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BUREAU OF INDIAN STANDARDS

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भारतीय मानक **मसौदा**

स्वचल वाहन — सड़क तलों के गुणांक की ब्रेकिंग की मापन पद्धिति
भाग 2 दोलन पद्धिति

(*प्रथम पुनरीक्षण*)

Draft *Indian Standard*

AUTOMOTIVE VEHICLES — METHODS OF MEASUREMENT OF BRAKING COEFFICIENT OF ROAD SURFACES
PART 2 PENDULUM METHOD

(*First Revision*)

ICS 43.040

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04	**Last date for receipt of comments is 16/06/2024**

Automotive Braking and Steering Systems, Vehicle Testing and Performance Evaluation Sectional Committee, TED 04

FOREWORD
(Formal Clause to be added later)

This standard was first published in 2014. In this Standard Friction is the force that opposes the relative motion or tendency of such motion of two surfaces in contact. The coefficient of friction (also known as the frictional coefficient or the friction coefficient) is a scalar value which describes the ratio of the force of friction between two bodies and the force pressing them together.

This standard specifies two test methods for measurement of Braking Coefficient of road surfaces; namely; Standard Reference Test Tyre (SRTT) method and Pendulum method. While Part 1 covers the test method for measurement of Peak Braking Coefficient (PBC) using SRTT method; Part 2 covers Pendulum test method for quick and periodical checks of skid resistance on the road surfaces to evaluate its status of surface roughness.

This standard does not support to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

While formulating this standard considerable assistance has been derived from ASTM E 303: 2022 ‘Standard test method for measuring surface frictional properties using the British pendulum tester’.

The composition of the Committee responsible for the formulation of this standard is given at **Annex B (Will be added later).**

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of test or analysis, shall be rounded off in accordance with IS 2: 2022‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded offvalue should be the same as that of the specified value in this standard.

Draft *Indian Standard*

AUTOMOTIVE VEHICLES — METHODS OF MEASUREMENT OF BRAKING COEFFICIENT OF ROAD SURFACES

PART 2 PENDULUM METHOD

(*First Revision*)

1 SCOPE

1.1 This standard specifies test method for quick and periodical measurements of skid resistance of road surfaces using pendulum tester.

2 REFERENCE

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS/ Other	*Title*
ASTM E 501	Specification for Standard Rib Tire for Pavement Skid-Resistance Tests

3 SUMMARY OF TEST METHOD

3.1 This test method consists of using a pendulum- type tester with a standard rubber slider to determine the frictional properties of a test surface. The British Pendulum Tester is a dynamic pendulum impact-type tester used to measure the energy loss when a rubber slider edge is propelled over a test surface. The tester is suited for road surfaces/test surfaces.

3.2 The values measured, BPN = British Pendulum (Tester) Number for test tracks represent the frictional properties obtained with the apparatus and the procedures stated herein and do not necessarily agree or correlate with other measuring equipments.

3.3 The test track surface is cleaned and thoroughly wetted (for tracks intended to be used in wetted condition, e.g. wet grip track, low mu surfaces, etc.) prior to testing.

3.4 The pendulum slider is positioned to barely come in contact with the test surface prior to conducting the test. This slider should be swing in the direction of the traffic. The pendulum is raised to a locked position, then released, thus allowing the slider to make contact with the test surface. Four readings are taken in the test track (usually the near side of wheel track) spread at approximately 5 to 10 m intervals are taken along the length under test. The mean of these reading gives a representative value of the skid resistance of the road.

3.5 A drag pointer indicates the British Pendulum (Tester) Number. The term pendulum test value (PTV) is synonymous with BPN in the pedestrian surface industry. The greater the friction between the slider and the test track surface, the more the swing is retarded, and the larger the BPN reading.

4 SIGNIFICANCE AND USE

4.1 This test method provides a measure of a frictional property, micro texture, of road surfaces.

4.2 The values measured in accordance with this method do not necessari1y agree or directly correlate with those obtained utilizing other methods of determining friction properties or skid resistance.

NOTE — BPN and polish values from similar types of surfaces wi1l not be numerically equal, primarily because of the differences in slide length and surface shape. Theoretical correction of the polish values to obtain numerical equality, either by mathematical manipulation or by use of special measuring scales is not recommended.

