1. SCOPE

This test covers preparation of specimens and measurement of the change of tensile strength resulting from the effects of saturation and accelerated water conditioning of compacted asphalt mixtures in the laboratory. KT-56 reflects testing found in AASHTO T 283. The results may be used to:

1. Predict the ability of an asphalt mix to withstand long-term stripping,
2. Evaluate liquid anti-stripping additives which are added to the asphalt cement, or
3. Evaluate pulverized solids, such as hydrated lime, which are added to the mineral aggregate.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9.; Sampling and Test Methods Foreword

2.2. KT-6; Specific Gravity and Absorption of Aggregate

2.3. KT-14; Marshall Tests of Bituminous Mixes

2.4. KT-15; Bulk Specific Gravity and Unit Weight of Compacted Hot Mix Asphalt (HMA)

2.5. KT-25; Sampling and Splitting Plant Mixed Asphalt Mixtures

2.6. KT-32; Method of Test for Density of Compacted Asphalt Mixtures by Nuclear Method

2.7. KT-39; Theoretical Maximum Specific Gravity of Asphalt Paving Mixtures

2.8. KT-58; Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor

2.9. AASHTO T 283; Resistance of Compacted Asphalt Mixture to Moisture Induced Damage

3. APPARATUS

3.1. Equipment for preparing and compacting specimens from KT-58 of this manual.

3.2 Vacuum container with a minimum inside diameter of 8 in (200 mm) and an inside height capable of placing a minimum of 1 in (25 mm) of water above specimen plus base plate prior to vacuum. Vacuum container capable of withstanding a 1.2 in (30 mm) of Hg absolute pressure. Base plates to be made of perforated Polypropylene material with a minimum of 6 in (150 mm) diameter.

3.3. Vacuum pump or water aspirator capable of obtaining a 1.2 in (30 mm) of Hg absolute pressure. To include a manometer or vacuum gauge and appropriate hose to accommodate pressure and distance requirements.

3.4. The balance shall conform to the requirements of Part V, 5.9; Sampling and Test Methods Foreword, for the class of general purpose balance required for the principal sample mass of the sample being tested.
3.5. Water bath capable of maintaining a temperature of 77 ± 1°F (25 ± 0.5°C).
3.6. Water bath capable of maintaining a temperature of 140 ± 2°F (60 ± 1°C).
3.7. Freezer maintained at 0 ± 5°F (-18 ± 3°C).
3.8. A supply of plastic film for wrapping, heavy-duty leak proof plastic bags to enclose the saturated specimens and masking tape.
3.9. 10 mL graduated cylinder.
3.10. Loading jack and ring dynamometer from **KT-14** of this manual to provide controlled vertical deformation at the rate of 2 in (50.8 mm) per minute.
3.11. Breaking head will consist of stainless steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. For specimens 4 in (102 mm) in diameter the loading strips are to be 0.5 in (12.7 mm) wide, and for specimens 6 in (150 mm) in diameter the loading strips are to be 0.75 in (19.05 mm) wide. The length to thickness ratio of the loading strips is to exceed one. Round the edge of the loading strips.
3.12. Pans having a surface area of 75-100 square inches (48,400-64,500 square millimeters) in the bottom and a depth of approximately 1 in (25 mm).
3.13. Forced air draft oven, thermostatically controlled, capable of maintaining any desired temperature setting from room temperature to 350° ± 5°F (176° ± 3°C).

4. PREPARATION OF LABORATORY TEST SPECIMENS

4.1. Use specimens that are 6 in (150 mm) in diameter and 3.75 ± 0.20 in (95 ± 5 mm) thick.
4.2. Build the aggregate material in the same manner as described in **KT-14 Sections e.2.b. or e.2.c.** of this manual. A minimum of six plugs will be required to perform this test. The asphalt quantity is based on the optimum design content. Additional material for **KT-39** of this manual may be required.
4.3. Preparation of mixes: Combine individual aggregates or reclaimed material and virgin aggregates by weighing out in a separate pan for each test specimen, proportionate amounts of each size fraction for each individual aggregate to produce the desired combined gradation. The combined aggregate should be sufficient to produce a compacted specimen as described in **Section 4.1.**
4.4. Heat the aggregate and asphalt within the limits of mixing temperature determined in **KT-14 Section d.1.** of this manual. Charge the mixing bowl with the heated aggregate and form a crater in the top. Add the required amount of asphalt and mix the aggregate and asphalt until thoroughly coated, at least 2 minutes. Care should be taken to keep the entire sample in the mixing bowl during this process.
4.5. Either prior to, or after compaction, permit the mix to age at room temperature for 24 ± 1 hours before continuing to **Section 6** of this test method.
4.6. Place the mixture in an oven set at the appropriate compaction temperature and age the material for 2 hours as outlined in **KT-58 7.5** of this manual. Compact the mixture to 7.0 ± 0.5 % air voids. This level

