Transport Roads & Maritime Services

NSW GOVERNMENT

Test method T640

Propensity for moisture damage in asphalt (Specimens compacted in the laboratory)

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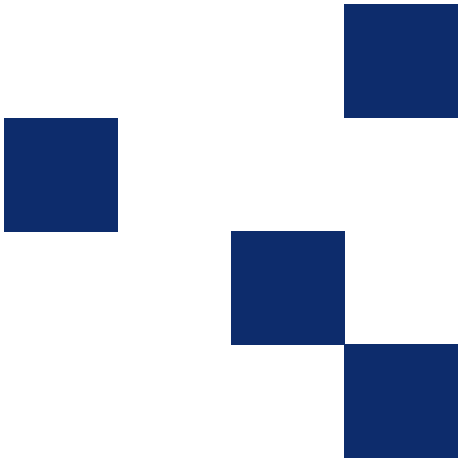

Revision Summary

Ed/Rev Number	Clause Number	Description of Revision	Authorisation	Date
		Reformatted and Revision Summary added.	D Dash	Jan 2000
		Typographical error - 7.2(e) on renumbered.	D Dash	May 2000
		Test Method date altered to agree with Revision Summary.	D Dash	Oct 2001
Ed 2/Rev 0	ALL	New Issue. Revised title. General revision of test. Minor change to temperature tolerances. Method modified for selecting groups.	G Hall	July 2009
Ed 2/Rev 1		Amended to allow for warm mix asphalt additives. Amended to "Indirect Tensile".	J Friedrich	July 2011
	2(e), 3(b), (c), (f), (g).	Document list. Test machine "at least"; balance requ'ts, temp.		
	4.1(b), (c), (d), Table 1, 4.2	Combined into table. Reworded and "heating temperature" defined, mass formula included.		
	5.1(b), 5.2(b), (c), 5.4(c). (f), 5.6(a), 5.7(g), Table 2,	'Compact' used, ref to T662, altered subscripts, explicit swell step, revised table.		
	6.1(a), 6.2(a), 6.3	Vol and bulk density from AS 2891.9.2. *h* & *D* subscripts added, UOM kPa corrected, 'Indirect' tensile referred to.		
	7(c) to (f)	Temp tolerance, 'Indirect' tensile referred to.		
Ed 3/ Rev 0		Reformatted RMS template	J Friedrich	November 2012

Note that Roads and Maritime Services is hereafter referred to as 'RMS'.

The most recent revision to Test method T640 (other than minor editorial changes) are indicated by a vertical line in the margin as shown here.

Test method T640

Propensity for moisture damage in asphalt (Specimens compacted in the laboratory)

1. Scope

This test method sets out the procedure for preparing asphalt specimens and measuring the change of Indirect Tensile Strength resulting from the effects of saturation and freeze/thaw.

NOTE: The Test Method has been adapted from the Modified Lottman Test, ASTM D 4867-92 Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures and AASHTO T 283-85 Resistance of Compacted Bituminous Mixture to Moisture Induced Damage. A similar Austroads test is AG:PT/T232 - Stripping Potential of Asphalt – Tensile Strength Ratio with the Freeze/Thaw option.

2. General

(a) The results are used to assess the propensity for stripping of dense graded asphalt using either:

(i) Asphalt prepared in the laboratory for evaluation of a mix design.

OR

(ii) Fresh asphalt produced by an asphalt manufacturing plant

NOTE: Fresh asphalt samples may be taken at the plant or on site.

(b) Complete the Gyratory compaction of each specimen Step 5.1(b) within 4 h of dividing the sample into sub-samples (i.e. Step 4.2(c))

(c) The specified air voids content must be 8% ± 1%.

(d) The following is an outline of the test:

(i) At least 6 specimens are compacted from loose asphalt. An additional 2 specimens may be required to establish the partial saturation procedure

(ii) Volumes of the specimens are determined based on mensuration

(iii) The air voids from approximately a 4 min immersion are used for selecting 2 matched groups and for the degree of saturation

(iv) The 6 specimens are divided into 2 matched groups – one group for conditioning (Freeze/Thaw group) and the other as the Control group

(v) The Control group is conditioned after the initial soaked density determination

(vi) The Freeze/Thaw group is "saturated" so that the voids are filled 55 to 80% with water. This group is then put through a regime of freezing and thawing

NOTE: The freezing is intended to stress the sample and not just simulate environmental freezing.