5 APPARATUS

5.1 British Pendulum Tester (*see* Fig. 1)

The pendulum with slider and slider mount shall weigh 1 500 ± 30 g. The distance of the center of gravity of the pendulum from the center of oscillation shall be 411 ± 5 mm. The tester shall be capable of vertical adjustment to provide a slider contact path of 125 ± 1.6 mm for tests on flat surfaces, and 76 to 78 mm for tests on polishing - wheel specimens. The spring and lever arrangement (*see* Fig. 2) shall give an average normal slider load between the 76 mm wide slider and test surface of 2 500 ± 100 g as measured by the method described in Annex A.

5.2 Slider

The slider assembly shall consist of an aluminum backing plate to which is bonded a 6 mm × 25 mm × 76 mm rubber strip for testing flat surfaces or a 6 mm × 25 mm × 32 mm rubber strip for testing curved polishing wheel specimens.

5.2.1 *The rubber compound shall be one of the following*:

5.2.1.1 Natural rubber meeting the requirements of the Road Research Laboratory, commonly referenced as the TRL slider,

5.2.1.2 Natural rubber having an international rubber hardness of 96 ± 2, commonly referenced as "4S" (standard shoe sole simulating) rubber, or

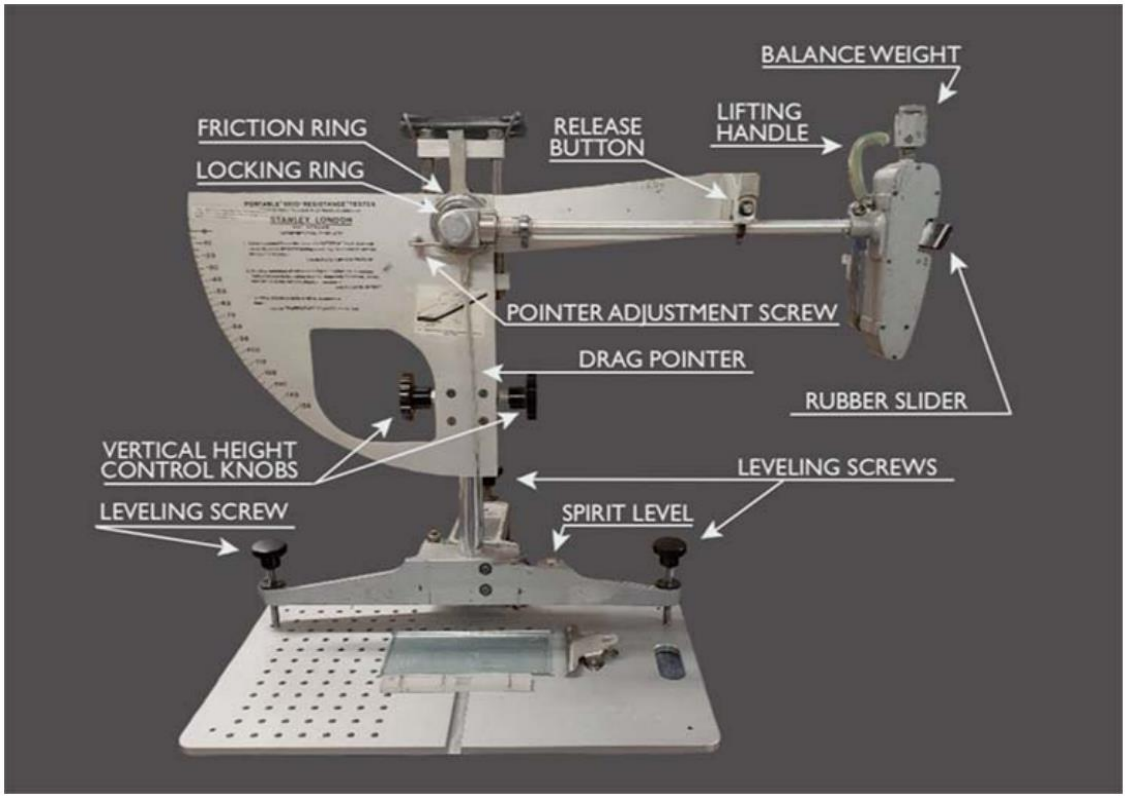

FIG.1 BRITISH PENDULUM TESTER

5.2.1.3 Synthetic rubber as specified in Specification ASTM E501. The rubber compound shall be natural rubber meeting the requirements of the Road Research Laboratory or synthetic rubber as specified in ASTM E 501.

