TECHNICAL NOTE

Surveillance of Field Density Testing by Nuclear Density Gauge 106

Nuclear density gauges are used to determine compaction acceptance of earthworks, granular pavement materials, and asphalt. Aspects for surveillance of the field test include gauge operation, lot testing, site selection, conduct of the field test and sampling for laboratory work.

Introduction

This Technical Note provides staff undertaking general surveillance with guidance on the general aspects of field density testing as applied to earthworks and pavement materials placed and compacted for road applications in accordance to VicRoads specifications.

Compliance with the specified compaction and density requirements is a key acceptance criterion for VicRoads earthworks and pavements specifications. Nuclear density gauges (NDG) are often used for testing on VicRoads works for compaction acceptance. The NDG soil meter (Figure 1) is used on earthworks and granular pavement materials, and the NDG asphalt thin-layer gauge (Figure 2) is used for asphalt materials.

A checklist (Annexure A) is included to assist the general surveillance of field density testing when the NDG is used.

Where surveillance of the field density testing reveals non-conformance, specialist surveillance personnel may need to review the detail of practices associated with the application of the test method, both in the field and in the laboratory.

The technical note is restricted to field density testing using the NDG, although other methods involving volume or sand replacement methods can be used for field density testing. The laboratory testing and the preparation of test reports associated with the field test are not discussed in this technical note. This technical note is not applicable to the testing of compaction of rock fill or concrete.

Compaction and Density Ratio

Road making techniques need to achieve adequate compaction of placed material during construction to prevent in-service problems such as densification, settlement, rutting etc and to inhibit movement of water in and out of the material. The level of compaction (the density ratio) is usually determined by field density testing using a nuclear density gauge (NDG) and laboratory-based reference density testing on samples of the material.

The key density testing requirements for the assessment of field compaction are:

- field density measurements by NDG,
- sampling of material for laboratory-based testing,
- laboratory testing using calibrated apparatus to obtain the reference density; and production of results and test reports.

Figure 1 NDG Soil Meter – Setup for standard counts, seated on reference block. Note position of block handle to keypad. Gauge handle at top of index rod.

Figure 2 NDG Asphalt thin-layer gauge – Setup for standard counts. Note position of reference plate handle to keypad. Gauge handle at top of index rod.

Compaction assessment of road making materials is based on Characteristic Density Ratio (CDR), as determined in VicRoads Test Method RC 316.00, using a number of test sites per lot. The acceptance limits for CDR for different road making materials are specified in VicRoads Standard Specification Sections for Roadworks and Bridgeworks. These limits are based on the type of material and its location in the pavement, earthworks or subgrade layers, as appropriate.

Test Rolling

Test rolling (proof rolling) is used in earthworks and pavement construction to verify both uniform behaviour and stability of the layer before the next layer is placed and compacted. Test rolling is complimentary to assessment of compaction by field density testing. For more information about test rolling, refer to VicRoads Section 173.

Test Methods

VicRoads permits the use of the nuclear density gauge for the determination of field density. Reference density measurements using laboratory compaction methods, with standard or modified compaction effort, are carried out on material sampled from the compacted layer at the site and within the lot.

The test methods are detailed in VicRoads and Australian Standard test methods, with specific application requirements detailed in VicRoads Code of Practice 500.05. Laboratories carrying out the testing must be accredited for each test that is involved by the National Association of Testing Laboratories, Australia (NATA). The acceptance of work using density and compaction criteria is based on the test being performed in accordance with the relevant test methods.

Lot Testing

Roadmaking materials for earthworks and pavements are tested in lots for acceptance. A lot is based on the lesser of one day's production or an area limit, and must only contain an area of work that is defined as a single layer, batch or area of like work which has been constructed or produced under essentially uniform conditions and is essentially homogeneous with respect to material and appearance (Refer VicRoads Section 173). For example, a test lot for earthworks and pavement materials may be broadly defined as those areas of work that are substantially alike for:

- material properties and source;
- general appearance (for example, colour; surface texture);
- moisture condition during compaction;
- compaction technique, including number of passes;
- layer thickness; and
- state of underlying materials.

Discrete portions of a lot which are non-homogeneous with respect to material and appearance are to be excluded from the lot, as detailed in VicRoads Section 173. Increasing the number of lots within a specified area will increase the cost of compliance testing but does provide an equitable approach to the assessment of the construction work. Maximum lot sizes or areas are detailed in the specification for each type of material, for example, for unbound flexible pavement constructed to VicRoads Section 304, a maximum lot area of 4000 m^2 applies.

