biases have not been applied via the nuclear gauge microprocessor, adjust the average nuclear gauge dry density calculated in Step 9.1.1 by applying these biases as follows:

\[ \rho_d = \bar{\rho}_{Gd} + B_p - B_w \]

where

- \( \rho_d \) = compacted dry density (t/m³)
- \( \bar{\rho}_{Gd} \) = average nuclear gauge dry density (t/m³)
- \( B_p \) = material wet density bias (t/m³)
- \( B_w \) = material moisture bias (t/m³)

9.1.3 Determine the insitu moisture content for the test site by averaging the measured moisture content values obtained at the 0° and 90° orientations.

9.1.4 Where a moisture bias has not been applied via the nuclear gauge microprocessor, adjust the average standard blocks moisture content calculated in Step 9.1.3 by applying this bias as follows:

\[ w = \frac{(\bar{W}_G + B_w)100}{\rho_d} \]

where

- \( w \) = insitu moisture content (%)
- \( \bar{W}_G \) = average standard blocks moisture content (t/m³)
- \( B_w \) = material moisture bias (t/m³)
- \( \rho_d \) = compacted dry density (t/m³)
9.2 **Nuclear gauge density and standard oven drying or subsidiary moisture measurement**

9.2.1 Determine the insitu wet density for the test site by averaging the wet density values obtained at the 0º and 90º orientations.

9.2.2 Where any relevant biases have not been applied via the nuclear gauge microprocessor, adjust the average standard blocks wet density calculated in Step 9.2.1 by applying these biases as follows:

\[ \rho = \rho_G + B_\rho \]

where \( \rho \) = insitu wet density (t/m³)
\( \rho_G \) = average standard blocks wet density (t/m³)
\( B_\rho \) = material wet density bias (t/m³)

9.2.3 Determine the insitu moisture content for the test site as follows:

\[ W = \frac{\rho_w}{100 + w} \]

where \( W \) = insitu moisture content (t/m³)
\( \rho \) = insitu wet density (t/m³)
\( w \) = insitu oven dry or subsidiary moisture content (%)

9.2.4 Determine the compacted dry density for the test site as follows:

\[ \rho_d = \rho - W \]

where \( \rho_d \) = compacted dry density (t/m³)
\( \rho \) = insitu wet density (t/m³)
\( W \) = insitu moisture content (t/m³)

10 **Reporting**

The following shall be reported:

a) compacted dry density or insitu wet density to the nearest 0.01 t/m³

b) insitu moisture content to the nearest 0.1% and the test method used

c) date tested, depth tested, lot number, test site number, and chainage and offset

d) source and description of the material together with the layer type and layer depth

e) the report number for the wet density bias and moisture bias, and

f) the number of this test method, that is N01.

11 **Notes on method**

11.1 Recalibrate the nuclear gauge following any major repair or component replacement.

11.2 For pavement materials, it is necessary to determine the moisture bias and wet density bias for each material type and subtype obtained from a particular source.
11.3 A location is to be selected which is at least 2 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

11.4 Keep a record for each gauge to record operational check data (standard count and gauge function check) and the date of measurement.

11.5 Where there are no previous four standard counts taken within the previous five weeks of the current date or when moving the nuclear gauge to a new operating location and there is a new designated test location, it may be necessary to take four new standard counts as detailed in Steps 5.1.1 to 5.1.2.

11.6 It is expected that a standard count value will lie outside the range $L_{\rho}$ to $U_{\rho}$ about once in every 20 standard count checks. To have consecutive values outside this range is expected only once in 400 standard count checks. However, as the return of the gauge for checking and possible repair can be expensive and disruptive, it is acceptable to perform a gauge function check as detailed in Subsection 5.2. If verified that the gauge is not operating normally, remove the nuclear gauge from service and have it repaired by a licensed service agent.

11.7 Where an accepted form of statistical analysis is performed by the microprocessor, it is not necessary to record individual count values. Only record the density and moisture ratio values and omit Steps 5.2.3 and 5.2.4.

11.8 When using the nuclear gauge within 2 m of a large object or in a trench, take a separate standard count at each test site.

11.9 The scope of user definable test parameters is dependent on the make and model of nuclear gauge. Such parameters include:

a) counting time, units and measurement mode  

b) maximum dry density  

c) material density bias, and  

d) material moisture bias.

11.10 The test area is formed by two overlapping rectangles at right angles to each other, with each rectangle being at least the size of the guideplate and the hole being common within the overlapping area as shown below:

```
  90° ↑  
   0°→→
   ←Roller direction→
```

11.11 Where the underlying layer consists of the same material type and subtype as that in the layer under test, select the measurement depth that is closest to the nominal layer thickness. Under these conditions, it is acceptable for the source rod to penetrate into the underlying layer.

11.12 To improve operator safety, it is recommended that the source rod containing radioactive materials not be extended out of its shielded (SAFE) position prior to placing it into the formed hole. Where possible, align the gauge to allow the placing of the source rod directly into the formed hole from the shielded position.
11.13 If unable to obtain firm seating of the nuclear gauge, prepare a new test site immediately adjacent to the original site.

**Table 1 – Nuclear gauge prescale factors**

<table>
<thead>
<tr>
<th>Nuclear gauge make / model</th>
<th>Prescale factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>1</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>8</td>
</tr>
<tr>
<td>Troxler/except Model 3450</td>
<td>16</td>
</tr>
<tr>
<td>Troxler/Model 3450</td>
<td>8</td>
</tr>
<tr>
<td>Humboldt/All</td>
<td>16</td>
</tr>
<tr>
<td>InstroTek/Xplorer series</td>
<td>16</td>
</tr>
</tbody>
</table>

**Table 2 – Gauge function check – density and moisture ratio limits**

<table>
<thead>
<tr>
<th>Nuclear gauge make/model</th>
<th>Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>0.75</td>
<td>1.25</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>Troxler/except Model 3450</td>
<td>0.17</td>
<td>0.33</td>
</tr>
<tr>
<td>Troxler/Model 3450</td>
<td>0.225</td>
<td>0.465</td>
</tr>
<tr>
<td>Humboldt/All</td>
<td>0.60</td>
<td>1.40</td>
</tr>
<tr>
<td>InstroTek/Xplorer series</td>
<td>0.18</td>
<td>0.35</td>
</tr>
</tbody>
</table>

**Table 3 – Minimum test data**

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Routine test</th>
<th>Material bias or bias check</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Nuclear gauge density and moisture</td>
<td>Nuclear gauge density and oven dry/subsidiary moisture</td>
</tr>
<tr>
<td>density standard count</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>moisture standard count</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>wet density (t/m³)</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>dry density (t/m³)</td>
<td>✓</td>
<td>✓[*]</td>
</tr>
<tr>
<td>moisture content (t/m³)</td>
<td>✓[#]</td>
<td></td>
</tr>
<tr>
<td>moisture content (%)</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>density count</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>moisture count</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>relative compaction</td>
<td>✓[^]</td>
<td></td>
</tr>
</tbody>
</table>

* These values are only recorded as a means of monitoring the validity of the test results (refer to Step 8.6).
# This value is only recorded when the moisture bias is not applied by the microprocessor.
[^] This value is only valid when all relevant biases have been applied by the microprocessor.
Test Method N02: Material bias – soil moisture content

1 Source
This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope
This method sets out the procedure for the determination of the moisture bias associated with the measurement of in situ moisture content of soils and crushed rock materials using a nuclear gauge. The moisture bias represents the average moisture content difference between the nuclear gauge and oven drying tests for a particular nuclear gauge and material. Differences in the moisture content values obtained by the nuclear gauge and oven drying tests are due to differences in the material sampled by both tests, the effect of moisture gradients, the presence of any bound water on nuclear gauge results and any moisture losses from the sample prior to oven drying.