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1 AASHTO **T 283 Section 6.3** requires the material to be cured in an oven at 60°C for 16 hours prior to curing.
of voids can be obtained by adjusting the specimen mass or the height in Sect. 4.1 of this test method. The exact procedure must be determined experimentally for each mixture before compaction the specimens for each set.

4.7. Extract the specimens from the molds and allow cooling to room temperature. Due to the elevated void content and potential instability of the specimens, verify that each specimen is adequately cool and stable prior to removal from the mold.

5. PREPARATION OF FIELD TEST SPECIMENS

5.1. Select locations on the completed pavement to be sampled as outlined in KT-25 of this manual.

5.2. Place the field mixture in an oven set at the appropriate compaction temperature. Do not age the field mixture in the oven. Compact the field mixture as outlined in KT-58 of this manual beginning at Sect. 7.7. Compact the mixture to 7.0 ± 0.5 % air voids. This level of voids can be obtained by adjusting the specimen mass or the height in Sect. 4.1 of this method. The exact procedure must be determined experimentally for each mixture before compaction the specimens for each set.

5.3. Do not age for 24 hours as stated in Sect. 4.5.

6. EVALUATION OF TEST SPECIMEN AND GROUPING

6.1. Determine the theoretical maximum specific gravity of mixture by KT-39 of this manual.

6.2. Determine the specimen thickness, to the nearest 0.001 in (0.01 mm), at approximately quarter points on the periphery of the plug. Average the results and record. For height, a specimen measuring device can also be used in lieu of averaging. Also determine the diameter to the nearest 0.001 in (0.01 mm).

6.3. Determine the bulk specific gravity by KT-15, Procedure III of this manual. Express volume of specimens in mL.

6.4. Calculate air voids by using the following formula:

\[
\text{% Air Voids} = \frac{100(\text{Theoretical Max. S.G. – Bulk S.G.})}{\text{Theoretical Max. S.G.}}
\]

6.5. Sort specimens into two subsets of three specimens each so the average air voids of the two subsets are approximately equal.

7. PRECONDITIONING OF TEST SPECIMENS

7.1. Test one subset dry and test the other subset after preconditioning.

7.2. Store the dry subset at room temperature until testing. Measure the height and diameter of the dry set. Wrap the specimens with plastic, heavy duty leak proof plastic bag or place in plastic concrete cylinder molds\(^2\). Place the specimens in the 77 ± 1°F (25 ± 0.5°C) water bath for 2 hours ± 10 minutes and then test as described in Section 8 of this test method.

\[^2\] Concrete cylinder molds have found to successfully keep the plugs from becoming saturated. Care must be taken so the lid is fitted properly thus keeping the plugs dry.
7.3. Condition the other subset as follows:

7.3.1. Place the specimen in the vacuum container supported by a base plate positioned above the container bottom. Fill the container with potable water at room temperature so that the specimens have at least 1 in (25 mm) of water above their surface. Apply partial vacuum (10 to 26 in [250 to 650 mm] of Hg) for a short time (5 to 10 minutes). These are only estimates for vacuum and time. Remove the vacuum and leave the specimens submerged in water for a short time (5 to 10 minutes).

7.3.2. Determine bulk specific gravity of the three conditioned samples by KT-15, Procedure I of this manual with noted exception in Section 6.3 of this test method. Prior to placing the sample in the water bucket, place a sheet of plastic wrap on the balance and zero the balance. Within two minutes of taking the sample from the water bucket, determine the SSD mass of the sample, calculate the degree of saturation, and determine if the degree of saturation is acceptable as shown in Section 7.3.3 of this test method. If the degree of saturation is acceptable, wrap the samples with the plastic wrap. All moisture draining from the plug during this process is to be collected by the plastic wrap and is not permitted to be discarded. Compare saturated surface dry mass with dry mass determined in Section 6.3 of this test method. Calculate volume of absorbed water.

