SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1981

REV. MAR2005

Issued 1994-06
Revised 2005-03

Superseding J1981 MAY2002

Road Hazard Impact Test for Wheel and Tire Assemblies (Passenger Car, Light Truck, and Multipurpose Vehicles)

Foreword

This SAE Recommended Practice provides a uniform test procedure for evaluating the effect, on wheel and tire assemblies, of impacting a road hazard such as a pothole. Since this document was first issued comparative testing with instrumented wheels has shown that an improved simulation of a pothole impact can be achieved by setting the striker at an angle. For this reason, the document has been revised to show a striker that can be set to impact the wheel and tire assembly at angles between ±6 degrees at 1 degree increments. The method of articulating the striker is optional but the geometry and mass distribution of the pendulum must be as specified. The equipment can now be used to more closely simulate the conditions of a vehicle pothole test or can be used to evaluate inboard and outboard tire and rim damage separately. Threshold conditions at which damage first occurs can be determined accurately.

1. Scope

The test is designed to evaluate the frontal impact resistance of wheel and tire assemblies used with passenger cars, light trucks and multi-purpose vehicles. The test is specifically related to vehicle pothole tests that are undertaken by most vehicle manufacturers. The scope has been expanded to allow the use of a striker that can be angled to preferentially impact the inboard and outboard wheel flange. For side impact of the outboard rim flange only, please refer to SAE J175. This SAE Recommended Practice provides a procedure to test a wheel or a tire and the test failure criteria. The specific test for a vehicle requires input from a pothole test on that vehicle to establish the drop height of the striker used in this test.

1.1 Rationale

The current SAE 1981 covers equipment and procedures to conduct a frontal impact test on a wheel to simulate a road hazard impact. This review adds the performance requirements for a wheel undergoing the test. The revisions to the standard includes the test parameters of the tire and the wheel. This performance criteria establishes a functional degradation of the wheel due to impact and not cosmetic issues. By establishing the performance level in addition to the test parameters, impact energy levels can be evaluated to further develop the standard for a minimum wheel performance on frontal impacts. Until this test is completed, the specification refers to the actual vehicle pothole test to establish the impact energy or to develop the energy from damage seen on the wheel for real world cases.

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2. References

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS

Available from SAE, 400 Commonwealth Dr. Warrendale, PA 15096-0001.

SAE J175—Wheels—Impact Test Procedure—Road Vehicles
SAE J1982—Nomenclature—Wheels for Passenger Cars, Light Trucks, and Multipurpose Vehicles

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this specification.

2.2.1 SAE PUBLICATION

Available from SAE, 400 Commonwealth Dr. Warrendale, PA 15096-0001.

SAE Technical Paper 940534—Development of the SAE J1981 Road Hazard Impact Test for Wheel and Tire Assemblies. Authors Trevor Brown and Rick Wallace – 1994

2.2.2 ISO PUBLICATIONS

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 7141—Road vehicles—Wheels—Impact procedures
ISO 3911—Wheel/rim for pneumatic tyres—Vocabulary, designation and marking

3. Definitions

For terms and definitions specific to passenger car, light truck and multi-purpose vehicle wheels please refer to SAE J1982.

3.1 Frontal Impact Test Fixture

Test fixture for evaluating the frontal (radial) impact performance of a wheel and tire assemblies.

3.2 Drop Mass

The mass acting through the striker.

3.3 Striker

The shaped projection bolted to the pendulum that impacts the wheel and tire assembly.

3.4 Drop Height

The falling height of the drop mass. (The height of the striker mass center above the wheel hub center).

3.5 Drop Angle

The angle through which the pendulum falls before striking the rim flange. (Using an angle transducer on the pendulum is the best way to calculate the drop height, particularly when the striker is set at an angle.)

3.6 Striker Mass Center

The intersection of the vertical axis through the fulcrum and the horizontal axis through the striker nose center with the pendulum hanging freely.

3.7 Wheel Holding Fixture

Fixture used to securely hold the wheel/tire assembly during testing.

3.8 Pendulum

The swing arm having a fulcrum at one end and the striker at the other end.

3.9 Bed Plate

A substantial member used to locate and securely clamp the wheel holding fixture.

3.10 Frame

A substantial member used to support the fulcrum of the pendulum.

3.11 Catcher

A mechanism that drops into place, after impact, to prevent a second hit.