Included in the method is a procedure for monitoring the applicability of an existing moisture bias and for providing ongoing adjustment of the bias to reflect subtle changes in material composition.

This method makes no provision for concurrent determination of wet density bias, and where both moisture content bias and wet density bias are required, reference Test Method N03.

3 Procedure
The procedure shall be as follows:

3.1 Select at least six test sites within the lot under consideration using Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Materials Testing Manual Test Method Q050 (Note 7.1). For stabilised materials, work to determine the wet density must be completed to a stage where the wet density has been determined within 24 hours after the end of the work shift where stabilisation works were completed for the corresponding lot. Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge moisture content, and dry density and wet density as detailed in Test Method N01, except that no material moisture bias and material wet density bias are applied. The moisture content and wet density values obtained are referred to as the standard blocks moisture content and standard blocks wet density. Record the measured moisture count and moisture content, dry density and wet density values for both the 0º and 90º orientations.

3.2.2 Obtain a moisture content sample as detailed in Materials Testing Manual Test Method Q061.

A: probe access hole location (small circle)
B: oven dry moisture content test location (large circle)
3.2.3 Determine the oven dry moisture content of the sample obtained as detailed in Test Method AS 1289.2.1.1. For stabilised materials, moisture content samples must be returned to a laboratory and placed in drying ovens within the same work shift as the stabilisation works for the corresponding lot.

4 Calculations

Calculations shall be as follows:

4.1 Field test data

4.1.1 Determine the moisture count, standard blocks moisture content and standard blocks wet density for each site by averaging the corresponding measurements for the 0° and 90° orientations.

4.1.2 Calculate the oven dry moisture content for each site as follows:

\[ W_o = \frac{\rho_G W_o}{100 + W_o} \]

where

- \( W_o \) = oven dry moisture content (t/m³)
- \( \rho_G \) = standard blocks wet density (t/m³)
- \( W_o \) = oven dry moisture content (%)

4.2 Data validation

4.2.1 Calculate the moisture count ratio for each site to four significant figures as follows:

\[ CR_w = \frac{C_w}{SC_w} \]

where

- \( CR_w \) = moisture count ratio
- \( C_w \) = moisture count
- \( SC_w \) = moisture standard count

4.2.2 Plot the standard blocks moisture content against the corresponding moisture count ratio using the data from all test sites (Note 7.2).

4.2.3 If any data pair does not lie on the linear plot, reject the standard blocks and oven dry moisture data for this test site.

4.3 Data acceptance

4.3.1 Calculate the average standard blocks moisture content and average oven dry moisture content for all remaining test sites.

4.3.2 Calculate the moisture standard error as follows:

\[ SE_w = \sqrt{\frac{\sum (W_o - W_G - \bar{W_o} + \bar{W_G})^2}{n - 2}} \]
where \( SE_W \) = moisture standard error (t/m³)

\( W_o \) = oven dry moisture content at each test site (t/m³)

\( W_G \) = standard blocks moisture content at each test site (t/m³)

\( \bar{W}_o \) = average oven dry moisture content for the test sites (t/m³)

\( \bar{W}_G \) = average standard blocks moisture content for the test sites (t/m³)

\( n \) = number of test sites

4.3.3 If the moisture standard error does not exceed 0.020 t/m³, accept the data and calculate the moisture bias as detailed in Subsection 4.4.

4.3.4 If the moisture standard error exceeds 0.020 t/m³, perform the following:

a) For each moisture data pair (oven dry and standard blocks), calculate the moisture error as follows:

\[
E_W = \left| \left( W_o - W_G \right) - \left( \bar{W}_o - \bar{W}_G \right) \right|
\]

where \( E_W \) = moisture error (t/m³)

\( W_o \) = oven dry moisture content at each test site (t/m³)

\( W_G \) = standard blocks moisture content at each test site (t/m³)

\( \bar{W}_o \) = average oven dry moisture content for the test sites (t/m³)

\( \bar{W}_G \) = average standard blocks moisture content for the test sites (t/m³)

b) Eliminate the moisture content data pair (oven dry and standard blocks), with the largest moisture error.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. If data from three or more test sites are eliminated, reject all test data and repeat the complete procedure.

ii. If there is acceptable data from less than six test sites, reject all test data and repeat the complete procedure.

iii. If all test data are again rejected, it is not appropriate to calculate a single wet density bias for the material.

4.4 Determination of moisture bias

Moisture bias may be calculated directly in t/m³ or expressed as a K value. Choose the form of moisture bias which is applicable to the particular nuclear gauge used.
4.4.1 Moisture bias (t/m³)

Calculate the moisture bias as follows:

\[ B_W = \overline{W_o} - \overline{W_G} \]

where

- \( B_W \) = moisture bias (t/m³)
- \( \overline{W_o} \) = average oven dry moisture content for all accepted test sites (t/m³)
- \( \overline{W_G} \) = average standard blocks moisture content for all accepted test sites (t/m³)

4.4.2 Moisture bias (K value)

There are a number of options for determining the K value, depending on the functionality of the nuclear gauge. The K value can be either calculated external to the nuclear gauge and stored in the microprocessor or calculated internally by the microprocessor using input values of average oven dry moisture content and average standard blocks moisture content.

**External calculation**

Calculate the moisture bias as a K value using the appropriate method as follows:

for a Humboldt nuclear gauge, calculate and record to the nearest 0.01;

\[ K = \frac{\overline{W_o} - \overline{W_a}}{P_o - \overline{W_o}} \]

or for a Troxler nuclear gauge, calculate and record to the nearest whole number;

\[ K = \frac{(\overline{W_o} - \overline{W_G})1000}{P_G - \overline{W_o}} \]

where

- \( K \) = K value
- \( \overline{W_o} \) = average oven dry moisture content for all accepted test sites (t/m³)
- \( \overline{W_G} \) = average standard blocks moisture content for all accepted test sites (t/m³)
- \( P_G \) = average standard blocks wet density for all accepted test sites (t/m³)

**Internal calculation**

i) Calculate the average oven dry moisture content as follows:

\[ W_o = \frac{100\overline{W_o}}{P_G - \overline{W_G}} \]

where

- \( W_o \) = average oven dry moisture content for all accepted test sites (%)  
- \( \overline{W_o} \) = average oven dry moisture content for all accepted test sites (t/m³)  
- \( \overline{W_G} \) = average standard blocks moisture content for all accepted test sites (t/m³)  
- \( P_G \) = average standard blocks wet density for all accepted test sites (t/m³)
ii) Calculate the average standard blocks moisture content as follows:

\[ w_G = \frac{100 \overline{W}_G}{\overline{P}_G - \overline{W}_G} \]

where

- \( w_G \) = average standard blocks moisture content for all accepted test sites (%)
- \( \overline{W}_G \) = average standard blocks moisture content for all accepted test sites (t/m³)
- \( \overline{P}_G \) = average standard blocks wet density for all accepted test sites (t/m³)

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the moisture bias by performing three additional standard blocks moisture and oven dry moisture content tests following the compaction of 10,000 tonnes of material. Select the three test sites from within the lot that contains the last of the 10,000 tonnes and perform testing as detailed in Section 3.

5.2 Determine and validate the nuclear gauge moisture count and standard blocks moisture content data as detailed in Steps 4.1 to 4.2.3.