(vii) The volumes of the Freeze/Thaw group after conditioning are again determined based on mensuration

(viii) Volumes, based on mensuration, are used to calculate the swell of the Freeze/Thaw group and Indirect Tensile Strength of both groups, but these volumes do not enter into calculations of air voids or the degree of saturation

(ix) The Indirect Tensile Strength of both groups, the ratio of the wet/dry Indirect Tensile Strength and visual assessments are reported. The swell of the Freeze/Thaw group conditioned samples are also reported

(e) The following documents are referred to in this Test Method:

(i) T100 Sampling of Road Construction Materials (Soil, Gravel, Sand, Aggregate, Rock and Recycled Products)

(ii) T661 Mixing, Quartering and Conditioning of Asphalt in the Laboratory

(iii) T662 Compaction of Asphalt Test Specimens Using a Gyratory Compactor

(iv) AS 1984 Vernier callipers

(v) AS 2193 Calibration & classification of force-measuring systems

(vi) AS 2891 Methods of sampling and testing asphalt:

- AS 2891.1.1 Sampling of loose asphalt
- AS 2891.5 Methods of sampling and testing asphalt - Determination of stability and flow - Marshall procedure
- AS 2891.7.3 Determination of maximum density of asphalt - Methylated spirits displacement method
- AS 2891.8 Voids and density relationships for compacted asphalt mixes
- AS 2891.9.2 Determination of bulk density of compacted asphalt - Presaturation method
- AS 2891.9.3 Determination of bulk density of compacted asphalt-Mensuration method
- AS 2891.13.1 Determination of the resilient modulus of asphalt

3. Apparatus

(a) A cylindrical metal mould with the following dimensions:

(i) 100 mm ± 2 mm internal diameter by at least 70 mm high;

OR

(ii) 150 mm ± 2 mm internal diameter by at least 90 mm high

NOTE: The appropriate sized mould is selected in Step 4.1(b).

(b) Apparatus specified in the documents referred to that includes:

(i) Mixing and quartering equipment as specified in T661

(ii) Gyratory compactor as specified in T662

(iii) Suspension device, water container and suspension bridge as specified in AS 2891.9.2

(iv) Apparatus as specified in AS 2891.13.1 (e.g. loading jig, strips)

(c) Testing machine driven at a constant speed to give a rate of platen travel of 51 ± 3 mm/min and able to measure force up to at least 22 kN to a readability, accuracy and repeatability of Class B as specified in AS 2193

(d) Vacuum pump, rotary oil type, with gauge or manometer capable of providing a minimum vacuum of approximately 650 mm Hg readable to 25 mm

NOTE: Precision and calibration of the vacuum is not required because the result is voids filled with water so that the vacuum may be increased until this is achieved.

(e) Vacuum desiccator fitted with a tap and a shelf of perforated porcelain or stainless steel mesh, large enough to completely immerse samples with a cover of 25 mm. It is used as a vacuum chamber only so that the desiccant is not required

(f) Balance of not less than 5 kg capacity readable to 0.1 g and with a limit of performance of ± 5g

(g) A thermostatically controlled air environment capable of maintaining temperatures of 23° ± 3°C

NOTE: The conditioning chamber in the UMATTA machine is suitable/

(h) A thermostatically controlled oven(s), with good air circulation and capable of maintaining temperatures of 150° ± 5°C:

(i) Thermostatically controlled water bath(s) equipped with a snug-fitting lid and fitted with a water circulating device and having a depth of at least 150 mm and capable of:

(i) Maintaining temperatures of 25° ± 1°C

(ii) Maintaining temperatures of 60°C ± 2°C

(j) Thermostatically controlled freezer capable of maintaining temperatures at -18° ± 3°C

(k) Temperature measuring device, covering the range of 0° to 100°C graduated to 1°C or less with a limit of performance of ± 0.5°C

(l) Calibrated timing device readable to ± 0.5 second

(m) Vernier callipers conforming to AS 1984 and readable to 0.1 mm

(n) 10 mL graduated measuring cylinder of suitable capacity

(o) Insulated gloves and tongs for handling hot apparatus

(p) Marking crayon

(q) Damp cloths to wipe the specimens

(r) Plastic cling wrap, thick leak-proof plastic bags and tape to seal single specimens