5.2.2 New sliders shall be conditioned prior to use by making ten swings on No. 60 grade silicon carbide c1oth or equivalent under dry conditions. The swings shall be made with a tester adjusted as given in 6.

5.2.3 Wear on the striking edge of the slider shall not exceed 3.2 mm in the plane of the slider of 1.6 mm vertical to it, as illustrated in Fig. 3.

5.3 Accessories

5.3.1 Contact path gage shall consist of a thin ruler suitably marked for measuring contact path length between 124 mm and 127 mm or between 75 mm and 78 mm as required for the particular test.

5.3.2 Miscellaneous equipment, such as water container, surface thermometer, and brush is recommended.

6 TEST SPECIMENS

6.1 Field

Field Test surfaces shal1 be free of loose particles and flushed with clean water. The test surface does not have to be horizontal provided the instrument can be level led in working position using only the leveling screws and the pendulum head will clear the surface.

6.2 Laboratory

Laboratory test panels shal1 be clean and free of loose particles and shall be held rigidly so as not to be moved by the force of the pendulum.

6.2.1 Flat laboratory test panels shal1 have a test surface of at least 89 mm × 152 mm.

6.2.2 Accelerated laboratory polishing-wheel specimens shall have a test surface of at least 44 mm × 89 mm and shall be curved in the arc of a circle 406 mm in diameter.

7 PREPARATIONS OF APPARATUS

7.1 Leveling

Level the instrument accurately by turning leveling screws until the bubble is centered in the spirit level.

7.2 Zero Adjustment

Raise pendulum mechanism by loosening locking knob (directly behind pendulum pivot) and turn either of pair of head movement knobs at center of tester to allow slider to swing free of test surface. Tighten locking knob firmly. Place pendulum in raised and locked position and rotate the drag pointer counter clockwise until it comes to rest against adjustment screw on pendulum arm. Release pendulum and note pointer reading. If reading is not zero, loosen locking ring and rotate friction ring on bearing spindle slightly and lock again. Repeat test and adjust friction ring until the pendulum swing carries pointer to zero.

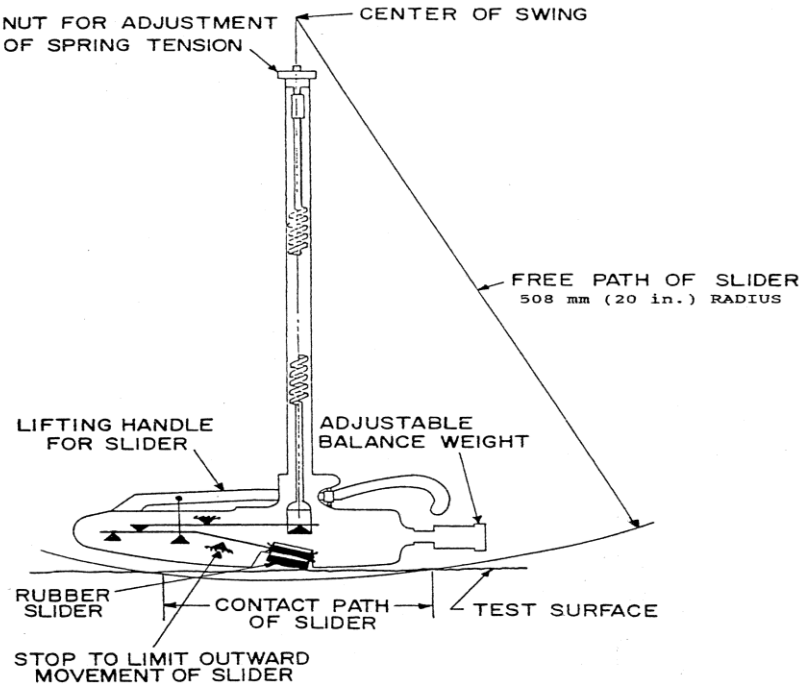

FIG. 2 SCHEMATIC DRAWING OF PENDULUM SHOWING SPRING AND LEVER ARRANGEMENT

7.3 Slide Length Adjustment

7.3.1 With pendulum hanging free, place spacer under adjusting screw of lifting handle. Lower pendulum so edge of slider just touches surface. Lock pendulum head firmly, raise lifting handle, and remove spacer.