5.3 Add the new moisture data pairs to the previously accepted data while removing three existing and consecutive moisture data pairs commencing at the lowest test site number (Note 7.3).

5.4 Analyse the revised moisture data for acceptance as detailed in Subsection 4.3, except that no more than one of the new moisture data points may be eliminated.

5.5 Calculate an amended moisture bias for the accepted data as detailed in Subsection 4.4.

6 Reporting

The following shall be reported:

a) moisture bias using one of the following conventions:
   - to the nearest 0.01 t/m³
   - a K value to the nearest 0.01 unit for a Humboldt nuclear gauge
   - a K value to the nearest whole number for a Troxler or Instrotek nuclear gauge, or
   - K value inputs, viz. average oven dry moisture content to the nearest 0.1% and average standard blocks moisture content to the nearest 0.1%.

b) source and description of the material, together with the layer type and layer depth

c) a tabulation containing the standard blocks and oven dry moisture data used to determine the bias (including any eliminated data), together with the date tested, depth tested, lot number, test site number, and chainage and offset

d) the date the bias was reported and, in the case of an amended moisture bias, the report number and date for the previous report, and

e) the number of this test method, that is N02.
7 Notes on method

7.1 In order to determine a moisture bias that is representative of the lot, distribute sampling locations throughout the lot.

7.2 The relationship between nuclear gauge moisture content and moisture count ratio is essentially linear over the expected moisture content range within a lot.

7.3 When there are only six existing data points, remove only two so that seven data points are available for analysis.
Test Method N03: Material bias – soil wet density

1 Source
This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope
This method sets out the procedure for the determination of the wet density bias associated with the measurement of compacted density of soils and crushed rock materials using a nuclear gauge. The wet density bias represents the average wet density difference between the nuclear gauge and sand replacement tests for a particular nuclear gauge, material and test depth. Differences in the wet density values obtained by the nuclear gauge and sand replacement tests are due to differences in the material sampled by both tests, the effect of chemical composition and test site characteristics (for example, density and moisture gradients, surface condition, particle size, homogeneity) on nuclear gauge results and inadequacies in the sand replacement test for some materials.

Included in the method is a procedure for monitoring the applicability of an existing wet density bias and for providing ongoing adjustment of the bias to reflect subtle changes in material composition.

This method also caters for concurrent determination of a moisture bias as detailed in Test Method N02.

3 Procedure
The procedure shall be as follows:

3.1 Select at least six test sites within the lot under consideration using Random Stratified Sampling: Selection of Location - Available Area (unless otherwise specified) in accordance with Materials Testing Manual Test Method Q050 (Note 7.1). For stabilised materials, work to determine the wet density must be completed to a stage where the wet density has been determined within 24 hours after the end of the work shift where stabilisation works were completed for the corresponding lot. Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge wet density as detailed in Test Method N01, ensuring that any relevant alignment and gauge biases are applied but that no material wet density bias is applied. This wet density is referred to as the standard blocks wet density. Record the measured density counts, dry density and wet density values for both the 0º and 90º orientations.

Where a moisture content bias is required in conjunction with a wet density bias, obtain and record nuclear gauge moisture counts and moisture content values as detailed in Test Method N02.

3.2.2 Select a position for a sand replacement test at either position D for a 150 mm diameter hole or position E for a 200 mm diameter hole.

A: probe access hole location (small circle)
D: 150 mm dia. sand replacement test location (medium circle)
E: 200 mm dia. sand replacement test location (large circle)
3.2.3 Remove any fine sand or fines from the nuclear gauge test position as selected in Step 3.2.2. Undertake a sand replacement test as detailed in Test Method Q141B and determine the wet density and oven dry moisture content. Excavate to one of the following depths while avoiding the probe access hole and any associated surface cracking:

a) the full depth of the layer where the sampled material is from a pavement or earthworks, or
b) the depth used in the nuclear gauge measurement of wet density where the sampled material is from earthworks and no layer depth is applicable.

For stabilised materials, moisture content samples must be returned to a laboratory and placed in drying ovens within the same work shift as the stabilisation works for the corresponding lot.

4 Calculations
Calculations shall be as follows:

4.1 Field test data
Determine the density count and standard blocks wet density for each site by averaging the corresponding measurements for the 0º and 90º orientations.

4.2 Data validation
4.2.1 Calculate the density count ratio for each site to four significant figures as follows:

$$CR_{\rho} = \frac{C_{\rho}}{SC_{\rho}}$$

where $CR_{\rho}$ = density count ratio
$C_{\rho}$ = density count
$SC_{\rho}$ = density standard count

4.2.2 Plot the standard blocks wet density against the corresponding density count ratio using the data from all test sites (Note 7.2).

4.2.3 If any data point does not lie on the linear plot, reject the standard blocks and sand replacement wet density data for this test site.

4.3 Data acceptance
4.3.1 Calculate the average standard blocks wet density and average sand replacement wet density for all remaining test sites.
4.3.2 Calculate the wet density standard error as follows:

\[ SE_\rho = \sqrt{\frac{\sum (\rho_S - \rho_G - \overline{\rho}_S + \overline{\rho}_G)^2}{n - 2}} \]

where

- \( SE_\rho \) = wet density standard error (t/m³)
- \( \rho_S \) = sand replacement wet density at each test site (t/m³)
- \( \rho_G \) = standard blocks wet density at each test site (t/m³)
- \( \overline{\rho}_S \) = average sand replacement wet density for all test sites (t/m³)
- \( \overline{\rho}_G \) = average standard blocks wet density for all test sites (t/m³)
- \( n \) = number of test sites

4.3.3 If the wet density standard error does not exceed 0.055 t/m³, accept the data and calculate the wet density bias as detailed in Subsection 4.4.

4.3.4 If the wet density standard error exceeds 0.055 t/m³, perform the following:

a) For each density data pair (sand replacement and standard blocks), calculate the wet density error and follows:

\[ E_\rho = \left( \rho_S - \rho_G \right) - \left( \overline{\rho}_S - \overline{\rho}_G \right) \]

where

- \( E_\rho \) = wet density error (t/m³)
- \( \rho_S \) = sand replacement wet density at each test site (t/m³)
- \( \rho_G \) = standard blocks wet density at each test site (t/m³)
- \( \overline{\rho}_S \) = average sand replacement wet density for the test sites (t/m³)
- \( \overline{\rho}_G \) = average standard blocks wet density for the test sites (t/m³)

b) Eliminate the wet density data pair (sand replacement and standard blocks), with the largest wet density error.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. If data from three or more test sites are eliminated, reject all test data and repeat the complete procedure.

ii. If there is acceptable data from less than six test sites, reject all test data and repeat the complete procedure.

iii. If all test data are again rejected, it is not appropriate to calculate a single wet density bias for the material.
4.4 **Wet density basis**

Calculate the wet density bias as follows:

\[ B_p = \bar{\rho}_s - \bar{\rho}_G \]

where

- \( B_p \) = wet density bias (t/m³)
- \( \bar{\rho}_s \) = average sand replacement wet density for all accepted test sites (t/m³)
- \( \bar{\rho}_G \) = standard blocks wet density for all accepted test sites (t/m³)

5 **Bias check**

Bias checks shall be performed as follows:

5.1 Monitor the wet density bias by performing three additional standard blocks wet density and sand replacement wet density tests following the compaction of 10,000 tonnes of material. Select the three test sites from within the lot that contains the last of the 10,000 tonnes and perform the testing as detailed in Section 3.