Each lot must be clearly identified on-site by reference points.

Once the contractor engages the testing officer to undertake field density testing, the contractor has declared the field compaction process is complete and the test lot is ready. The field testing should continue through to completion whether or not the lot is perceived during testing to become nonconforming. If the density for the lot is nonconforming (either from test results or from abandonment of testing), the compaction process as detailed by the compaction routine, and any allowance for reduced frequency of testing, must be reviewed by the contractor.

Test Site Selection

The validity of lot testing depends on and requires the random selection of test site locations. At the start of the selection process, every point in the lot must have an equal chance of being selected. Test site selection is to be in accordance with VicRoads Test Method RC 316.10. A blank worksheet and a worked example for using RC 316.10 are provided in Annexure B.

For test lots, six test sites must be selected, tested and assessed as specified. In the case of small lots, where the lot area is less than 500 m^2, three test sites may be selected, tested and assessed using the mean plus 2% criteria as specified in VicRoads Section 173.04(d). Alternatively, contractors may elect to test lots of area less than 500 m^2, with six test sites and using the full characteristic density ratio assessment process.

The gauge may be re-located or shifted within 0.5 m of the selected test site location if the surface at the original selected site is found to be unsuitable or if there are protruding aggregates that may affect the reading.

At the completion of testing, there should be either three or six test holes (not more), at even longitudinal spacing, and test holes should not be on the same transverse offset.

Nuclear Density Gauge Safety

NDG equipment uses radioactive materials which may be hazardous to health unless proper precautions are taken. Nuclear gauges must be used in accordance with the Victorian Radiation Act 2005 and Regulations 2007. The Code of Practice and Safety Guide for Portable Density/ Moisture Gauges Containing Radioactive Sources provides guidance on the safe use of nuclear density gauges. As a guide to site practices, the operator and the gauge must be licensed, personal radiation badges must be worn and monitored, and warning signs and vehicle placards must be used. The NDG operator is aware of these precautions and is responsible for supervision of the testing site. Effective precautions are to keep more than 3 metres from the gauge and to minimize any time close to the gauge.

How does the NDG Work?

The radioactive sources in NDG's are always emitting radiation. When the NDG is not making readings, the source must always be retracted to the "Safe" position, with the source secured inside the tungsten shielding block.

The NDG is schematically shown in Figure 3 (from American Portable Nuclear Gauge Association manual), with the major parts identified.

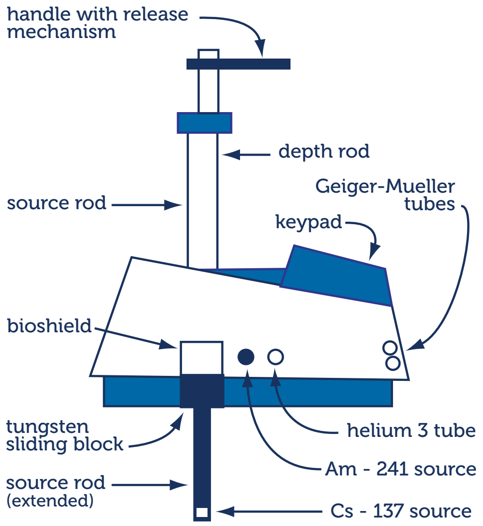

Figure 3 The major parts of an NDG soil meter

Wet density is measured using a Caesium 137 (Cs-137) gamma radiation source, a pea-sized pellet fixed in the bottom of the source rod, and two Geiger-Muller tube gamma detectors at the rear of the gauge. The cesium gamma source is lowered to the desired test depth by releasing the handle. When the test is started, the detectors in the gauge record the count rate of the radiation transmitted directly through the soil layer, displaying wet density readings on the keypad. A more dense material absorbs more gamma radiation, resulting in a lower gamma count reading, which converts to a higher wet density value. The volume of material assessed includes the material between the source and the detectors, but the actual volume is not precisely known (Figure 4, from APNGA Manual).