7.3.3. Determine degree of saturation by comparing volume of absorbed water with volume of air voids from Section 6.4 of this test method. If the volume of water is between 70 to 80% of the volume of air, proceed to Section 7.3.4. If volume of water is less than 70%, repeat the procedure beginning with Section 7.3.1 of this test method using more vacuum and/or time. If volume of water is more than 80%, specimen has been damaged and is discarded. Using a new specimen repeat the procedure using less vacuum and/or time.

7.3.4. Cover the vacuum saturated specimens tightly with a second layer of plastic wrap. Place each wrapped specimen in a plastic bag containing 10 mL of water and seal the bag.

7.3.5. Within 2 minutes, place the plastic bag containing the specimens in a freezer at 0 ± 5°F (-18 ± 3°C) for a minimum of 16 hours.

7.3.6. After removal from the freezer, place the specimens into a 140 ± 2°F (60 ± 1°C) water bath for 24 ± 1 hours. Remove the plastic bag and film from the specimens as soon as possible after placement in the water bath.

7.3.7. After 24 ± 1 hours in the 140 ± 2°F (60 ± 1°C) water bath, remove the specimens and place them in a water bath already at 77 ± 1°F (25 ± 0.5°C) for 2 hours ± 10 minutes. It may be necessary to add ice to the water bath to prevent the water temperature from rising above 77 ± 1°F (25 ± 0.5°C). Not more than 15 minutes should be required for the water bath to reach 77 ± 1°F (25 ± 0.5°C).

7.3.8. Remove the conditioned plugs from the water bath. Quickly damp dry the saturated specimen with a damp absorbent cloth and weigh the specimen. Any water which seeps from the specimen during the weighing operation is considered part of the saturated specimen. Place the specimen in the basket or bucket and determine the mass to the nearest 0.5 g while immersed in water at 77 ± 1°F (25 ± 0.5°C). The mass of the specimen in water shall be determined as quickly as possible after the specimen is immersed.

7.3.9. Determine the height and diameter of the plug prior to testing.

8. TESTING
8.1. Determine the indirect tensile strength of dry and conditioned specimens at 77 ± 1°F (25 ± 0.5°C).

8.1.1. Place the specimens between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of the specimen. Apply the load to the specimens by means of the constant rate of movement of the testing head of 2 in (50.8 mm) per minute.

8.1.2. Record the maximum compressive strength noted on the testing machine, and maintain continuous loading until a vertical crack appears. Remove the specimen from the machine and pull apart at the crack. Inspect the interior surface for stripping and record the observations.

9. CALCULATIONS

9.1. Calculate the tensile strength as follows:

\[
S_t (\text{English}) = \frac{2(P)}{\pi (t)(D)}
\]

\[
S_t (\text{Metric}) = \frac{2000(P)}{\pi (t)(D)}
\]

Where:
- \(S_t\) = Tensile strength, psi (kPa)
- \(P\) = Maximum load, lbf (N)
- \(t\) = Specimen thickness, in (mm)
- \(t'\) = Conditioned specimen thickness, in (mm)
- \(D\) = Specimen diameter, in (mm), and
- \(D'\) = Conditioned specimen diameter, in (mm)

(D' and \(t'\) replace \(D\) and \(t\) when calculating the conditioned specimen’s tensile strength)

9.2. Express the numerical index or resistance of asphalt mixtures to the detrimental effect of water as the ratio of the original strength that is retained after the freeze-warm water conditioning. Calculate as follows:

\[
\% \text{Tensile Strength Ratio} \left(\%\text{TSR}\right) = \frac{100(S_2)}{S_1}
\]

Where:
- \(S_1\) = Average tensile strength of dry subset, and
- \(S_2\) = Average tensile strength of conditioned subset

NOTE: If an anti-stripping agent is used, include the agent in all asphalt mixtures for the conditioned and unconditioned subsets.

10. ADDITIVES

10.1. If additives are found to be necessary, return to Section 4 of this test method and proceed through the test procedure. If lime is proposed, add to the aggregate portion during Section 4.3 of this test method. If liquid anti-strip agents are proposed, add to the asphalt material prior to Section 4 of this test method. The contractor will supply the lime or liquid anti-strip agent along with the quantity and method.
to be used on the project. Use the proposed quantity and method during the test procedure to determine the effectiveness of additives on the bituminous mixture.