5.2 Determine and validate the nuclear gauge density count and standard blocks wet density data as detailed in Steps 4.1 to 4.2.3.

5.3 Add the new density data pairs to the previously accepted data while removing three existing and consecutive density data pairs commencing at the lowest test site number (Note 7.3).

5.4 Analyse the revised wet density data for acceptance as detailed in Subsection 4.3, except that no more than one of the new density data pairs may be eliminated.

5.5 Calculate an amended wet density bias for the accepted data as detailed in Subsection 4.4.

6 **Reporting**

The following shall be reported:

a) wet density bias to the nearest 0.01 t/m³

b) source and description of the material together with the layer type and layer depth

c) a tabulation containing the standard blocks and sand replacement wet density data used to determine the bias (including any eliminated data), together with the date tested, depth tested, lot number, test site number, and chainage and offset

d) the date the bias was reported, and

e) the number of this test method, that is N03.

7 **Notes on method**

7.1 In order to determine a wet density bias that is representative of the lot, distribute the sampling locations throughout the lot.

7.2 The relationship between nuclear gauge wet density and density count ratio is essentially linear over the expected density range within a lot.

7.3 Where there are only six existing data points, remove only two so that seven data points are available for analysis.
Test Method N04: Compacted density of asphalt

1 Source
This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope
This method sets out the procedure for the determination of the compacted density of asphalt using a nuclear gauge. The method is based on the backscatter mode of measurement and records the wet density output from the nuclear gauge as the compacted density of the asphalt.

An adjustment is made to the standard blocks wet density calibration as determined from comparative nuclear gauge wet density and core compacted density results.

3 Apparatus
The following apparatus is required:

3.1 Nuclear gauge of an approved make and model as listed in Section 1 of the Nuclear Gauge Testing Manual and with a calibration density uncertainty of less than 0.08 t/m³ for gauges used in backscatter mode and for thin-layer gauges such as Troxler 4640B.

3.2 Reference block, as supplied by the manufacturer with the nuclear gauge and traceable to the nuclear gauge.

3.3 Guideplate or straightedge.

3.3.1 Guideplate, a flat metal template at least the same size as the base of the nuclear gauge.

3.3.2 Straightedge, a steel straightedge about 300 mm long and 5 mm thick.

3.4 Dry fine sand passing a 0.600 mm test sieve.

4 Calibration and biasing
Calibration and biasing shall be performed as follows:

4.1 Standard blocks calibration
Calibrate the nuclear gauge on standard blocks at least once every two years for density measurement as detailed in the relevant Australian Standard as follows (Note 11.1):

- Nuclear thin-layer density gauge AS 2891.14.3
- Nuclear moisture-density gauge (backscatter) AS 2891.14.4

4.2 Asphalt density bias

4.2.1 Determine a density bias for the particular nuclear gauge, asphalt mix and gauge layer thickness setting (thin-layer gauge only) as detailed in Test Method N05.

This bias is to be re-determined whenever any of the following apply:

a) there is a change to the mix design, or

b) there is a change to the gauge layer thickness setting.
4.2.2 In addition to the requirements of Steps 4.2.1, check any applied density bias in accordance with Test Method N05 as follows:

a) whenever there is a change in site conditions (for example, surface roughness, nominal layer thickness, composition of underlying layer, density of underlying layer)

b) following the compaction of every 10,000 tonnes of material (such that the check is within the lot that contains the last of the 10,000 tonnes), or

c) if the density bias has not been used with the nuclear gauge for two months or more.

5 Operational checks

To ensure that the nuclear gauge is operating normally, checks are to be undertaken routinely or following repair as follows:

5.1 Standard count check (frequency: each day of use)

5.1.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.2).

5.1.2 Take a standard count for each density detection system in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) the density standard count values are recorded (Note 11.3).

5.1.3 Calculate the average of the previous four recorded and accepted density standard counts (Note 11.4).

5.1.4 Calculate the density limits for each density detection system as follows and record the limits (Note 11.3):

\[
L_p = \overline{SC} - 2\sqrt{\frac{SC}{PS}}
\]

\[
U_p = \overline{SC} + 2\sqrt{\frac{SC}{PS}}
\]

where \( \overline{SC} \) = average density standard count (DS)

\( L_p \) = lower limit for density

\( U_p \) = upper limit for density

PS = nuclear gauge prescale factor (Refer to Table 1)

5.1.5 If the recorded standard count value for each system lies within the range \( L_p \) to \( U_p \), the density standard count is accepted and the nuclear gauge may be used for testing.

5.1.6 If either recorded standard count value lies outside the range \( L_p \) to \( U_p \), repeat Steps 5.1.2 to 5.1.5. If either standard count is again outside the range, remove the nuclear gauge from service and have it repaired by a licensed service agent (Notes 11.4 and 11.5).
5.2  **Gauge function check – statistical performance (frequency: monthly)**

5.2.1  Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.2).

5.2.2  Take at least 16 density counts for each density detection system in accordance with the appropriate statistical count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a)  the nuclear gauge is correctly located on the reference block

b)  the source rod handle is correctly located in the shielded position, and

c)  the density count values are recorded (Notes 11.3 and 11.6).

5.2.3  Calculate the mean and standard deviation of the density counts.

5.2.4  Calculate the density ratio for each density detection system as follows and record the value (Note 11.3):

\[
\rho_r = \frac{s}{\sqrt{C_\rho}}
\]

where

- \( \rho_r \) = density ratio
- \( s \) = standard deviation of the density counts
- \( C_\rho \) = mean density count

5.2.5  If the density ratio for each system lies within the limits given in Table 2, the nuclear gauge is verified to be operating normally and may be used for testing.

5.2.6  If any density ratio lies outside the relevant limits given in Table 2, repeat Steps 5.2.2 to 5.2.5. If any ratio is again outside the limits, remove the nuclear gauge from service and have it repaired by a licensed service agent.

5.3  **Density system consistency check (frequency: monthly)**

Perform a density system consistency check in accordance with Section 2, Subsection 1.2 of the Nuclear Gauge Testing Manual.

6  **Configuration**

On each day of use, configure the nuclear gauge before testing by undertaking a standard count and setting or checking test parameters appropriate to the asphalt mix design as follows:

6.1  **Standard count**

6.1.1  Remove the nuclear gauge and reference block from the transport case and place the reference block on the surface of the particular asphalt mix under test (Note 11.7).

6.1.2  Take a standard count in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a)  the nuclear gauge is correctly located on the reference block

b)  the source rod handle is correctly located in the shielded position, and
c) the density standard count value is recorded with the test data and, where the functionality exists, stored in the nuclear gauge microprocessor.

6.2 Test parameters
Check or set user definable test parameters in accordance with the appropriate test parameters operating instruction detailed in Section 4: Operating Instructions: Testing – Asphalt of the Nuclear Gauge Testing Manual (Note 11.8).

7 Test site selection and preparation
Determination of test locations and preparation of each test site shall be as follows:

7.1 Use Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Test Method Q050 to determine each test location.

7.2 At a designated test location, use the guideplate or straightedge to define a test site which is flat and free from depressions.

7.3 Sweep all loose material from the test site and sprinkle fine sand on the surface. Move the guideplate or straightedge over the surface until the voids are just filled, ensuring that the sand does not form an added layer. Remove the guideplate or straightedge.

8 Testing
Testing shall be performed as follows:

8.1 Place the nuclear gauge on the prepared test site such that the longitudinal axis of the nuclear gauge is parallel to the direction of rolling.