7.3.2 Raise slider by lifting handle, move pendulum to right lower slider, and allow pendulum to move slowly to left until edge of slider touches surface. Place gauge beside slider and parallel to direction of swing to verify length of contact path. Raise slider, using lifting handle, and move pendulum to left, then slowly lower until slider edge again comes to rest on surface. If the length of the contact path is not between 124 mm and 127 mm on flat test specimens or between 75 mm and 78 mm on curved polishing-wheel specimens, measured from trailing edge to trailing edge of the rubber slide, adjust by raising of lowering instrument with the height control knob. Lift pendulum and lock in the ready-to release position. Rotate the drag pointer counterclockwise until it comes to rest against adjustment screw on pendulum arm.

NOTE —Operational best practice includes observations of the following aspects of the pendulum tester prior to and during measurements:

a) No obvious damage to any part of the pendulum, main tube support, or face plate;
b) Leveling screws are easy to operate and function properly;
c) Release knob operates properly, and the pendulum arm's catch does not rub or snag in the catch block;
d) Pendulum foot is parallel to the front two feet and frame;
e) Drag pointer is straight, undamaged, and swings with uniform friction;
f) Friction adjustment rings operate and lock properly;
g) Counterweight on the foot is complete and secure; and
h) Slider spring is in place and slider can rotate on the support rod.

8 SLIDER RUBBER STORAGE

8.1 Rubber sliders should be stored at room temperature and out of direct sunlight.

8.2 Discard rubber sliders that don't meet the specified hardness.

8.2.1 *Verification Surface*—A verification surface shall be used at a regular interval to ensure proper operation and accuracy of the pendulum tester. The verification surface shall have a known value against which the results are compared.

NOTE —Several commonly used verification surfaces are available to include: Float glass (BPN 4S value of 5 to 10), 3 mil polyester film made of 3 µm aluminum oxide, commonly referred to as pink lapping film (BPN 4S value of 59 to 64), conditioned Pavigres tile available

from pendulum manufacturers (BPN 4S value of 32 to 36), or No. 60 grade silicon carbide cloth (BPN 4S value of 85 ± 10).

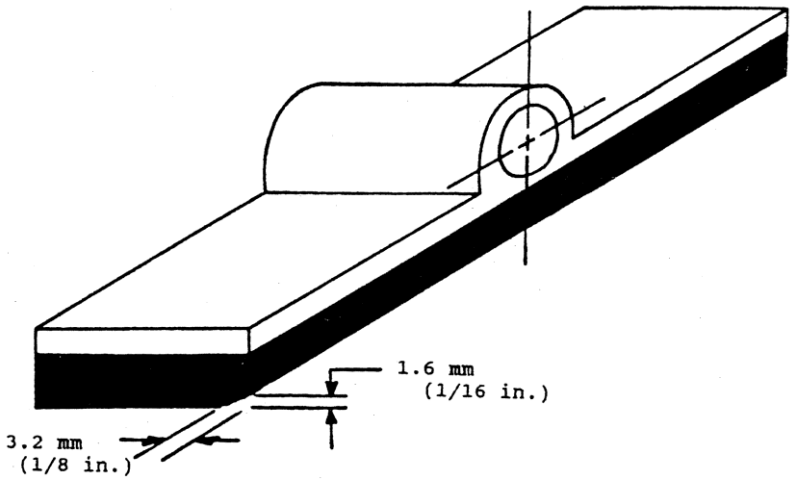

FIG. 3 SLIDER ASSEMBLY ILLUSTRATING THE MAXIMUM WEAR ON STRIKING EDGE

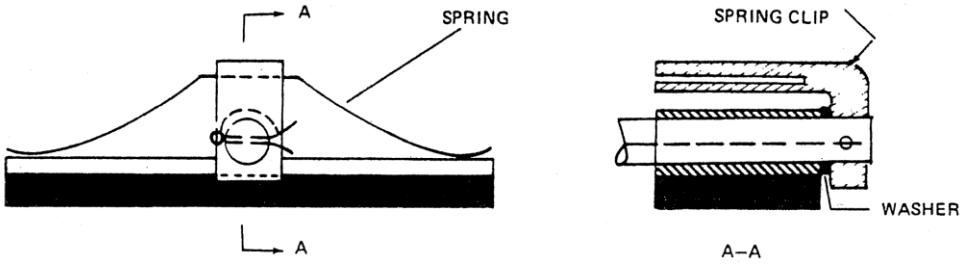

FIG. 4 SPRING CLIP AND SPRING TO INHIBIT SLIDER ROTATION

9 PROCEDURES

9.1 Apply sufficient water to cover the test area thoroughly. Execute one swing, but do not record reading.

NOTE— **9.1** may be omitted to perform dry surface measurements. Data obtained using a dry test method shall be an optional method and must be noted.