Moisture Measurement

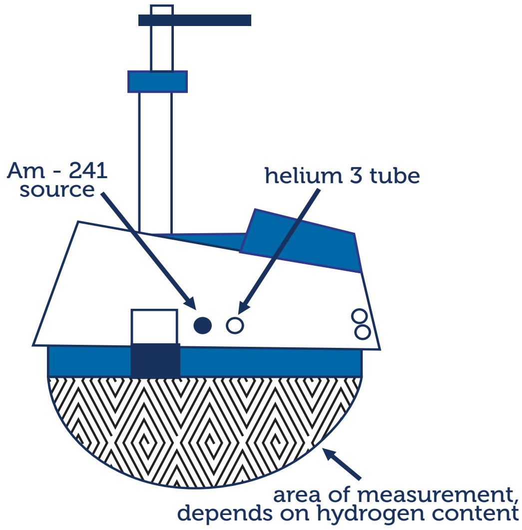

Figure 4 NDG in direct transmission - gamma paths

Moisture content is measured using an Americium-241 /Beryllium (Am-241/Be) neutron radiation source that releases high-energy neutrons. These "fast" neutrons are slowed by interaction with the hydrogen atoms in water molecules. A "cloud" of slow neutrons forms around the gauge, passing through a Helium 3 tube detector. This detects only the count rate of the "slow" neutrons. The neutron source is fixed inside the gauge base, with the detector beside. A wetter material will slow a greater number of neutrons, and also reduce the zone of influence into the material (Figure 5, from APNGA Manual).

Direct Transmission

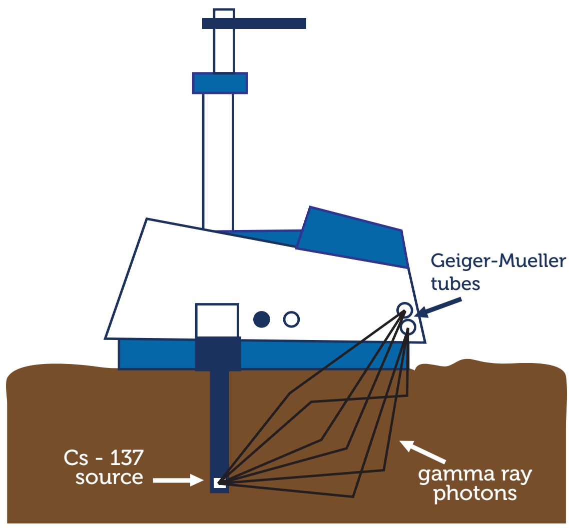

Figure 5 Zone or area of influence for moisture measurement

The NDG asphalt gauge uses the Cesium 137 gamma radiation source and two separate sets of Geiger-Muller tube gamma detectors, at gauge mid-base and at gauge rear. This NDG cannot make moisture measurements.

Radioactive sources decay over time, producing lower raw count levels. The field counts must be standardized by comparison with the "Standard Count", taken using a standard setup as shown in Figures 1 and 2. All calculations and processing of results uses the count ratio, the field count divided by the standard count. This applies to both density and moisture systems.

The radiation systems of the NDG provide indirect measures of wet density and moisture content. The systems (the count ratio response) are calibrated against blocks of known wet density and moisture content, prior to use of the NDG in the field. The maximum calibration interval is two years.

NDG Testing using the Soil Meter

Compaction testing of unbound granular pavement and earthworks material using the NDG soil meter (Figure 6) is carried out to AS 1289.5.8.1. This method can be used on most materials, except when more than 20% of material is retained on the 37.5 mm sieve, to a maximum test depth of 300 mm. The NDG soil meter determines the wet density of the material in direct transmission mode, where gamma radiation passes from the source, at the test depth, straight to the detectors. The NDG can also determine the moisture content of the material.

The key on-site requirements in AS 1289.5.8.1 are:

- The NDG must have a current calibration certificate (maximum calibration interval of two years);
- The site for the NDG must be essentially flat and free of depressions and/or cracks;
- One density standard count and one moisture standard count (taken together as a 4 minute count) should be taken and recorded at the start of each test lot of six sites, on the material being tested;
- The probe access hole, formed by drilling or spiking prior to the test, is 25 mm deeper than the required test depth;
- The probe must be moved longitudinally so that the side of the probe nearest to the density detector is in contact with the side of the access hole (Figure 7);
- The NDG must be firmly seated, without rocking; and
- The field wet density and the density and moisture counts for each test site are recorded.

Specific VicRoads requirements for using the NDG detailed in VicRoads Code of Practice 500.05 are:

- The gauge is to be seated on either fines of the material under test or fine dry sand passing the 0.425 mm sieve (Figure 8). The fines or sand must not form an added layer (Figure 9 and Figure 10);
- The test probe is to be located at the required test depth. For example, a 200 mm layer is to be tested at a probe depth of 175 mm (Figure 6); and
- Two sets of 60 second density and moisture readings are to be obtained at each site with the gauge remaining in the same position for both readings (AS 1289.5.8.1 covers obtaining a single set of readings).