8.2 Confirm that the nuclear gauge is firmly seated without rocking (Note 11.9). Move the source rod to the backscatter (BS) position.

8.3 Take a 1-minute count in accordance with the appropriate measurement operating instruction detailed in Section 4: Operating Instructions: Testing – Asphalt of the Nuclear Gauge Testing Manual. Record the wet density and the density count.

8.4 Rotate the nuclear gauge through 180° ensuring that the test site is not disturbed. Repeat Steps 8.2 to 8.3 and then move the source rod to the shielded position (Note 11.10).

8.5 Compare the wet density values from the two orientations. If the difference exceeds 0.075 t/m³, examine and further prepare the test site as necessary and repeat Steps 8.1 to 8.4.

8.6 If the wet density difference again exceeds 0.075 t/m³, abandon the test site and select a new site immediately adjacent.

9 Calculations
Calculations shall be as follows:

9.1 Determine the compacted density for the test site to the nearest 0.001 t/m³ by averaging the wet density values obtained at the 0° and 180° orientations.
9.2 Where the asphalt density bias has not been applied via the nuclear gauge microprocessor, adjust the compacted density calculated in Step 9.1 as follows:

\[ D_C = \rho_G + B_p \]

where

- \( D_C \) = compacted density (t/m³)
- \( \rho_G \) = average nuclear gauge wet density (t/m³)
- \( B_p \) = asphalt density bias (t/m³)

10 Reporting

The following shall be reported:

a) compacted density to the nearest 0.001 t/m³
b) date tested, test mode, lot number, test site number, and chainage and offset
c) source and type of the asphalt together with the mix code number and nominal layer depth
d) for thin-layer gauges (such as Troxler 4640B) the gauge layer thickness setting to the nearest 1 mm
e) report number for the asphalt density bias and, in the case of an amended bias, the date and report number for the previous report, and
f) the number of this test method, that is N04.

11 Notes on method

11.1 Recalibrate the nuclear gauge following any major repair or component replacement.

11.2 A location is to be selected which is at least 2 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

11.3 A record is to be kept for each gauge to record operational check data (standard count check and gauge function check) and the date of measurement. For nuclear gauges with two detection systems (for example, the nuclear thin-layer density gauge), record the check data for each system separately.

11.4 Where the previous four standard counts have not been taken within the previous five weeks of the current date or the nuclear gauge has been moved to a new operating location and has a new designated test location, it may be necessary to take four new standard counts as detailed in Steps 5.1.1 to 5.1.2.

11.5 It is expected that a standard count value will lie outside the range \( L_\rho \) to \( U_\rho \) about once in every 20 standard count checks. To have consecutive values outside this range is expected only once in 400 standard count checks. However, as the return of the gauge for checking and possible repair can be expensive and disruptive, it is acceptable to perform a gauge function check as detailed in Subsection 5.2. If the gauge is not verified as operating normally, remove the nuclear gauge from service and have it repaired by a licensed service agent.

11.6 Where an accepted form of statistical analysis is performed by the microprocessor, it is not necessary to record individual count values. Only the density ratio value needs to be recorded and Steps 5.2.3 and 5.2.4 may then be omitted.
11.7 Where the nuclear gauge is to be used within 2 m of a large object or in a trench, take a separate standard count at each test site.

11.8 The scope of user definable test parameters is dependent on the make and model of nuclear gauge. Such parameters include:

a) counting time, units and measurement mode
b) maximum density
c) asphalt density bias, and
d) for thin-layer gauges (such as Troxler 4640B) the gauge layer thickness setting.

11.9 If the nuclear gauge cannot be firmly seated, prepare a new test site immediately adjacent to the original site.

11.10 The test area is formed by a single rectangle being at least the size of the guide plate with the source rod being over the surface of the asphalt at each end of the test area.

Position A is the source rod location for 0° measurement and position B is the source rod location for 180° measurement.

### Table 1 – Nuclear gauge prescale factors

<table>
<thead>
<tr>
<th>Nuclear gauge make/model</th>
<th>Prescale factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>1</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>8</td>
</tr>
<tr>
<td>Troxler/except Models 3450 and 4640B</td>
<td>16</td>
</tr>
<tr>
<td>Troxler/Models 3450 and 4640B</td>
<td>8</td>
</tr>
<tr>
<td>Humboldt/All</td>
<td>16</td>
</tr>
<tr>
<td>InstroTek/Xplorer series</td>
<td>16</td>
</tr>
</tbody>
</table>

### Table 2 – Gauge function check – density ratio limits

<table>
<thead>
<tr>
<th>Nuclear gauge make/model</th>
<th>Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>0.75</td>
<td>1.25</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>Troxler/except Models 3450 and 4640B</td>
<td>0.17</td>
<td>0.33</td>
</tr>
<tr>
<td>Troxler/Model 3450</td>
<td>0.225</td>
<td>0.465</td>
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<tr>
<td>Troxler/Model 4640B</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>Humboldt/All</td>
<td>0.60</td>
<td>1.40</td>
</tr>
<tr>
<td>InstroTek/All</td>
<td>0.18</td>
<td>0.35</td>
</tr>
</tbody>
</table>
**Test Method N05: Asphalt density bias**

1 **Source**
This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 **Scope**
This method sets out the procedure for the determination of the asphalt density bias associated with the measurement of compacted density of asphalt using a nuclear gauge. The asphalt density bias represents the average density difference between nuclear gauge wet density and core compacted density for a particular nuclear gauge, asphalt mix and layer thickness. Differences between nuclear gauge wet density and core compacted density are due to differences in the material sampled by both tests and the effect of chemical composition and test site characteristics (for example, density gradients, surface condition, homogeneity) on nuclear gauge results.

Included in the method is a procedure for monitoring the applicability of an existing asphalt density bias and providing ongoing adjustment of the bias to reflect subtle changes in asphalt mix composition/site conditions.

3 **Procedure**
The procedure shall be as follows:

3.1 Select at least 10 test sites within the lot under consideration using Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Test Method Q050 (Note 7.1). Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge wet density as detailed in Test Method N04, except that no asphalt density bias is applied. This wet density is referred to as the standard blocks wet density. For thin-layer gauges, the gauge layer thickness should be set to the nominal thickness of the layer. Record the measured density counts and wet density values to the nearest 0.001 t/m³, for both the 0º and 180º orientations (Note 7.2).

3.2.2 Obtain a 150 mm diameter core sample centrally within the site in accordance with Test Method AS 2891.1.2.

3.2.3 Measure the compacted density of the core sample in accordance with Test Method Q306B or Q306C as appropriate (Note 7.3).

4 **Calculations**
Calculations shall be as follows:

4.1 **Field test data**
Determine the density count and standard blocks wet density for each site by averaging the corresponding measurements for the 0º and 180º orientations (Note 7.2).

4.2 **Data validation**
Validate the density count, density standard count and standard blocks wet density data as follows (Note 7.4):
4.2.1 Calculate the density count ratio for each site to four significant figures as follows:

\[ CR_\rho = \frac{C_\rho}{SC_\rho} \]

where

- \( CR_\rho \) = density count ratio
- \( C_\rho \) = density count
- \( SC_\rho \) = density standard count

4.2.2 Plot the standard blocks wet density against the corresponding density count ratio using the data from all test sites (Note 7.5).

4.2.3 If any data pair does not lie on the linear plot, reject the standard blocks and core compacted density wet density data for this test site.