9.2 Execute two swings, but do not record readings.

NOTE — Always catch the pendulum during the early portion of its return swing. While returning the pendulum to its starting position, raise the slider with its lifting handle to prevent contact between the slider and the test surface. Prior to each swing, the pointer should be returned until it rests against the adjustment screw.

9.3 Without delay, make four more swings, rewetting the test area each time and record the results.

NOTE — Care should be taken that the slider remains parallel to the test surface during the swings, and does not rotate so that one end rather than the entire striking edge makes the initial contact. Available data indicate that tilting of the slider may cause erroneous BPN readings. Installation of a small flat spring will relieve the problem. The spring can be inserted into a slot in the spring clip and the assembly secured by the cotter pin (*see* Fig. 4). The free ends of the spring can rest on the slider backing plate to restrain the slider from tilting.

9.4 Recheck the slide contact length in accordance with **5.3**. Recheck zero adjustment as described in **7.2**. When upon recheck slider length or zero is not correct, repeat measurements.

10 REPORTS

Report the following information:

a) Individual values in BPN or polish value units;
b) Identify dry surface measurements;
c) Temperature of the test surface;
d) Type, hardness, condition, texture and test surface;
e) Type and source of aggregate for polish value tests; and
f) Type and age of the rubber slider.

11 PRECISION AND BIAS

NOTE — The following material pertains only to the precision and bias of BPN units.

11.1 Repeated tests show standard deviations as follows:

British rubber sliders 1.0 BPN unit
Rubber sliders (conforming to 1.2 BPN units ASTM E 501)

In both cases the upper quartile of variability is represented in prevailing test instruments. As there is no marked correlation between standard deviation and arithmetic mean of sets of test values, it appears that standard deviations are pertinent to this test regardless of the average skid resistance being tested.

11.2 The relationship, if any exists, of observed BPN units to some 'true' value of skid resistance has not and probably cannot be studied. As a result, precision and bias of this test in relation to a true skid resistance measure cannot be evaluated, and only repeatability is given for the method.

11.3 Determine the testing error as follows:

$$E = t \times \sigma \times n^{-1/2}$$

where,

E = testing error,
t = normal curve of 1.96 or 2.0 rounded,
σ = standard deviation of individual test results (BPN units), and
n = number of tests.

11.4 In order to ensure that the testing error stays within 1.0 BPN unit at a 95 percent confidence level (corresponding to a normal curve of 1.96 or 2.0 rounded), the following sample sizes are needed:

British natural rubber slider 4
Synthetic rubber sliders (conforming to 5 ASTM E 501)

ANNEX A

(*Clause* 5.1)

A-1 CALIBRATION

A British pendulum tester calibration procedure is provided in this annex. Calibration may be performed in accordance with the pendulum tester manufacturer's calibration procedure provided the requirements within this standard are met.

A-1.1 Weight of Pendulum

The pendulum arm with mounted rubber slider shall be disconnected from the instrument and weighed to the nearest 1 g.

A-1.2 Center of Gravity

The center of gravity of the pendulum with amountedrubber slider shall be determined by placing the pendulum assembly over a knife edge and experimentally locating the point of balance as shownin Fig. 5. The adapter nut shall be held at the far end ofthe arm by a light paper wedge. After the point of balance has been obtained, the position of the balanceweight shall be adjusted until the sides of the pendulum foot are horizontal.

A-1.3 Distance of Center of Gravity from Center of Oscillation

With the pendulum reconnected to the tester and knurledbearing cap removed, distance shall be measured fromthe center of oscillation (center of bearing nut) to the point of balance (center of gravity). This distance shall be measured directly to the nearest 1 mm.

A-1.4 Slider Load

To verify that the slider (spring) load is 2500 ± 100g , set the pendulum over an electronic scale with a bearing plate so that the pendulum and rubber slider hang directly over the scale without touching as shown in Fig. 6. Insert the spacer supplied by the manufacturer as shown in Fig. 7. The pendulum, with a slider, shall be lowered with the vertical height knobs of the tester until the slider is approximately 0.25 mm from the top surface of the balance. Lock vertical height knob and remove the spacer as shown in Fig. 8. If the average, normal slider load between the 76 mm wide slider and the electronic scale is not within the requirements stated in **5.1**, adjust the spring tension nut illustrated in Fig. 2 and redetermine the slider load.