(s) Magnifying glass/lamp with at least 3x magnification

4. Preparation

4.1 Sampling and Mould Selection

(a) The test requires a minimum of 6 specimens to be compacted and 1 sub-sample for the maximum density in Step 4.2(e)(ii). Two additional compacted specimens may be required for the trial in Step 5.3

(b) Select the mould diameter and specimen height that is appropriate for the nominal size of aggregate in the asphalt being tested according to Table 1

(c) The corresponding minimum quantity of sample required for 8 specimens and 1 density sub-sample is listed in Table 1

Table 1–Specimen Dimensions and Minimum Sample Quantity

Nominal Size of Mix	Mould Diameter	Specimen Height	Minimum Quantity
≤ 20 mm	100 ±2 mm	65 ±1 mm	20 kg
> 20 mm and ≤ 40 mm	150 ±2 mm	85 ± 1 mm	30 kg

(d) Where asphalt is to be batched in the laboratory, obtain a sample of the constituent materials according to T100 and Australian Standards as appropriate

(e) Where asphalt is produced in an asphalt manufacturing plant, sample as required either at the plant or on site in accordance with AS 2891.1.1

4.2 Preparation of Asphalt Sub-samples

(a) Where asphalt is to be batched in the laboratory:

(i) Prepare the asphalt sample in accordance with T661. Use the same type and class of materials from the same source of supply or manufacture as proposed for manufacture

(ii) The heating temperature and tolerance is the same as the asphalt conditioning temperature in Table 1 of T661

(b) Where the sample of asphalt was produced in an asphalt manufacturing plant, prepare the sample of asphalt as follows:

(i) The heating temperature is the lesser of the manufactured temperature or 150° with tolerance of ± 5°C

(ii) Heat the sample in an oven at the heating temperature for no more than 1 h

(iii) Remove the sample from the oven when the sample is workable and immediately recombine into one sample

NOTE: If more time in the oven is required report the duration.

(c) Without delay divide the sample in accordance with AS 2891.1.1 into the required number of sub-samples (refer to Step 4.1)

(d) Place the sub-samples required for specimens in an oven at the required heating temperature and maintain for 1 h ± 5 min

NOTE: Stagger heating of sub-samples as required to complete gyratory compaction.

(e) Before compacting the specimen, carry out the following steps:

(i) Preheat the moulds to the heating temperature

NOTE: Heating reduces rapid cooling of the specimen at the edges and helps achieve an even air voids distribution.

(ii) Determine the maximum density (ρ_{max}) of the asphalt sample in accordance with AS 2891.7.3 as appropriate:

- Where available, the average of the mix results taken on the day of manufacture for the lot

OR

- Determined in the laboratory from a loose sub-sample

(iii) Calculate the mass of the material (m) required for the specimen based on the required specimen volume (V), maximum density (ρ_{max}) and specified air voids content (AV from Step 2(c)) as follows:

$$m = \rho_{max} \times V\left(1 - \frac{AV}{100}\right)$$

(f) After the required time in Step 4.2(d) start Step 5.1 immediately

5. Procedure

5.1 Compacting Specimens

(a) Immediately remove the sub-sample from the oven after the required time

(b) Compact the specimen in accordance with T662

NOTE: Where necessary modify the compaction procedure to give the target air voids content for the mix (refer to Step 2(c).

(c) Mark each specimen with a unique identification

(d) Repeat Steps 5.1 for each additional sub-sample

NOTE: Reheating is minimised otherwise the sample will be altered.

5.2 Grouping by Volumetric Characteristics

(a) Allow specimens to cool to ambient temperature

(b) For each of the specimens:

(i) Determine the dry mass (M_d) to 0.1 g

(ii) Determine the diameter (D_d), height (h_d) and volume (V_{md}) by mensuration in accordance with AS 2891.9.3

(iii) Determine the bulk density (ρ_{bulk}) and volume by presaturation (V_d) in accordance with AS 2891.9.2

NOTE: At no stage shake the specimens to remove free water.