4.3 Data acceptance

4.3.1 Calculate the average standard blocks wet density and average core compacted density for all remaining test sites.

4.3.2 Calculate the density standard error as follows:

\[ SE_\rho = \sqrt{\frac{\sum (D_C - \rho_G - \overline{D}_C + \overline{\rho}_G)^2}{n-2}} \]

where

- \( SE_\rho \) = density standard error (t/m³)
- \( D_C \) = core compacted density at each test site (t/m³)
- \( \rho_G \) = standard blocks wet density at each test site (t/m³)
- \( \overline{D}_C \) = average core compacted density for the test sites (t/m³)
- \( \overline{\rho}_G \) = average standard blocks wet density for the test sites (t/m³)
- \( n \) = number of test sites

4.3.3 If the density standard error does not exceed 0.025 t/m³, accept the data and calculate the asphalt density bias as detailed in Subsection 4.4.

4.3.4 If the density standard error exceeds 0.025 t/m³, perform the following:

a) For each density data pair (core compacted density and standard blocks wet density), calculate the density error as follows:

\[ E_\rho = \left( (D_C - \rho_G) - (\overline{D}_C - \overline{\rho}_G) \right) \]

where

- \( E_\rho \) = density error (t/m³)
- \( D_C \) = core compacted density at each test site (t/m³)
- \( \rho_G \) = standard blocks wet density at each test site (t/m³)
Test Method N05: Asphalt density bias

\[
\bar{D}_C = \frac{\sum D_C}{n} = \text{average core compacted density for the test sites (t/m}^3\text{)}
\]

\[
\bar{\rho}_G = \frac{\sum \rho_G}{n} = \text{average standard blocks wet density for the test sites (t/m}^3\text{)}
\]

b) Eliminate the density data pair (core compacted density and standard blocks wet density) with the largest density error.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. If data from more than 20% of test sites are eliminated, reject all test data and repeat the complete procedure.

ii. If all test data are again rejected, it is not appropriate to calculate a single asphalt density bias for the material.

4.4 Asphalt density bias

Calculate the asphalt density bias using accepted data to the nearest 0.001 t/m³ as follows:

\[
B_\rho = \bar{D}_C - \bar{\rho}_G
\]

where

- \(B_\rho\) = asphalt density bias (t/m³)
- \(\bar{D}_C\) = average core compacted density for the test sites (t/m³)
- \(\bar{\rho}_G\) = average standard blocks wet density for the test sites (t/m³)

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the asphalt density bias by performing three additional nuclear gauge wet density and core compacted density tests following the compaction of 10,000 tonnes of material. Select the three test sites from within the lot that contains the last of the 10,000 tonnes and perform testing as detailed in Section 3.

5.2 Determine and validate the nuclear gauge density count and standard blocks wet density data as detailed in Steps 4.1 to 4.2.3.

5.3 Add the new density data pairs to the previously accepted data while removing three existing and consecutive density data pairs commencing at the lowest test site number (Note 7.6).

5.4 Analyse the revised density data for acceptance as detailed in Subsection 4.3, except that no more than one of the new density data pairs may be eliminated.

5.5 Calculate an amended asphalt density bias for the accepted data as detailed in Subsection 4.4.

6 Reporting

The following shall be reported:

a) asphalt density bias to the nearest 0.001 t/m³

b) source and type of the asphalt together with the mix code number and nominal layer depth
c) a tabulation containing the standard blocks wet density and core compacted density data used to determine the bias (including any eliminated data), together with the date tested, lot number, test site number, and chainage and offset

d) the date the bias was calculated and, in the case of an amended asphalt density bias, the report number and date for the previous report, and

e) for thin-layer gauges (such as Troxler 4640B) the gauge layer thickness setting to the nearest 1 mm.

7 Notes on method

7.1 In order to determine an asphalt density bias which is representative of the lot, distribute sampling locations throughout the lot.

7.2 The test area is formed by a single rectangle being at least the size of the guide plate with the source rod being over the surface of the asphalt at each end of the test area.

Position A is the source rod location for 0º measurement and position B is the source rod location for 180º measurement.

7.3 For stone mastic asphalt and open graded asphalt, determine the core sample compacted density in accordance with Test Method Q306C. For dense graded asphalt, the core sample may be tested in accordance with Test Method Q306B rather than Test Method Q306C, provided that its air void content is not less than the minimum specified level. Use the same compacted density method for both the bias determination and bias checks.

7.4 For thin-layer gauges with two detection systems, validate the density system 1 data (that is density count, density standard count and the standards blocks wet density) as detailed in Steps 4.2.1 to 4.2.4. Then validate the density system 2 data (that is density count, density standard count and the standards blocks wet density) as detailed in Steps 4.2.1 to 4.2.4.

7.5 The relationship between nuclear gauge wet density and density count ratio is essentially linear over the expected density range within a lot.

7.6 Where there are only eight existing data points, remove only two so that nine data points are available for analysis.
Test Method N06: Compacted density of concrete

1 Source

This method is based on ASTM C1040: Standard test method for in-place density of unhardened and hardened concrete, including roller compacted concrete, by nuclear methods. It varies from this method by only testing hardened concrete, using only the backscatter mode and incorporating practices from the Nuclear Gauge Testing Manual into the method.

2 Scope

This method sets out the procedure for the determination of the compacted density of hardened concrete using a nuclear gauge. The method is based on the backscatter mode of measurement and records the wet density output from the nuclear gauge as the compacted density of the concrete.

An adjustment is made to the standard blocks wet density calibration as determined from comparative nuclear gauge wet density and core density results.

3 Apparatus

The following apparatus is required:

3.1 Nuclear gauge of an approved make and model as listed in Section 1 of the Nuclear Gauge Testing Manual and with a calibration density uncertainty of less than 0.08 t/m³.

3.2 Reference block, as supplied by the manufacturer with the nuclear gauge and traceable to the nuclear gauge.

3.3 Guideplate or straightedge.

3.3.1 Guideplate, a flat metal template at least the same size as the base of the nuclear gauge.

3.3.2 Straightedge, a steel straightedge about 300 mm long and 5 mm thick.

3.4 Dry fine sand passing a 0.600 mm test sieve.

4 Calibration and biasing

Calibration and biasing shall be performed as follows:

4.1 Standard blocks calibration

Calibrate the nuclear gauge on standard blocks at least once every two years for density measurement as detailed in the relevant Australian Standard as follows (Note 11.1):

- Nuclear moisture-density gauge (backscatter) AS 2891.14.4

4.2 Concrete density bias

4.2.1 Determine a density bias for the particular concrete mix and nuclear gauge (backscatter) in accordance with Test Method N07. This bias is to be re-determined whenever there is a change to the mix design and is to be checked whenever there is a change in site conditions (for example, surface roughness, nominal layer thickness, composition of underlying layer, density of underlying layer).

4.2.2 In addition to the requirements of Step 4.2.1, check any applied density bias in accordance with Test Method N07 as follows:

a) following the compaction of every 10,000 tonnes of material (such that the check is within the lot that contains the last of the 10,000 tonnes), and
5 Operational checks

To ensure that the nuclear gauge is operating normally, checks are to be undertaken routinely or following repair as follows:

5.1 Standard count check (frequency: each day of use)

5.1.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.2).

5.1.2 Take a standard count for each density detection system in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block
b) the source rod handle is correctly located in the shielded position, and
c) the density standard count values are recorded (Note 11.3).