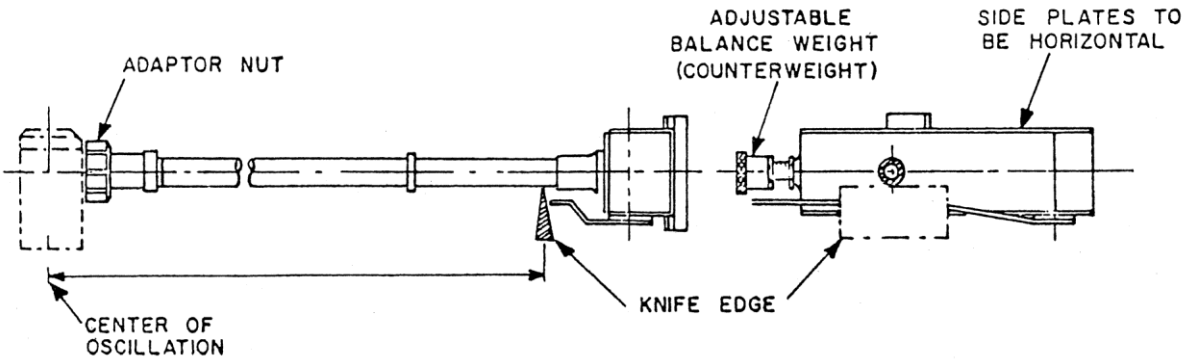

FIG. 5 PENDULAM ASSEMBLY SHOWING LOCATION OF THE POINT OF BALANCE

FIG. 6 ARRANGEMENT OF THE BRITISH PENDULUM TESTER, SHOWING PENDULUM ASSEMBLY AND ELECTRONIC SCALE WITH BEARING PLATE USED TO MEASURE SLIDER LOAD

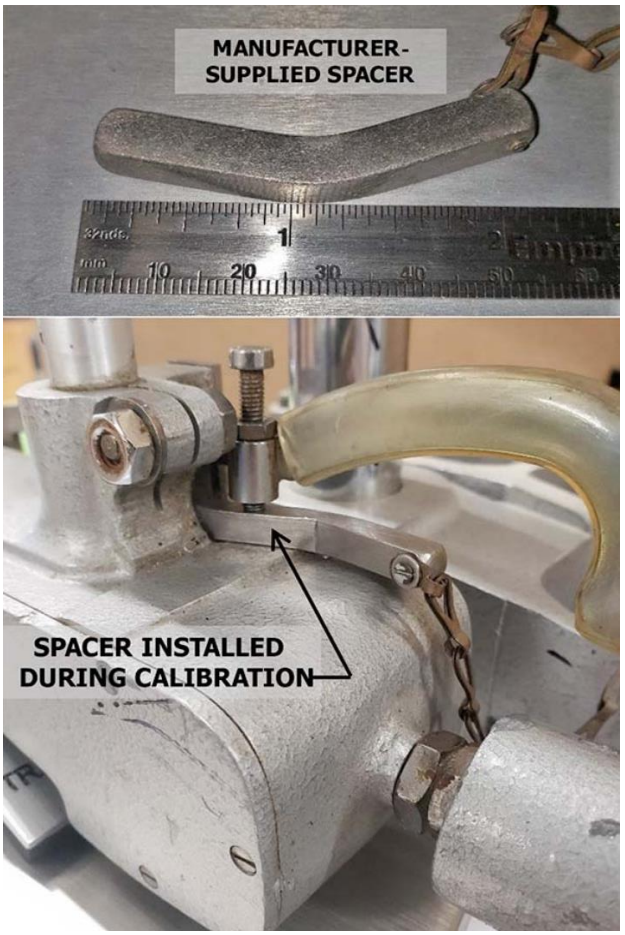

FIG. 7 MANUFACTURER-SUPPLIED SPACER AND LOCATION OF SPACER WHEN INSERTED DURING THE CALIBRATION PROCEDURE

FIG. 8 POSITION OF THE PENDULUM AND RUBBER SLIDER AFTER SPACER IS REMOVED DURING CALIBRATION PROCEDURE

ANNEX B

(*Foreword*)

COMMITTEE COMPOSITION

Automotive Braking Systems, Vehicle Testing, Steering and performance Evaluation Sectional Committee, TED 04

Will be added later