### 11. ESTABLISHING OUTLIERS IN A SUBSET OF PLUGS

11.1. The “T” Statistic test, as presented in KT-32 of this manual, represents a method to statistically analyze a subset for the potential of having an outlier. It requires the calculation of the mean, sample standard deviation and for the subset values to be oriented in an ascending order. Do not determine if there is an outlier, as described in this section, when the range (difference between highest and lowest value) of the three plugs do not exceed 11 psi (75 kPa). The following two examples illustrate how the “T” Statistic would be used to analyze a subset of conditioned plugs.

#### “T” Statistic Analysis of a Conditioned subset of plugs:

##### EXAMPLE 1: Subset passing the “T” Statistic Test

Conditioned subset plugs strengths:

1 – 430 kPa  
2 – 419 kPa  
3 – 495 kPa

\[ d_1 = 419 \text{ kPa} \]  
\[ d_2 = 448 \text{ kPa} \]  
\[ d_n = 495 \text{ kPa} \]

\[ T_1 = \frac{d_2 - d_1}{S} = \frac{448 - 419}{41.1} = \frac{39}{41.1} = 0.95 \]

\[ T_n = \frac{d_n - d_2}{S} = \frac{495 - 448}{41.1} = \frac{47}{41.1} = 1.14 \]

Where:

- \( d_1 \) = The lowest strength plug in the subset
- \( d_2 \) = The mean (average) of the subset
- \( d_n \) = The highest strength plug in the subset
- \( S \) = The sample standard deviation (n-1) of the subset
- \( T_{0.95} \) = The “T” Statistic value when n=3
- \( T_1 \) = The lower “T” value calculated from the subset
- \( T_n \) = The upper “T” value calculated from the subset

Since \( T_{0.95} \) (1.15) is greater than both \( T_1 \) (0.71) and \( T_n \) (1.14) then there is no outlier within the subset of plugs.

##### EXAMPLE 2: Subset Failing the “T” Statistic Test

If \( d_n = 530 \text{ kPa} \) (instead of 495 kPa), then \( d_2 = 460 \text{ kPa} \), \( S = 61.2 \text{ kPa} \), \( T_1 = 0.67 \) and \( T_n = 1.14 \). This would cause the highest strength plug \( (d_n) \) to be classified as an outlier and would therefore be discarded. The
two remaining plugs would be used to determine the average tensile strength for the subset (average subset strength = (419 + 430)/2 = 424 kPa).

12. Report

12.1. Record the TSR to the nearest 0.1% Report the TSR to the nearest 1%.

ADDENDUM TO KT-56
FOR INCLUDING LIME AS AN ANTISTRIPPING AGENT

The following information provides KT-56 with steps to incorporate hydrated lime as an antistripping agent.

Delete sections 4.3 and 4.4 of this test method and replace with the following:

4.3. Preparation of mixes: combine the virgin aggregates by weighing in a separate pan for each test specimen, proportionate amounts of each size fraction for each individual aggregate to produce the desired combined aggregate with a batch mass of approximately 1,125 g. Include the hydrated lime mass required to meet the specified percent of lime for the project as part of the total batch mass. The total aggregate mass should include lime, virgin aggregate and reclaimed material (if applicable). The total aggregate should be sufficient to produce a compacted specimen as described in Section 4.1 of this test method.

4.3.1. Determine the SSD condition (KT-6) for the combined aggregate gradation. Add three percent of moisture to the percent moisture required to reach the SSD condition of the combined aggregate.

4.3.2. Place the combined virgin aggregate and hydrated lime in a mixing bowl. Carefully mix until the hydrated lime is combined with the aggregate. Add the appropriate water content, as determined in Section 4.3.1 of this addendum to the test method, and thoroughly mix.

4.3.3. Oven dry the aggregate mix at 230 ± 9°F (110 ± 5°C) to a constant mass.

4.4. Combine the virgin aggregate material with the reclaimed material, if applicable, and thoroughly mix. Heat the combined aggregate and asphalt within limits of the mixing temperature determined in KT-14, Section d.1., of this manual. Charge the mixing bowl with the heated aggregate and form a crater in the top. Add the required amount of asphalt and mix the aggregate and asphalt until thoroughly coated, at least 2 minutes. Care should be taken to keep the entire sample in the mixing bowl during this process.