4. Test Procedure

4.1 Wheels and Tires for Test

Only fully processed new wheels and tires intended for use on the vehicle should be used. The wheels and tires used for test should not be used subsequently on a vehicle intended for normal highway service.

4.2 Equipment

Road hazard test fixture (Figure 1) consisting of:

a. A 1828.8 mm (6ft) pendulum having a drop mass of 54 kg as shown in (Figure 2).
b. A rigid frame to support the pendulum.
c. A device for raising and releasing the pendulum.
d. A device (catcher) for limiting the impact to one hit.
e. A very low friction (self-aligning ball bearing) fulcrum.
f. Striker (Figure 3).
g. Striker Bracket (Figure 4) that allows the Striker to be set for inboard and outboard flange testing or for pothole simulation testing.
h. Striker Assembly (Figure 5) with angle adjustment of ±6 degrees. Bolt sizes are optional but should be substantial enough to resist all impact loads.
i. Bed Plate for rigid support of the frame and wheel holding fixture
j. A wheel holding fixture having a spindle height that matches the height of the striker nose when the pendulum is hanging freely. The stiffness of this fixture is very important; it should very closely approximate the stiffness of the fixture shown in Figure 6.
k. Gage for measuring the drop height or drop angle.

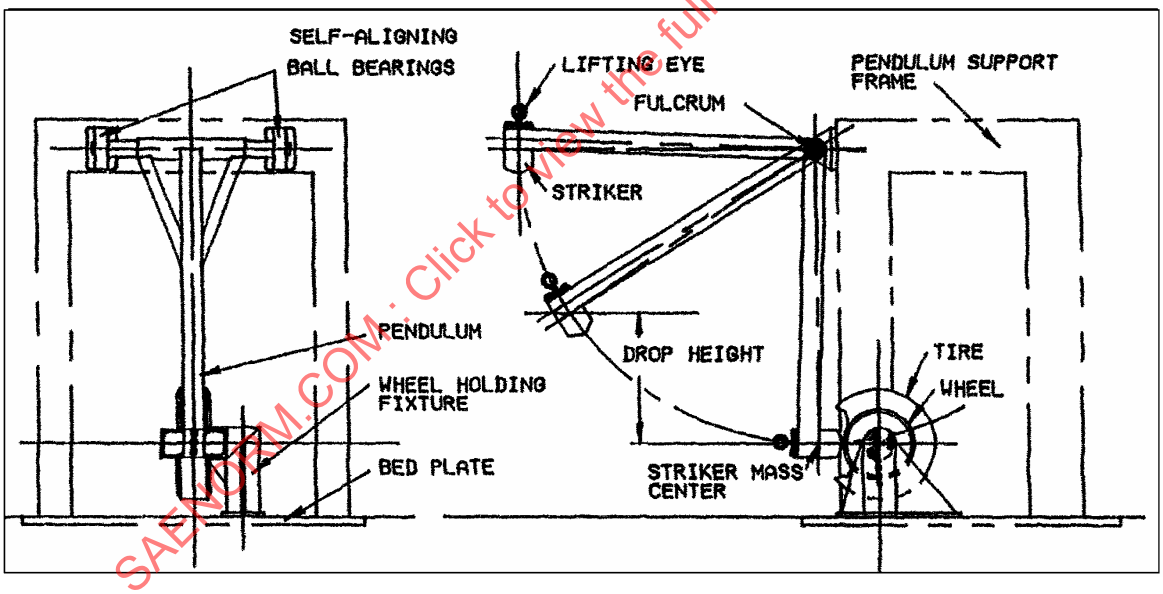