5.1.3 Calculate the average of the previous four recorded and accepted density standard counts (Note 11.4).

5.1.4 Calculate the density limits for each density detection system as follows and record the limits (Note 11.3):

\[
L_\rho = \overline{SC} - 2\sqrt{\frac{SC}{PS}}
\]
\[
U_\rho = \overline{SC} + 2\sqrt{\frac{SC}{PS}}
\]

where \( \overline{SC} \) = average density standard count (DS)
\( L_\rho \) = lower limit for density
\( U_\rho \) = upper limit for density
\( PS \) = nuclear gauge prescale factor (Refer to Table 1)

5.1.5 If the recorded standard count value for each system lies within the range \( L_\rho \) to \( U_\rho \), the density standard count is accepted and the nuclear gauge may be used for testing.

5.1.6 If either recorded standard count value lies outside the range \( L_\rho \) to \( U_\rho \), repeat Steps 5.1.2 to 5.1.5. If either standard count is again outside the range, remove the nuclear gauge from service and have it repaired by a licensed service agent (Notes 11.4 and 11.5).

5.2 Gauge function check – statistical performance (frequency: monthly)

5.2.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location (Note 11.2).

5.2.2 Take at least 16 density counts for each density detection system in accordance with the appropriate statistical count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block
b) the source rod handle is correctly located in the shielded position, and
c) the density count values are recorded (Notes 11.3 and 11.6).

5.2.3 Calculate the mean and standard deviation of the density counts.

5.2.4 Calculate the density ratio for each density detection system as follows and record the value (Note 11.3):

$$\rho_r = \frac{s}{\sqrt{C_p}}$$

where

- $\rho_r$ = density ratio
- $s$ = standard deviation of the density counts
- $C_p$ = mean density count

5.2.5 If the density ratio for each system lies within the limits given in Table 2, the nuclear gauge is verified to be operating normally and may be used for testing.

5.2.6 If any density ratio lies outside the relevant limits given in Table 2, repeat Steps 5.2.2 to 5.2.5. If any ratio is again outside the limits, remove the nuclear gauge from service and have it repaired by a licensed service agent.

5.3 Density system consistency check (frequency: monthly)

Perform a density system consistency check in accordance with Section 2, Subsection 1.2 of the Nuclear Gauge Testing Manual.

6 Configuration

On each day of use, configure the nuclear gauge before testing by undertaking a standard count and setting or checking test parameters appropriate to the concrete mix design as follows:

6.1 Standard count

6.1.1 Remove the nuclear gauge and reference block from the transport case and place the reference block on the surface of the particular concrete mix under test (Note 11.7).

6.1.2 Take a standard count in accordance with the appropriate standard count operating instruction detailed in Section 4: Operating Instructions: Operational Checks of the Nuclear Gauge Testing Manual and ensure the following:

a) the nuclear gauge is correctly located on the reference block
b) the source rod handle is correctly located in the shielded position, and
c) the density standard count value is recorded with the test data and, where the functionality exists, stored in the nuclear gauge microprocessor.

6.2 Test parameters

Check or set user definable test parameters in accordance with the appropriate test parameters operating instruction detailed in Section 4: Operating Instructions: Testing – Asphalt of the Nuclear Gauge Testing Manual (Note 11.8).
7 Test site selection and preparation

Determination of test locations and preparation of each test site shall be as follows:

7.1 Use Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Test Method Q050 to determine each test location. Test locations will be chosen to exclude joints, edges and, where applicable, steel reinforcement or tie bars (located with a metal detector or similarly appropriate device) (Note 11.9).

7.2 At a designated test location, use the guideplate or straightedge to define a test site which is flat and free from depressions.

7.3 Sweep all loose material from the test site and sprinkle fine sand on the surface. Move the guideplate or straightedge over the surface until the voids are just filled, ensuring that the sand does not form an added layer. Remove the guideplate or straightedge.

8 Testing

Testing shall be performed as follows:

8.1 Place the nuclear gauge on the prepared test site such that the longitudinal axis of the nuclear gauge is parallel to the direction of paving.

8.2 Confirm that the nuclear gauge is firmly seated without rocking (Note 11.10). Move the source rod to the backscatter (BS) position.

8.3 Take a 1-minute count in accordance with the appropriate measurement operating instruction detailed in Section 4: Operating Instructions: Testing – Asphalt of the Nuclear Gauge Testing Manual. Record the wet density and the density count.

8.4 Rotate the nuclear gauge through 180°, ensuring that the test site is not disturbed. Repeat Steps 8.2 to 8.3, and then move the source rod to the shielded position (Note 11.11).

8.5 Compare the wet density values from the two orientations. If the difference exceeds 0.075 t/m³, examine and further prepare the test site as necessary and repeat Steps 8.1 to 8.4.

8.6 If the wet density difference again exceeds 0.075 t/m³, abandon the test site and select a new site immediately adjacent.

9 Calculations

Calculations shall be as follows:

9.1 Determine the compacted density for the test site to the nearest 0.001 t/m³ by averaging the wet density values obtained at the 0° and 180° orientations.

9.2 Where the concrete density bias has not been applied via the nuclear gauge microprocessor, adjust the compacted density calculated in Step 9.1 as follows:

\[ D_c = \rho_G + B_p \]

where

- \( D_c \) = compacted density (t/m³)
- \( \rho_G \) = average nuclear gauge wet density (t/m³)
- \( B_p \) = concrete density bias (t/m³)
10 Reporting

The following shall be reported:

a) compacted density to the nearest 0.001 t/m³

b) date tested, test mode, lot number, test site number, and chainage and offset

c) source and type of the concrete together with the mix code number and nominal layer depth

d) report number for the concrete density bias, and

e) report number for the asphalt density bias and, in the case of an amended bias, the date and report number for the previous report.

11 Notes on method

11.1 Re-calibrate the nuclear gauge following any major repair or component replacement.

11.2 A location is to be selected which is at least 2 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

11.3 A record is to be kept for each gauge to record operational check data (standard count check and gauge function check) and the date of measurement.

11.4 Where the previous four standard counts have not been taken within the previous five weeks of the current date or the nuclear gauge has been moved to a new operating location and has a new designated test location, it may be necessary to take four new standard counts as detailed in Steps 5.1.1 to 5.1.2.

11.5 It is expected that a standard count value will lie outside the range $L_{\rho}$ to $U_{\rho}$ about once in every 20 standard count checks. To have consecutive values outside this range is expected only once in 400 standard count checks. However, as the return of the gauge for checking and possible repair can be expensive and disruptive, it is acceptable to perform a gauge function check as detailed in Subsection 5.2. If the gauge is not verified as operating normally, remove the nuclear gauge from service and have it repaired by a licensed service agent.

11.6 Where an accepted form of statistical analysis is performed by the microprocessor, it is not necessary to record individual count values. Only the density ratio value needs to be recorded and Steps 5.2.3 and 5.2.4 may then be omitted.

11.7 Where the nuclear gauge is to be used within 2 m of a large object, take a separate standard count at each test site.

11.8 The scope of user definable test parameters is dependent on the make and model of nuclear gauge. Such parameters include:

a) counting time, units and measurement mode

b) maximum density, and

c) concrete density bias.

11.9 An edge or joint should be at least 250 mm from any point on the source/detector axis. Reinforcing steel with less than 75 mm cover should not lie directly under the source/detector axis.

11.10 If the nuclear gauge cannot be firmly seated, prepare a new test site immediately adjacent to the original site.
11.11 The test area is formed by a single rectangle being at least the size of the guide plate with the source rod being over the surface of the concrete at each end of the test area.

Position A is the source rod location for \(0^\circ\) measurement and Position B is the source rod location for \(180^\circ\) measurement.