Figure 7 Cross section of NDG showing test probe against detector side of access hole

Figure 6 NDG soil meter on earthworks test site with test probe at test depth of 175 mm

Figure 8 Test site, showing access hole, with sand spread to minimum thickness, after sweeping to remove loose material

Trench Testing

Special requirements apply for testing in trenches, including the testing of culvert backfill (VicRoads CoP 500.05). When testing in trenches, the standard counts must be taken inside the trench at each test site. During testing, the gauge is sited at least 200 mm from the sides, with the long side of the gauge parallel to the trench wall. If the material to be tested is overlying a pipe, the end of the probe should be at least 50 mm above the pipe.

Moisture Content Testing

Oven-dried moisture methods are frequently used as a laboratory-based test to determine the moisture content of granular pavement materials. Material must be sampled from each field test site in the road or in the trench and oven dried in accordance with the relevant test method.

The moisture content of uniform subgrade and pavement material can also be measured using the NDG soils meter and establishing a moisture intercept as described in Appendix B of AS 1289.5.8.1. This is frequently done for high volume crushed rocks to which an optimum moisture content (OMC) and maximum dry density (MDD) can be assigned. Field samples are taken at specified frequencies to establish or validate the assigned values. The presence of some chemicals, such as lime, gypsum, arsenic and cadmium, can influence the NDG moisture readings.

The moisture content of earthworks materials is determined using oven-dried moisture methods on samples taken from the test site in the road.

Figure 9 Fine sand at minimum thickness – not an added layer

Sampling for Laboratory-Based Testing

Correct sampling technique must be followed and a sufficient quantity of material be taken to obtain both reliable moisture content results and, when required, reference maximum or peak density values of MDD and OMC. The sand or natural fines used to seat the gauge must be swept clear of the plan area of the nuclear gauge prior to excavating for a moisture content sample. Sampling requires that all material from a vertical-sided hole (excavated to the depth that the NDG source rod was placed) must be recovered for the oven-dried moisture methods, with the hole permitted to be enlarged in plan to obtain sufficient material for other tests (Figure 11).

An air tight container is required to hold the sample until laboratory testing commences. All samples must be labelled so that they are readily identified to the test site and the intended use of the sample.

The contractor is responsible for re-instating the test hole using material of similar quality to that removed from test holes during testing (VicRoads Section 173.04(f)). The backfill material is to be compacted in the holes in layers with a suitable compaction device and the top of the compacted backfill should match the level of the adjoining surface.

Materials that have assigned values of maximum dry density and optimum moisture content (such as a crushed rock produced from a quality assured quarry process) are not always sampled from each test location and for every test lot. The determination and frequency of monitoring of assigned values is specified in AS 1289.5.4.2.

Figure 10 Fine sand forming an added layer – not to method

Figure 11 Appropriate sampling from the road for moisture content and other laboratory tests

In contrast, earthworks fill materials are not usually assignable for maximum dry density and optimum moisture content, and these materials require sampling to tested depth from each test site within every lot.

Sufficient material should be taken when sampling at each test site to provide for all testing that is required.

Common poor practices regarding sampling from the road (Figure 12) include:

- Excavations not vertically sided;
- Large rock particles discarded from sample, upsetting the oversize correction process for density and moisture ratios;
- Inclusion in samples of significant quantities of sand from gauge seating;
- Samples not adequately sealed against moisture loss, or exposed to sunlight and temperature variations;
- Samples not transported to the laboratory on the same day they were obtained; and
- Poor labelling of samples.

Testing Dry-Back or Pavement

The NDG soil meter is also used for assessing the reduction of moisture content (dry-back) of the uppermost layer of granular pavement materials prior to application of bituminous surfacing (spray seal) using VicRoads Test Method RC316.14. The method relies on the following differences to the normal NDG test:

- The same NDG soil meter being used both for compaction acceptance testing and testing for moisture dry-back;
- Moisture dry-back testing is done with the probe in the test probe backscatter position;
- No access hole in the pavement; and
- Moisture counts only are recorded (Method RC316.14 does not require the wet density counts or readings).

This testing is appropriate for specialist surveillance.

Testing Stabilised or Bound Material

Cement or lime is used in some instances to stabilise in-situ material, or cement treated granular material is imported and placed prior to placement of asphalt. The NDG soil meter is used for assessment of compaction of cement and lime stabilised materials, using the same test method as for unbound material. For testing of this bound material, the probe access hole usually needs to be drilled and the surface of the test probe may become coated with fines containing cement.