FIGURE 1—SAE J1981 ROAD HAZARD TEST FIXTURE

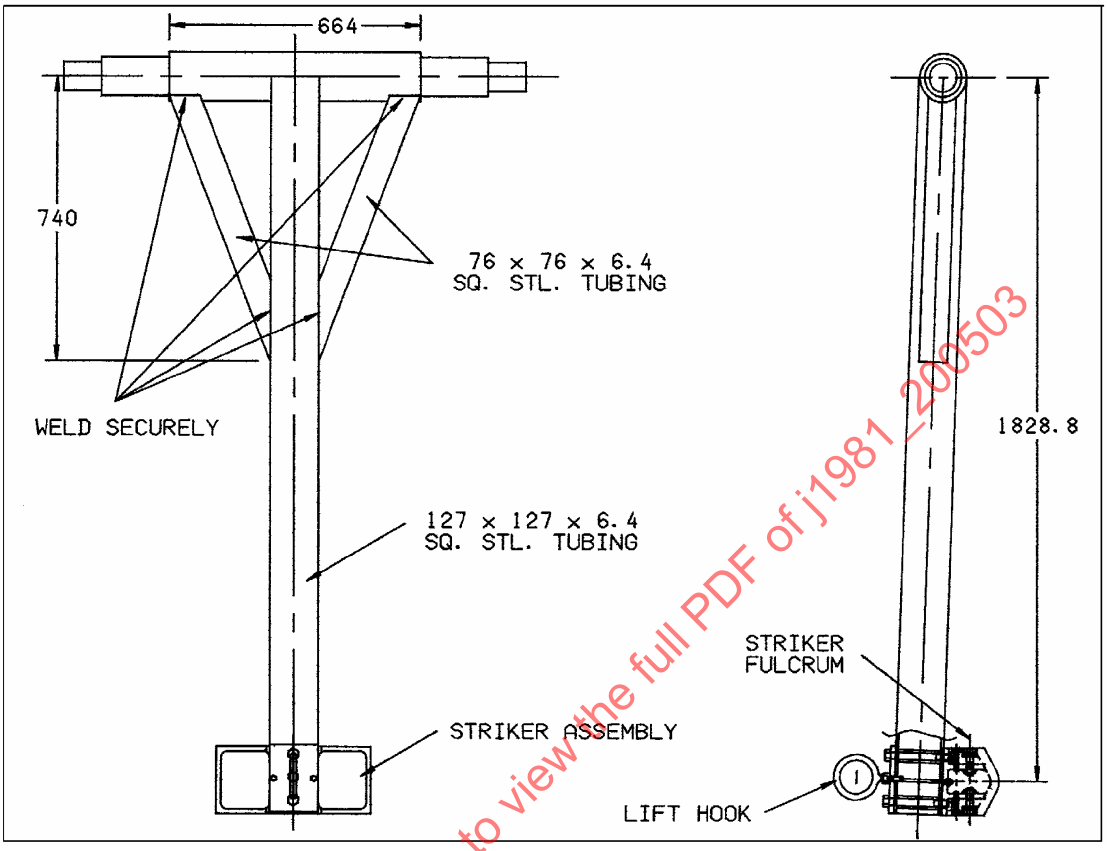

FIGURE 2—SAE J1981 PENDULUM

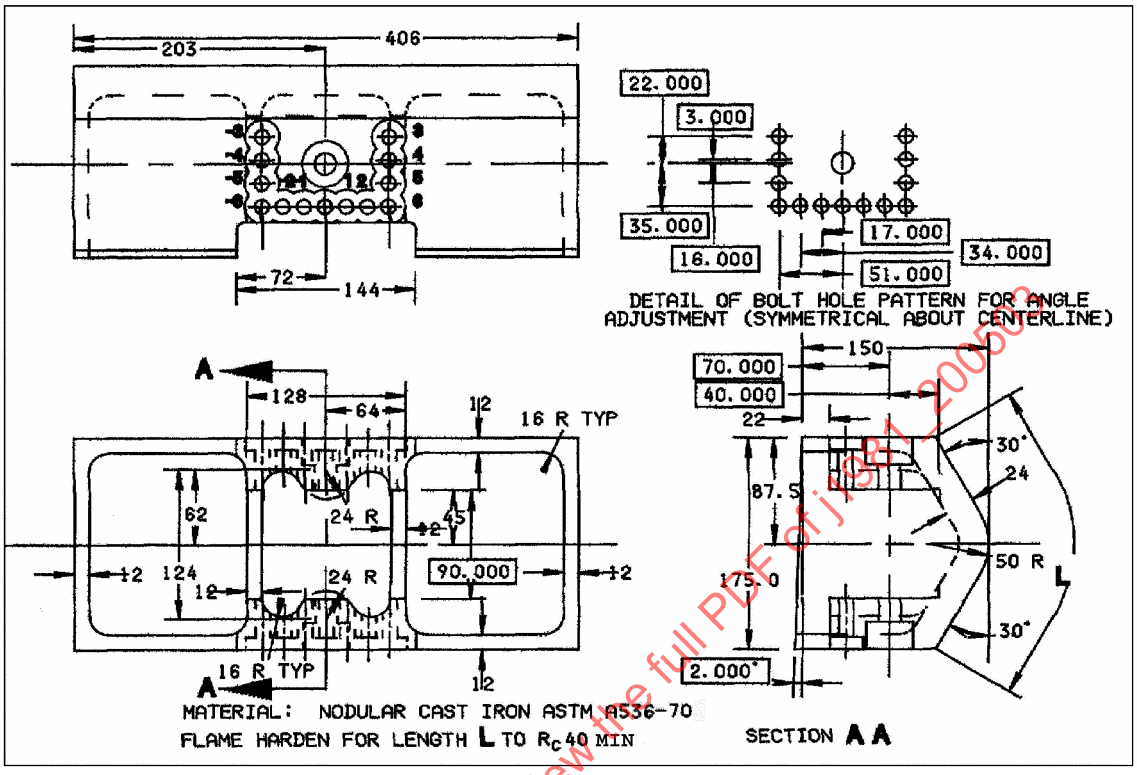

FIGURE 3—SAE J1981 STRIKER

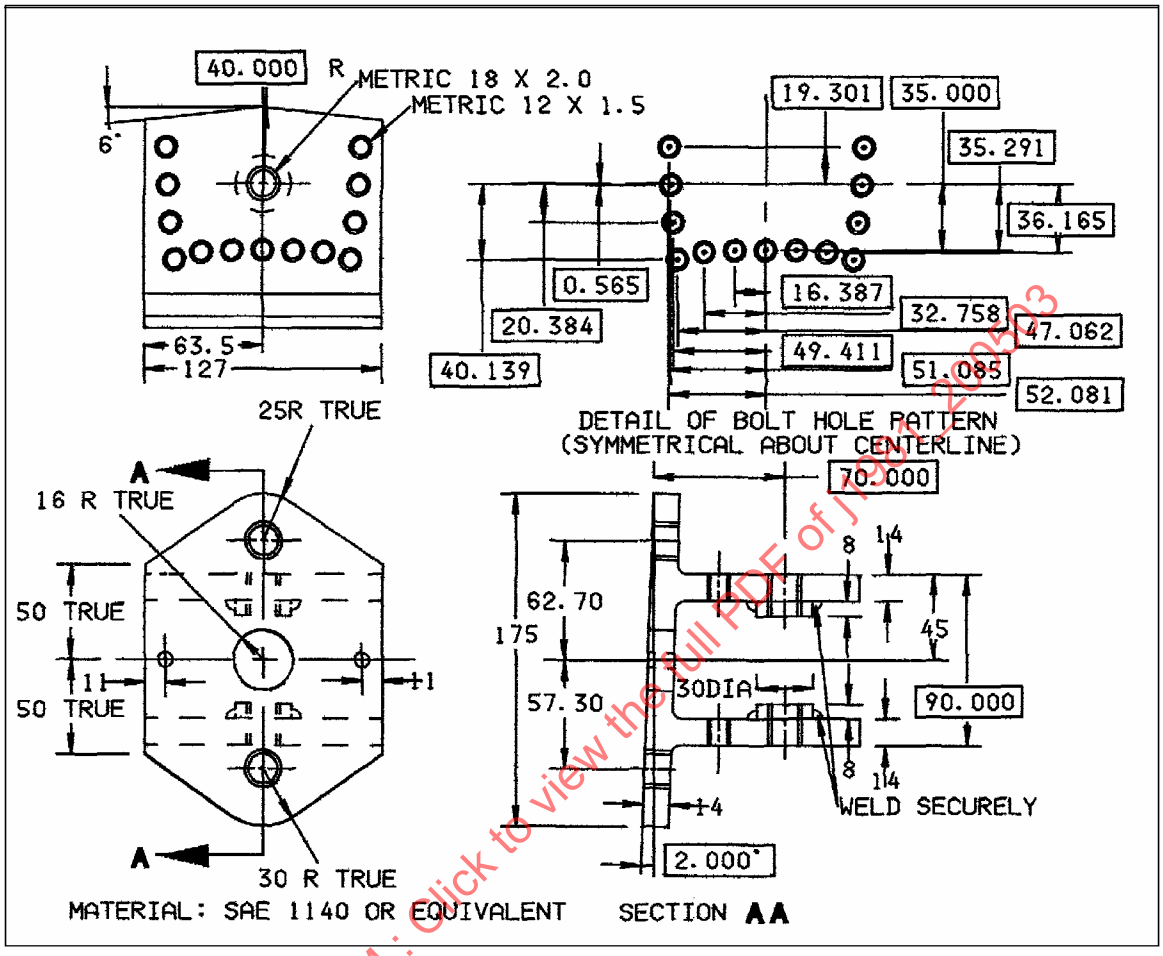

FIGURE 4—SAE J1981 STRIKER BRACKET

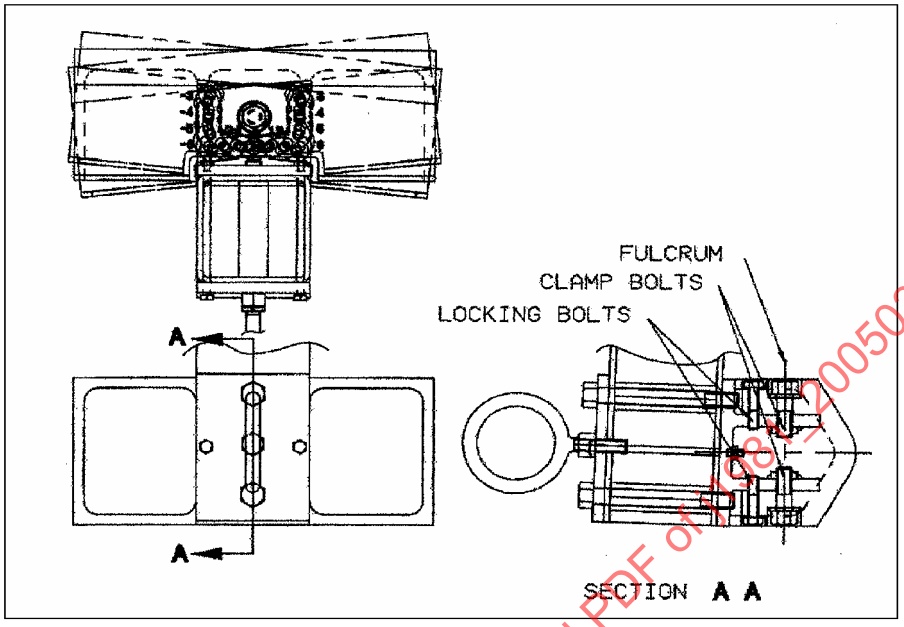

FIGURE 5—SAE J1981 STRIKER ASSEMBLY

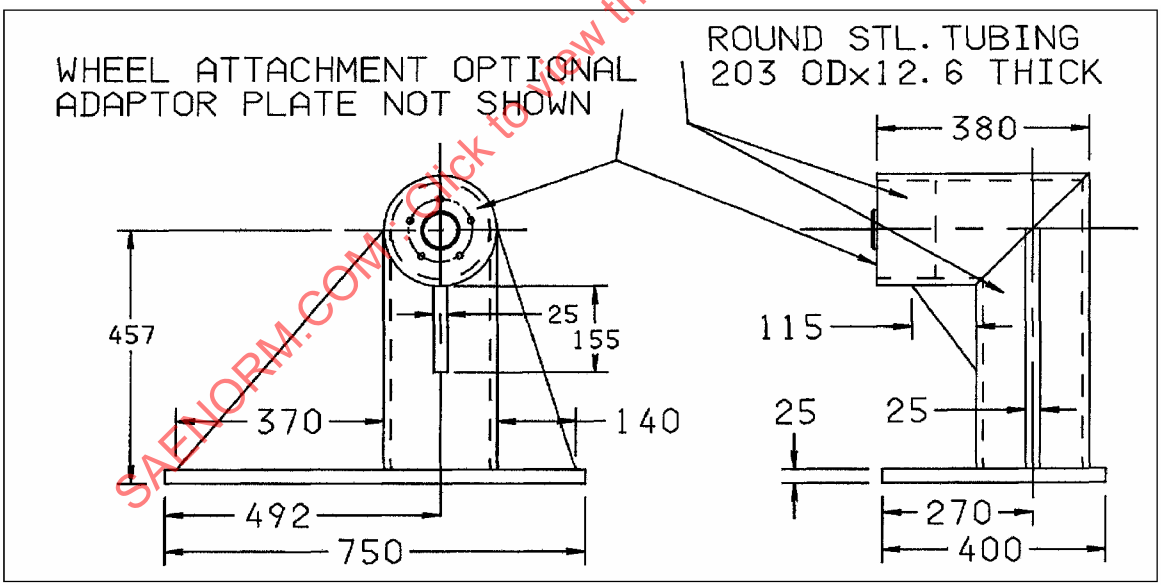

FIGURE 6—SAE J1981 WHEEL HOLDING FIXTURE

4.2.1 EQUIPMENT CALIBRATION

The impact force on the wheel and tire assembly depends upon the length of the pendulum, the inertia of the pendulum, the shape and angle of the striker and the friction at the fulcrum. To be sure the impact force is correct