(iv) Calculate the percent Air Voids (AV) in accordance with AS 2891.8 to the nearest 0.1% (refer to Step 6.1(a))

(v) Calculate the volume of air (V_a) in mL (refer to Step 6.1(b)). Reject any specimen that is outside the tolerance in Step 2(c)

(c) Select 6 from the 8 specimens so that the difference between the maximum and minimum air voids content is < 1%. Create 2 groups of 3 specimens so that the specimen air void content within each group does not differ by more than 0.5%

NOTE: The spare specimens may be required in the trial in Step 5.3(a) or as a replacement in Step 5.4(g)(i) provided the specimen meets the criteria in this step.

(d) The group of 3 specimens with the lower average air voids is to be tested dry (referred to as the 'Control' group) and the group of 3 specimens with higher average air voids is to be freeze/thaw conditioned and then tested (referred to as the 'Freeze/Thaw' group). Mark each specimen with the group and record the unique identification

(e) Mark remaining specimens as 'Spare' for use in Step 5.3 or to replace a specimen that is rejected during testing. Store at ambient temperature until required

(f) Store the Freeze/Thaw group at ambient temperature until required in Step 5.4

(g) Wipe excess water from the Control group and store at ambient temperature until required in Step 5.6

5.3 Trial

(a) Omit this step where a reliable Partial Saturation Process (Step 5.4) has previously been recorded for the mix design being tested

(b) Select one of the spare specimens

(c) Carry out a trial of Step 5.4 to identify the best method for use in Step 5.5. When the required saturation is achieved, note the details of each of the steps with the following parameters:

(i) Temperature of water in the desiccator (°C)

(ii) Vacuum period (minutes)

(iii) Vacuum (mm Hg)

(d) Record the proven method for the mix design being tested and proceed to Step 5.4

5.4 Partial Saturation Process of Freeze/Thaw group

(a) Place the specimen on its side on the shelf in the vacuum desiccator. Ensure that the specimen is covered by at least 25 mm of water at 50° ± 5°C

(b) Allow the specimen to soak for at least 5 min

(c) Gradually apply a vacuum of 625 ± 25 mm Hg over about 5 min. Gently agitate the desiccator periodically to release any entrapped air or to release air clinging to the surface of the specimen

NOTE: The application of a vacuum over the minimum time period is to limit shock to the specimen.

(d) After the required time, stop the vacuum pump and gently agitate the desiccator to release any air which is clinging to the surface of the specimen. Gradually allow the pressure in the desiccator to return to atmospheric pressure. Remove the partially saturated specimen from the desiccator

(e) Wipe the partially saturated specimen with a damp cloth to bring the specimen to a saturated surface dry condition. Do not shake the specimen

(f) Determine the mass of the partially saturated specimen (M_{ps}) to 0.1 g

(g) Calculate the Degree of Saturation (S_p) as a percent (refer to Calculation 6.1(c)) and proceed based on the value as follows:

(i) If S_p > 80%, reject the specimen and repeat Steps 5.4(a) to 5.4(g) using a spare specimen that meets the criteria in Step 5.2(c)

(ii) If S_p < 55%, repeat the process on the same specimen from Step 5.4(a) with extra vacuum periods, increased in temperature up to 60°C or increased vacuum, until S_p is in the range 55% to 80%

NOTE: Extra vacuum periods of 5 min up to a total of 30 min each are suggested.

(iii) If S_p is in the range 55% to 80% of the required saturation, proceed to Step 5.5

5.5 Conditioning the Freeze/Thaw group

(a) For each of the 3 specimens in the Freeze/Thaw group:

(i) Partially saturate the specimen using the proven method identified in Step 5.3 and carry out Steps 5.4(a) to 5.4(g) on the specimen until the required saturation is achieved

(ii) Once a satisfactory degree of saturation is achieved, immediately wrap each specimen in several layers of plastic cling wrap. Place each wrapped specimen in a separate plastic bag containing about 10 mL of water and seal the bag

(iii) Place the sealed specimen upright on a shelf in the freezer and ensure that specimens are not in contact with other specimens. Maintain a temperature of -18° ± 3°C for 18 ± 1 h

(b) After the specified time, remove each specimen from the freezer, remove the plastic bag and wrapping and place each specimen in a water bath maintained at 60° ± 2°C for 24 ± 1 h. Record the order that specimens were placed in the bath. Ensure that specimens are not in contact with each other in the water bath. Ensure the water level in the bath covers all specimens by at least 25 mm

(c) After the specified time, remove each specimen from the water bath in the same order from Step 5.5(b), and place in the second water bath maintained at 25° ± 1°C for 2 h ± 5 min. Ensure that specimens are not in contact with each other in the water bath. Ensure the water level in the bath covers all specimens by at least 25 mm

NOTE: A suitable time interval must be allowed between placing each specimen into the water bath and testing so that the period of time for conditioning at 25°C before testing must not exceed 2.5 h for each specimen. An interval of 15 min is a guide.