NDG Testing of Asphalt

Compaction testing of asphalt is often carried out using the NDG thin-layer asphalt gauge (Figure 2 and Figure 13), to AS 2891.14.2.

The NDG asphalt gauge uses one radioactive source and two density measurement systems, operating in backscatter mode, (Figure 14) where radiation must be scattered or diverted from its original direction to reach the detectors. This method can be used on most asphalt types, except for open graded asphalt. The asphalt gauge

Figure 12 Examples of poor sampling practice. Both photos show sampling not to full layer depth, sides of hole not vertical, significant material (including oversize) not taken in sample

Figure 13 NDG thin-layer asphalt gauge in test mode on an asphalt surface (fine sand spread at minimum thickness)

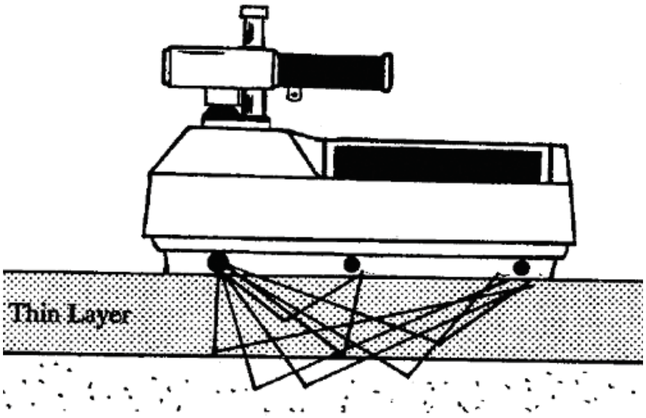

Figure 14 Thin layer NDG – backscatter gamma paths. Cs137 source is at left end of NDG. There are detectors at centre and at right end of gauge.

measures the density of asphalt, when the asphalt layer thickness is in the range of 25 to 100 mm.

The key requirements for AS 2891.14.2 and VicRoads Code of Practice 500.05 to cover on-site processes for the NDG asphalt gauge are similar to those for the soil meter, except that:

- Two separate density standard counts (one for each measurement system) must be taken simultaneously at the start of each lot (Figure 2);
- The long axis of the NDG asphalt gauge is aligned parallel to the direction of rolling;
- There is no probe access hole (reference in the checklist to probe depth does not apply);
- One 4 minute reading of layer density, with two separate density counts recorded, is required at each test site (Figure 13); and
- Density offsets must be determined and applied for each asphalt mix as described in AS 2891.14.2, to adjust the NDG readings for backscatter effects due to aggregate chemistry. Sampling of asphalt by coring is required for establishing or checking density offsets.

Checklist

Annexure A provides a checklist that may assist and be used by surveillance staff to carry out general surveillance of field density testing being carried out on site. The checklist highlights key aspects of site practices and requirements of the test.

References

1. VicRoads Test Method RC 316.00 - *Density Ratio and Moisture Ratio Lot Characteristics.*
2. VicRoads Standard Specification Section 173 – *Examination and Testing of Materials and Work (Roadworks).*
3. VicRoads Code of Practice, RC 500.05 – *Code of Practice for Acceptance of Field Compaction.*
4. VicRoads Standard Specification Section 304 – *Unbound Flexible Pavement Construction*
5. VicRoads Test Method RC 316.10 – *Selection of test sites within a test lot (random stratified sampling method).*
6. Australian Radiation Protection and Nuclear Safety Agency, Radiation Protection Series No. 5 - *Code of Practice and Safety Guide for Portable Density/ Moisture Gauges Containing Radioactive Sources (2004),* *link: http://www.arpansa.gov.au/publications/Codes/ rps5.cfm.*
7. American Portable Nuclear Gauge Association manual, July 2009 http://www.apnga.com/the_manual.pdf
8. AS 1289.5.8.1 (2007) - *Methods of testing soils for engineering purposes - Soil compaction and density tests - Determination of field density and field moisture content of a soil using a nuclear surface moisture-density gauge* - Direct transmission mode, Standards Australia, Sydney, NSW.
9. AS 1289.5.4.2 – *Soil compaction and density tests – Compaction control test – Assignment of maximum dry density and optimum moisture content values,* Standards Australia, Sydney, NSW.
10. VicRoads Test Method RC 316.14 – *Moisture Ratio Determination for Assessment of Dry-Back of Granular Pavement Materials*
11. AS 2891.14.2 (1999) - *Methods of sampling and testing asphalt - Field density tests - Determination of field density of compacted asphalt using a nuclear thin-layer density gauge,* Standards Australia, Sydney, NSW.