and distributed properly to the inboard and outboard rims make the following checks and calibrations:

a. With the pendulum hanging freely and the striker parallel to the wheel axis, locate and mark the striker mass center used to determine the drop height. The line between the mass center and the fulcrum is required in order to set the pendulum in a "horizontal" position for checks c and g (Figure 7).
b. Confirm the pendulum length (fulcrum to striker mass center) at 1828.8 mm (6 ft) ± 5mm.
c. With the pendulum horizontal and the striker set at zero angle, check that the mass at the striker nose is 54 kg ±0.5 kg (Figure 7).
d. Confirm that the included angle of the striker nose is 120 degrees ± 2°.
e. Confirm that the nose radius of the striker is 50 mm ± 2 mm.
f. Confirm that there is negligible friction or binding of the fulcrum by measuring the velocity of the striker at bottom dead center when released from the horizontal position. The velocity should be 24.3 ± 0.5 km/h. (A slave wheel and tire must be used to stop the pendulum beyond BDC).
g. Check that the wheel center height is the same as the striker mass center height at impact.

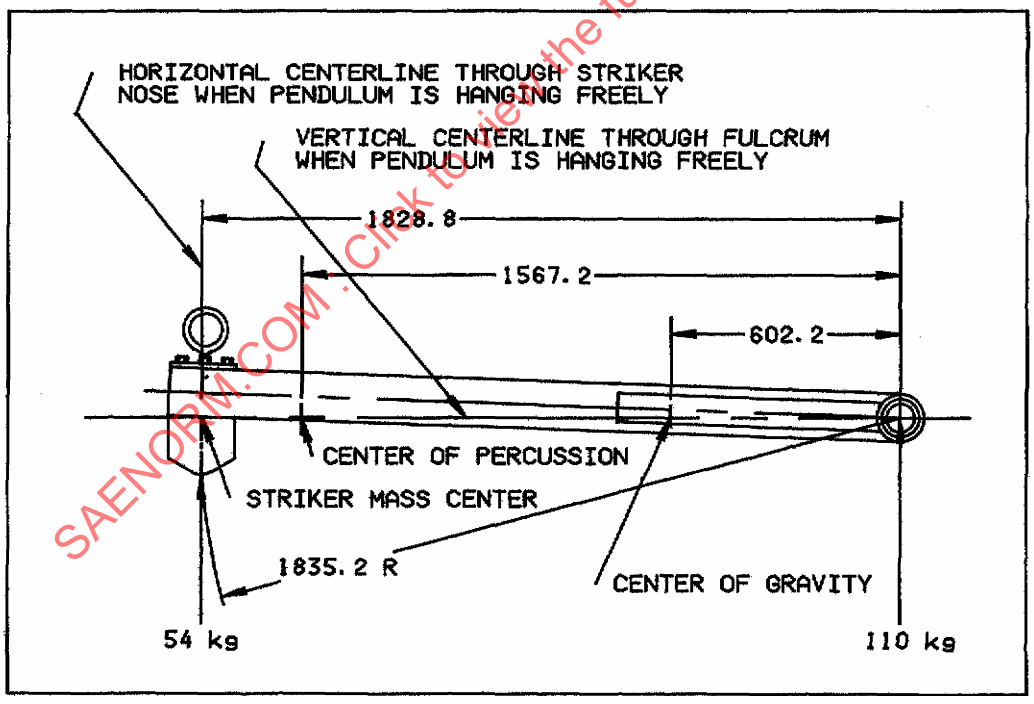

FIGURE 7—PENDULUM GEOMETRY AND MASS DISTRIBUTION

4.3 Procedure

When running the impact test all necessary precautions must be taken to provide a safe operation.