**Table 1 – Standard count prescale factors**

<table>
<thead>
<tr>
<th>Nuclear gauge make/model</th>
<th>Prescale factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>1</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>8</td>
</tr>
<tr>
<td>Troxler/except Model 3450 and 4640B</td>
<td>16</td>
</tr>
<tr>
<td>Troxler/Model 3450 and 4640B</td>
<td>8</td>
</tr>
<tr>
<td>Humboldt/All</td>
<td>16</td>
</tr>
<tr>
<td>InstroTek/Xplorer series</td>
<td>16</td>
</tr>
</tbody>
</table>

**Table 2 – Gauge function check – density ratio limits**

<table>
<thead>
<tr>
<th>Nuclear gauge make/model</th>
<th>Lower limit</th>
<th>Upper limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPN/except Elite series</td>
<td>0.75</td>
<td>1.25</td>
</tr>
<tr>
<td>CPN/Elite series</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>Troxler, except Models 3450 and 4640B</td>
<td>0.17</td>
<td>0.33</td>
</tr>
<tr>
<td>Troxler Model 3450</td>
<td>0.225</td>
<td>0.465</td>
</tr>
<tr>
<td>Troxler Model 4640B</td>
<td>0.25</td>
<td>0.45</td>
</tr>
<tr>
<td>Humboldt</td>
<td>0.60</td>
<td>1.40</td>
</tr>
<tr>
<td>InstroTek</td>
<td>0.18</td>
<td>0.35</td>
</tr>
</tbody>
</table>
Test Method N07: Concrete density bias

1 Source
This method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope
This method sets out the procedure for the determination of the concrete density bias associated with the measurement of compacted density of concrete using a nuclear gauge. The concrete density bias represents the average density difference between nuclear gauge wet density and core density for a particular nuclear gauge, concrete mix and layer thickness. Differences between nuclear gauge wet density and core density are due to differences in the material sampled by both tests and the effect of chemical composition and test site characteristics (for example, density gradients, surface condition, homogeneity) on nuclear gauge results.

Included in the method is a procedure for monitoring the applicability of an existing concrete density bias and providing ongoing adjustment of the bias to reflect subtle changes in concrete mix composition.

3 Procedure
The procedure shall be as follows:

3.1 Select at least 10 test sites within the lot under consideration using Random Stratified Sampling: Selection of Location – Available Area (unless otherwise specified) as detailed in Test Method Q050 (Note 7.1). Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge wet density as detailed in Test Method N06, except that no concrete density bias is applied. This wet density is referred to as the standard blocks wet density. Record the measured density counts and wet density values to the nearest 0.001 t/m³ for both the 0º and 180º orientations (Note 7.2).

3.2.2 Obtain a core sample centrally within the site in accordance with Test Method AS 1012.14.

3.2.3 Measure the density of the core sample in accordance with Test Method Q473.

4 Calculations
Calculations shall be as follows:

4.1 Field test data
Determine the density count and standard blocks wet density for each site by averaging the corresponding measurements for the 0º and 180º orientations (Note 7.2).

4.2 Data validation
Validate the density count, density standard count and standard blocks wet density data as follows:

4.2.1 Calculate the density count ratio for each site to four significant figures as follows:

\[ CR_\rho = \frac{C_\rho}{SC_\rho} \]
Test Method N07: Concrete density bias

where

\[ CR_p = \text{density count ratio} \]
\[ C_p = \text{density count} \]
\[ SC_p = \text{density standard count} \]

4.2.2 Plot the standard blocks wet density against the corresponding density count ratio using the data from all test sites (Note 7.3).

4.2.3 If any data pair does not lie on the linear plot, reject the standard blocks and core density wet density data for this test site.

4.3 Data acceptance

4.3.1 Calculate the average standard blocks wet density and average core density for all remaining test sites.

4.3.2 Calculate the density standard error as follows:

\[
SE_p = \sqrt{\frac{\sum (C_p - G_p + C_p - G_p)^2}{n-2}}
\]

where

\[ SE_p = \text{density standard error (t/m}^3\text{)} \]
\[ C_p = \text{core density at each test site (t/m}^3\text{)} \]
\[ G_p = \text{standard blocks wet density at each test site (t/m}^3\text{)} \]
\[ C_p = \text{average core density for the test sites (t/m}^3\text{)} \]
\[ G_p = \text{average standard blocks wet density for the test sites (t/m}^3\text{)} \]
\[ n = \text{number of test sites} \]

4.3.3 If the density standard error does not exceed 0.035 t/m³, accept the data and calculate the concrete density bias as detailed in Subsection 4.4.

4.3.4 If the density standard error exceeds 0.035 t/m³, perform the following:

a) For each density data pair (core density and standard blocks wet density), calculate the density error as follows:

\[
E_p = \left| (C_p - G_p - C_p + G_p) \right|
\]

where

\[ E_p = \text{density error (t/m}^3\text{)} \]
\[ C_p = \text{core density at each test site (t/m}^3\text{)} \]
\[ G_p = \text{standard blocks wet density at each test site (t/m}^3\text{)} \]
\[ C_p = \text{average core density for the test sites (t/m}^3\text{)} \]
\[ G_p = \text{average standard blocks wet density for the test sites (t/m}^3\text{)} \]

b) Eliminate the density data pair (core density and standard blocks wet density) with the largest density error.
c) If data from three or more test sites are eliminated, reject all test data and repeat the complete procedure.

d) If all test data are again rejected, it is not appropriate to calculate a single concrete density bias for the material.

e) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4.

4.4 Concrete density bias

Calculate the concrete density bias using accepted data to the nearest 0.001 t/m$^3$ as follows:

$$B_p = \bar{\rho}_C - \bar{\rho}_G$$

where

- $B_p$ = concrete density bias (t/m$^3$)
- $\bar{\rho}_C$ = average core density for the test sites (t/m$^3$)
- $\bar{\rho}_G$ = average standard blocks wet density for the test sites (t/m$^3$)

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the concrete density bias by performing three additional nuclear gauge wet density and core density tests following the compaction of 10,000 tonnes of material. Select the three test sites from within the lot that contains the last of the 10,000 tonnes and perform testing as detailed in Section 3.

5.2 Determine and validate the nuclear gauge density count and standard blocks wet density data as detailed in Steps 4.1 to 4.2.3.

5.3 Add the new density data pairs to the previously accepted data while removing three existing and consecutive density data pairs commencing at the lowest test site number (Note 7.4).

5.4 Analyse the revised density data for acceptance as detailed in Subsection 4.3, except that no more than one of the new density data pairs may be eliminated.

5.5 Calculate an amended concrete density bias for the accepted data as detailed in Subsection 4.4.

6 Reporting

The following shall be reported:

6.1 Concrete density bias to the nearest 0.001 t/m$^3$.

6.2 Source and type of the concrete together with the mix code number and nominal layer depth.

6.3 A tabulation containing the standard blocks wet density and core density data used to determine the bias (including any eliminated data), together with the date tested, lot number, test site number, and chainage and offset.

6.4 The date the bias was calculated and, in the case of an amended concrete density bias, the report number and date for the previous report.

7 Notes on method

7.1 In order to determine a concrete density bias that is representative of the lot, distribute sampling locations throughout the lot.
7.2 The test area is formed by a single rectangle being at least the size of the guide plate with the source rod being over the surface of the concrete at each end of the test area.

Position A is the source rod location for 0° measurement and position B is the source rod location for 180° measurement.

7.3 The relationship between nuclear gauge wet density and density count ratio is essentially linear over the expected density range within a lot.

7.4 Where there are only eight existing data points, remove only two so that nine data points are available for analysis.