Contact Officers

For further information on field density testing, please contact the following officers:

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Technical Note 106 Annexure A:
Field Density Testing Checklist – Nuclear Density Gauge (NDG)

Job	Date
Location	Chainage
Tester	Surveillance Officer
Layer & material	Comments

1. Is the testing company NATA accredited for the nuclear gauge test?
   ☐ **Yes** ☐ **No** ☐ **Action required**

2. Does the gauge operator hold a Victorian licence to use radiation sources and have a personal radiation monitor?
   ☐ **Yes** ☐ **No** ☐ **Action required**

3. Has a "request for testing" been generated?
   ☐ **Yes** ☐ **No** ☐ **Action required**

4. Have the test lot boundaries been clearly defined by the contractor?
   ☐ **Yes** ☐ **No** ☐ **Action required**

5. What is the area of the test lot? ______________________ square metres
   ☐ **< 500m²: three test sites required** ☐ **>500m²: six test sites required**

6. Has the test lot been accepted for compliance with test (proof) rolling, and have any areas been excluded?
   ☐ **Yes** ☐ **No** ☐ **Action required**

7. Has random site selection for the test lot been calculated (to RC 316.10) prior to density testing?
   ☐ **Yes** ☐ **No** ☐ **Action required**

8. Is the surface of the test site essentially flat and free of depressions and cracks?
   ☐ **Yes** ☐ **No** ☐ **Action required**

9. Has dry fine sand or natural fine material been used to seat the NDG, without forming an added layer?
   ☐ **Yes** ☐ **No** ☐ **Action required**

10. Are the test results recorded on the tester's worksheet, and has a NATA endorsed test certificate been provided?
    ☐ **Yes** ☐ **No** ☐ **Action required**

Testing Granular Pavement and Earthworks Material

Using NDG soil meter

11. Has a 4-minute Standard Count for density and moisture for the NDG soil meter, been taken and recorded at the start of each test lot, using the reference block placed on the material being tested?
    ☐ **Yes** ☐ **No** ☐ **Action required**

12. Has the access hole for the NDG test probe been driven or drilled to the correct depth (> 25 mm deeper than test depth) without causing surface ridges or cracks? (Note: no access hole for dry-back test)
    ☐ **Yes** ☐ **No** ☐ **Action required**

13. Has the NDG test probe been located to the correct test depth, within 25 mm of the nominal bottom of the layer?
    ☐ **Yes** ☐ **No** ☐ **Action required**

VicRoads Technical Note 106 Annexure A : Field Density Testing Checklist Nuclear Density Gauge

14. Has the NDG test probe been placed in contact with the detector side of the access hole?
   ☐ **Yes** ☐ **No** ☐ **Action required**

15. Have two 60-second density and moisture counts been taken for each test site and recorded?
   ☐ **Yes** ☐ **No** ☐ **Action required**

16. Has the wet density reading from the NDG been recorded?
   ☐ **Yes** ☐ **No** ☐ **Action required**

17. How many test access holes have been created on the test lot?
   ☐ **Yes** ☐ **No** ☐ **Action required**

18. Is material moisture content being determined from:
   ☐ **Nuclear guage reading using a moisture intercept (Appendix B or AS 1289.5.8.1), or**
   ☐ **Laboratory testing by oven dry determination**

19. Has a sample been taken from the test site by excavating a hole with vertical sides to the depth at which the NDG test probe was located during the test?
   ☐ **Yes** ☐ **No** ☐ **Action required**

20. Has all the material been recovered / sampled from the test site, to the probe depth?
   ☐ **Yes** ☐ **No** ☐ **Action required**

21. Has the sample been placed in a container / plastic bag and sealed adequately to ensure moisture and material is not lost?
   ☐ **Yes** ☐ **No** ☐ **Action required**

22. Have the samples been uniquely identified and this identification clearly marked on the samples?
   ☐ **Yes** ☐ **No** ☐ **Action required**

23. Has the test hole been re-instated with similar material and compacted to the required density and moisture ratio?
   ☐ **Yes** ☐ **No** ☐ **Action required**

Testing Of Asphalt,

Using NDG thin layer gauge

24. Has a 4-minute Standard Count for both density systems of the NDG asphalt gauge, been taken and recorded at the start of each test lot, using the reference plate and spacer placed on the asphalt being tested?
   ☐ **Yes** ☐ **No** ☐ **Action required**