4.3.1 Mount the wheel to the holding fixture and move the holding fixture or pendulum laterally so that the striker is centered with the rim flanges. With the pendulum hanging freely and the striker set parallel to the wheel axis move the holding fixture fore or aft until the striker nose just touches the rim flanges. Bolt the wheel holding fixture securely to the bed plate and lock in place with a suitable stop plate. Remove the wheel from the holding fixture.

4.3.2 Set and lock the striker at the angle required for outboard or inboard flange impact.

4.3.3 TIRE AND WHEEL INSTALLATION

4.3.3.1 Tire and Wheel Selection

The tubeless tire selected for the test wheel shall be the smallest section height tire intended for use with the wheel as specified by the vehicle or wheel manufacturer.

Mount the tire to the wheel.

The test inflation pressure shall be that specified by the vehicle manufacturer for the intended use; in absence of such a specification it shall be 200kPa.

4.3.3.2 Holding Fixture and Torque

The wheel and tire assembly shall be mounted to the holding fixture by a means dimensionally representative of the attachment used on the vehicle. The wheel attachment system shall be manually tightened to 115 Nm ± 7Nm or the torque recommended by the vehicle or wheel manufacturer.

4.3.3.3 Orientation of the Wheel

Orient the wheel spoke to the required test position. When observing for visible damage the same test wheel can be reoriented and retested at one other impact site. The two impact sites should be separated by at least 300mm circumferentially.

4.3.4 Raise the pendulum to the predetermined drop height or equivalent angle. (Height of the striker mass center above the wheel hub center). Set the trigger of the device that prevents the second hit.

4.3.5 Allow the pendulum to fall freely from this predetermined height.

4.3.6 Note and record any visible damage to either rim flange.

4.3.7 Repeat the procedure if the wheel is to be tested with a different spoke orientation.

5. Performance Criteria

5.1 Vehicle Information Required

The angle at which the striker should be set, to simulate a pothole test, must be determined using vehicle test data, in absence of such a specification it shall be 3° ± 1° bias toward the inboard flange (strikes the inboard flange first).

The drop height correlating to a pothole vehicle test must be determined from the vehicle test and similar damage can be developed on this test to relate to this pothole test and to actual field performance of individual vehicles.

5.2 Test Acceptance Crtieria for Wheels

5.2.1 No visible fracture(s) penetrating through a section of the wheel.

5.2.2 No separation of the center member from the rim.

5.2.3 Local radial indentation less than 10mm on the outermost portion of the rim flange in the area directly impacted and no total air loss of the tire pressure within one minute due to the rim indentation.

6. Notes

6.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE WHEEL STANDARDS COMMITTEE

APPENDIX A

A.1 Pendulum Specifications

A.1.1 Fixed

a. Center of Gravity from Fulcrum (a) = 0.6022 m
b. Center of Percussion from C of G (c) = 0.9650 m
c. Moment of Inertia about Fulcrum (I) = 154.77 kg.m²
d. Radius of Gyration about axis through C of G (k) = 0.7623m
e. Fulcrum to Striker Mass Center Length (L) = 1.8288 m
f. Total Mass of Pendulum (m) = 164.0 kg
g. Periodic Time (n) = 0.39812 oscillations/s
h. Equivalent Mass at Center of Percussion (p) = 63 kg
i. Fulcrum to Striker Nose (r) = 1.8352 m

A.1.2 Variable

a. Fall Height of Pendulum C of G (h)
b. Fall Height of Striker Mass Center (H)

A.2 Calculation for Radius of Gyration About Axis through the C of G

$$n = \frac{\sqrt{\frac{9.80665*a}{k^2+a^2}}}{2\pi} \quad \text{(Eq. A1)}$$

$$k^2 = \frac{9.80665*a}{(n*2\pi)^2} - a^2 \quad \text{(Eq. A2)}$$

$$k^2 = \frac{9.80665*0.6022}{(0.39812*2\pi)^2} - 0.6022^2 = 0.581123 \quad \text{(Eq. A3)}$$

$$k = \sqrt{0.581123} = 0.7623 \text{ m} \quad \text{(Eq. A4)}$$

A.3 Calculation for Location (c) of the Center of Percussion from C of G

$$k^2 = a*c \quad \text{(Eq. A5)}$$

$$c = \frac{k^2}{a} = \frac{0.581123}{0.6022} = 0.9650 \text{ m} \quad \text{(Eq. A6)}$$