5.6 Conditioning the Control group

(a) For each of the 3 specimens in the Control group, place the specimens in a temperature controlled air environment maintained at 23° ± 3°C for at least 18 h

(b) Keep in the temperature controlled air environment at 23° ± 3°C until required for testing (i.e. until after the Freeze/Thaw group is tested)

5.7 Testing Specimens

(a) After the specified period of conditioning, test each of the 3 specimens of the Freeze/Thaw group followed by each of the 3 specimens of the Control group. The order for testing is to follow the same order as that for conditioning

(b) Remove one specimen and within 15 min complete the test in a temperature controlled environment maintained at 25° ± 1°C

NOTE: Ensure that no part of a sample belonging to the Freeze/Thaw group dries out.

(c) For each specimen from the Freeze/Thaw group measure the height (h_f) and diameter (D_f) of the specimen in accordance with AS 2891.9.3(6)

(d) Determine the Indirect Tensile Strength as follows:

(i) Place the specimen centrally on its side into the loading jig

(ii) Apply load to the specimen at the specified constant rate

(iii) Record the maximum applied force (P) to the nearest 0.1 kN

(iv) Continue loading at the specified constant rate until the specimen fractures

(e) Carefully separate the fractured parts of the specimen and set aside to dry for at least 12 h at ambient temperature

(f) Repeat Steps 5.7(b) to (e) for the remaining specimens

(g) Calculate the swell (V_s) of each Freeze/Thaw conditioned specimen (refer to Step 6.2)

(h) When the sample has dried, carry out a visual inspection under a magnifying lamp of the fractured faces of the specimen. Record whether there is binder coated on the aggregate, cracked or broken aggregate and any other observations using Table 2

NOTE: A photograph of the face most representative of the sample assists interpretation of results.

Table 2–Visual Rating of Fracture faces of a Specimen

Aggregate Size	Property	Visual Rating
Coarse	Coating of binder to aggregate	Nil/Minimal/Moderate/ Complete*
	Binder condition	Flat/semi-gloss/gloss*
	Cracked or broken aggregate	Minimal/ Moderate/ Extensive*
Fine	Coating of binder to aggregate	Minimal/ Moderate/ Complete*
	Binder condition	Flat/semi-gloss/gloss*
	Cracked or broken aggregate	Nil/Minimal/Moderate/ Extensive*

*NOTE: * Select the most appropriate rating from the list.*

6. Calculations

6.1 Degree of Saturation

(a) Calculate the percent Air Voids (AV) as follows:

$$AV = \left(\frac{\rho_{max} - \rho_{bulk}}{\rho_{max}} \right) \times 100\%$$

Where:

AV = Percent air voids (%)

ρ_{max} = Maximum density (t/m^3) (from AS 2891.7.3)

ρ_{bulk} = Bulk density (t/m^3) (from AS 2891.9.2)

(b) Calculate the Volume of Air (V_a) in each specimen of the Freeze/Thaw group as follows:

$$V_a = \frac{AV \times V_d}{100}$$

Where:

V_a = Volume of air in the specimen (mL)

AV = Percent air voids (%) (from AS 2891.8)

V_d = Volume of the dry specimen by presaturation (cm^3 or mL) (from AS 2891.9.2)

(c) Calculate the Degree of Saturation (S_p) in each specimen of the Freeze/Thaw group as follows:

$$S_p = \left(\frac{M_{ps} - M_d}{V_a} \right) \times 100\%$$

Where:

S_p = Degree of Saturation of a vacuum saturated specimen (%)

M_{ps} = Mass of the partially saturated specimen (g)

M_d = Dry mass of the specimen (g)

V_a = Volume of air in the specimen (mL)

NOTE: Density of water is assumed to be 1.00g/mL and does not appear in the formula but makes S_p dimensionless.