25. Has the long axis of the NDG been placed in the direction of compaction (roller travel)?
   ☐ **Yes** ☐ **No** ☐ **Action required**

26. Has one 4 minute set of density counts (for Systems 1 & 2) been taken for each test site and recorded?
   ☐ **Yes** ☐ **No** ☐ **Action required**

27. Has the layer density reading from the NDG been recorded?
   ☐ **Yes** ☐ **No** ☐ **Action required**

Other observations:

TN 106 - Annexure B1

Test Site Selection to RC 316.10

Date :

Data entry required to green cells & orange cells if manual calculation

Job	
Test Lot description	

Random number R			
Date		Time	
day	**month**	**hour**	**minutes**
Date Time summation =			
Repeat summation =			
Repeat summation =			
Final Sum of digits (N) =			
From Table 1 below, R =			

Table 1

Sum of digits (N)	R (Random number)
1	0.4
2	0.9
3	0.1
4	0.6
5	0.3
6	0.2
7	0.7
8	0.8
9	0.5

Longitudinal position

	Start	Lower value		End	Higher value	
Lot boundaries	Start		m	End		m
Exclude 5 m each end	add	5	m	subtract	5	m
Lot test limits	Start limit		m	End limit		m
Lot length	L =		m	Lot area =		m^2
Approximate lot width			m	6 sites =	Lot test	
Number of test sites	n =			3 sites =	small lot	

Longitudinal distance between sites = d = L / n = m

Distance of first test site from start of lot = Ls = **d** * **R** = m

Chainage of first site = sum of =

lot start + 5 m exclusion + Ls = Site 1 longitudinal position

Transverse position

Width of test lot = m (Constant, unless carriageway width changes)

Longitudinal edge reduction 0.2 m on two sides

Day of month gives below, from Table 2

Datum line reference position (eg centreline, kerb, sawcut line) metres

Site	Calculation	Longitudinal position (m)	Width of lot (m)	less 0.2 m each edge	Number set (Table 2)	Datum	Lateral position (m)
Site 1 #	Start + 5 + Ls						
Site 2	Site 1 + d						
Site 3 #	Site 2 + d						
Site 4	Site 3 + d						
Site 5 #	Site 4 + d						
Site 6	Site 5 + d						

\# Test at odd-numbered sites for Small Lot

Calculation by

Lot Sketch

Table 2 : Number sets for selection of lateral positions
(based on day of month)

Day	Number set					
Number	site 1	Site 2	Site 3	Site 4	Site 5	Site 6
1	0.1	0.6	0.5	0.0	0.8	0.3
2	0.5	0.2	0.4	0.1	0.7	0.3
3	0.7	0.4	0.1	0.8	0.0	1.0
4	0.4	1.0	0.1	0.6	0.8	0.3
5	1.0	0.8	0.1	0.3	0.5	0.0
6	0.5	0.9	0.4	0.1	0.3	0.8
7	0.9	0.8	0.4	0.3	0.6	0.0
8	0.9	0.5	0.6	0.2	0.1	1.0
9	1.0	0.0	0.4	0.5	0.6	0.2
10	0.5	0.8	0.7	0.2	1.0	0.9
11	0.6	0.1	1.0	0.9	0.0	0.7
12	0.6	0.7	0.5	0.8	0.9	0.0
13	0.7	0.4	1.0	0.2	0.8	0.9
14	0.3	0.2	0.4	0.1	0.9	0.5
15	0.3	0.0	1.0	0.9	0.2	0.3
16	0.5	0.9	0.1	0.2	0.0	0.7
17	1.0	0.4	0.3	0.5	0.7	0.6
18	0.7	0.1	0.3	1.0	0.9	0.5
19	0.1	0.3	0.7	0.5	0.2	1.0
20	0.8	0.7	1.0	0.9	0.2	0.0
21	0.2	0.6	0.0	0.1	0.9	0.7
22	0.2	0.3	0.0	0.8	0.7	0.6
23	0.4	0.5	1.0	0.1	0.9	0.2
24	0.4	1.0	0.9	0.7	0.5	0.1
25	0.5	0.8	1.0	0.0	0.6	0.4
26	0.3	0.1	0.4	0.9	0.0	0.2
27	0.0	0.5	0.8	0.2	0.3	0.9
28	0.3	0.6	0.5	0.0	0.1	0.8
29	1.0	0.7	0.1	0.9	0.3	0.6
30	0.7	0.1	1.0	0.3	0.6	0.2
31	0.4	0.9	0.0	0.6	0.5	0.9

TN 106 - Annexure B2

Test Site Selection to RC 316.10

Date :