6.2 Swell after Conditioning

(a) Calculate the dry volume (V_{md}) of all 3 samples in the Freeze/Thaw group by mensuration as follows:

$$V_{md} = \frac{\pi \, h_d \, D_d^{\,2}}{4} \times 10^{-3}$$

Where:

V_{md} = Volume of the dry specimen by mensuration (mL)

h_d = Height of the specimen (mm)

D_d = Diameter of the specimen (mm)

(b) Calculate the volume (V_{mf}) after the Freeze/Thaw conditioning by mensuration as follows:

$$V_{mf} = \frac{\pi \, h_f \, D_f^{\,2}}{4} \times 10^{-3}$$

Where:

V_{mf} = Volume of the Freeze/Thaw conditioned specimen by mensuration (mL)

h_f = Height of the specimen after conditioning (mm)

D_f = Diameter of the specimen after conditioning (mm)

(c) Calculate the swell (V_S) of each Freeze/Thaw conditioned specimen as follows:

$$V_S = \left(\frac{V_{mf} - V_{md}}{V_{md}} \right) \times 100\%$$

Where:

V_S = Swell of Freeze/Thaw conditioned specimen (%)

V_{mf} = Volume of the Freeze/Thaw conditioned specimen by mensuration (mL)

V_{md} = Volume of the dry specimen by mensuration (mL)

6.3 Indirect Tensile Strength

(a) Calculate the Indirect Tensile Strength (T) of all specimens tested:

(i) For the Control group, use the height (h_d) and diameter (D_d) of the dry specimen

(ii) For the Freeze/Thaw group, use the height (h_f) and diameter (D_f) determined after conditioning. Where a specimen disintegrates during Freeze/Thaw conditioning, record the Indirect Tensile Strength (T) as NIL and use in subsequent calculations

$$T = \left(\frac{2 \, P}{\pi \, h_x \, D_x} \right) \times 10^{6}$$

Where:

T = Indirect Tensile Strength (kPa)

P = Maximum applied force indicated by the testing machine (kN)

h_x = Height of the particular specimen (mm)

D_x = Diameter of the particular specimen (mm)

$_x$ = Subscript stands for '*d*' for dry specimen or '*f*' for Freeze/Thaw specimen

(b) Calculate the average Indirect Tensile Strength of the two groups:

(i) For the 3 Control group specimens (S_C)

(ii) For the 3 Freeze/Thaw group specimens (S_f)

(c) Calculate the Indirect Tensile Strength Ratio (*TSR*) rounded up to the nearest whole number as follows:

NOTE: The TSR is undetermined if it is not based on the complete 2 groups of 3 specimens.

$$TSR = \left(\frac{S_f}{S_C}\right) \times 100\%$$

Where:

TSR = Indirect Tensile Strength Ratio rounded to the nearest whole %.

S_f = Average Indirect Tensile Strength of the Freeze/Thaw group (kPa)

S_C = Average Indirect Tensile Strength of the Control group (kPa)

7. Reporting

Include the following data and results in the report:

(a) The sample and mix identification

(b) Method used to prepare the asphalt (i.e. laboratory or plant manufactured). If plant mixed, the location where the sampling was taken (e.g. bin, truck, auger, pavement)

(c) The temperature at which the asphalt was mixed, conditioned and compacted to the nearest 5°C

(d) For the Control group:

(i) The Air Voids content (*AV*) for each specimen and average air voids content to the nearest 0.1%

(ii) The Indirect Tensile Strength (*T*) of each specimen and average Indirect Tensile Strength (S_C) to the nearest 10 kPa

(e) For the Freeze/Thaw group:

(i) The Air Voids content (*AV*) for each specimen and average air voids content to the nearest 0.1%

(ii) The Degree of Saturation (S_f) of each specimen and average Degree of Saturation to the nearest whole %

(iii) The Swell (V_S) of each specimen and the average Swell to the nearest 0.1%

(iv) The Indirect Tensile Strength (*T*) of each specimen and average Indirect Tensile Strength (S_f) to the nearest 10 kPa

(f) The Indirect Tensile Strength Ratio (*TSR*) to the nearest whole %. Provide comment if the *TSR* is undetermined or if any specimen disintegrated during conditioning

(g) Visual assessments according to Step 5.7(g)

(h) Reference to this Test Method