Data entry required to green cells & orange cells if manual calculation

Job	
Test Lot description	

Random number R

Date day	month	Time hour	minutes
23	7	7	10

Date Time summation =	47
Repeat summation =	11
Repeat summation =	2
Final Sum of digits (N) =	2
From Table 1 below, R =	**0.9**

Table 1

Sum of digits (N)	R (Random number)
1	0.4
2	0.9
3	0.1
4	0.6
5	0.3
6	0.2
7	0.7
8	0.8
9	0.5

Longitudinal position

	Start	Lower value		End	Higher value	
Lot boundaries	Start	10200	m	End	10440	m
Exclude 5 m each end	add	5	m	subtract	5	m
Lot test limits	Start limit	10205	m	End limit	10435	m
Lot length	L =	230	m	Lot area =	805	m^2
Approximate lot width		3.5	m			
Number of test sites	n =	6			6 test sites	

Longitudinal distance between sites = d = L / n = 38.3 m <=== 230 / 6

Distance of first test site from start of lot = Ls = **d** * **R** = 34.5 m <=== 38.3 x 0.9

Chainage of first site = sum of 10200 5 34.5 = 10240

lot start + 5 m exclusion + Ls = Site 1 longitudinal position

Transverse position

Width of test lot = 10 m (Constant, unless carriageway width changes)

Longitudinal edge reduction 0.2 m on two sides

Day of month 23 gives below, from Table 2

Datum line reference position (eg centreline, kerb, sawcut line) 0 metres

Site		Calculation	Longitudinal position (m)	Width of lot (m)	less 0.2 m each edge	Number set (Table 2)	Datum	Lateral position (m)
Site 1	#	Start + 5 + Ls	**10240**	10	9.6	0.4	0	**4.0**
Site 2		Site 1 + d	**10278**	10	9.6	0.5	0	**5.0**
Site 3	#	Site 2 + d	**10316**	10	9.6	1.0	0	**9.8**
Site 4		Site 3 + d	**10355**	10	9.6	0.1	0	**1.2**
Site 5	#	Site 4 + d	**10393**	10	9.6	0.9	0	**8.8**
Site 6		Site 5 + d	**10431**	10	9.6	0.2	0	**2.1**

\# Test at odd-numbered sites for Small Lot

Calculation by

Lot Sketch

Table 2 : Number sets for selection of lateral positions
(based on day of month)

Day Number	Number set: site 1	Site 2	Site 3	Site 4	Site 5	Site 6
1	0.1	0.6	0.5	0.0	0.8	0.3
2	0.5	0.2	0.4	0.1	0.7	0.3
3	0.7	0.4	0.1	0.8	0.0	1.0
4	0.4	1.0	0.1	0.6	0.8	0.3
5	1.0	0.8	0.1	0.3	0.5	0.0
6	0.5	0.9	0.4	0.1	0.3	0.8
7	0.9	0.8	0.4	0.3	0.6	0.0
8	0.9	0.5	0.6	0.2	0.1	1.0
9	1.0	0.0	0.4	0.5	0.6	0.2
10	0.5	0.8	0.7	0.2	1.0	0.9
11	0.6	0.1	1.0	0.9	0.0	0.7
12	0.6	0.7	0.5	0.8	0.9	0.0
13	0.7	0.4	1.0	0.2	0.8	0.9
14	0.3	0.2	0.4	0.1	0.9	0.5
15	0.3	0.0	1.0	0.9	0.2	0.3
16	0.5	0.9	0.1	0.2	0.0	0.7
17	1.0	0.4	0.3	0.5	0.7	0.6
18	0.7	0.1	0.3	1.0	0.9	0.5
19	0.1	0.3	0.7	0.5	0.2	1.0
20	0.8	0.7	1.0	0.9	0.2	0.0
21	0.2	0.6	0.0	0.1	0.9	0.7
22	0.2	0.3	0.0	0.8	0.7	0.6
23	0.4	0.5	1.0	0.1	0.9	0.2
24	0.4	1.0	0.9	0.7	0.5	0.1
25	0.5	0.8	1.0	0.0	0.6	0.4
26	0.3	0.1	0.4	0.9	0.0	0.2
27	0.0	0.5	0.8	0.2	0.3	0.9
28	0.3	0.6	0.5	0.0	0.1	0.8
29	1.0	0.7	0.1	0.9	0.3	0.6
30	0.7	0.1	1.0	0.3	0.6	0.2
31	0.4	0.9	0.0	0.6	0.5	0.9

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