



SURFACE VEHICLE RECOMMENDED PRACTICE

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Fatigue Test Procedures: Hubs and Wheels for Demountable Rims

RATIONALE

Document was updated as part of the standard Five-Year Review process to current standards and to clarify wording.

1. SCOPE

This SAE Recommended Practice provides uniform laboratory procedures for fatigue testing of wheels for demountable rims and hubs intended for normal highway use on trucks, buses, truck trailers, and multipurpose passenger vehicles. The hubs included have bolt circle diameters ranging from 165.1 to 335.0 mm (6.500 to 13.189 inches). It is up to each hub and/or wheel for demountable rims manufacturer to determine the appropriate test method, accelerated load factor and cycle life requirements applicable to obtain satisfactory service life for a given application. When deviations from the procedures recommended herein are made, it is the responsibility of the hub and/or wheel for demountable rims developer to modify other parameters as necessary to ensure satisfactory service life for the intended application. It should be noted that this test procedure focuses on fatigue resulting from vehicle loading and cornering forces. It does not consider loads imparted to the hub from braking events.

2. REFERENCES

2.1 Applicable Documents

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 International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

| | |
|-----------|--|
| SAE J393 | Nomenclature - Wheels, Hubs, and Rims for Commercial Vehicles |
| SAE J694 | Disc Wheel and Hub or Drum Interface Dimensions - Truck and Bus |
| SAE J851 | Dimensions - Wheels for Demountable Rims, Demountable Rims, and Spacer Bands - Truck and Bus |
| SAE J876 | Wide Base Disc Wheels and Demountable Rims |
| SAE J1671 | Outboard Mounted Brake Drum/Disc Wheel Hub Interface Dimensions - Truck and Bus |
| SAE J1835 | Fastener Hardware for Wheels for Demountable Rims |

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For more information on this standard, visit
https://www.sae.org/standards/content/J1095_202105

SAE J1842 Disc Wheel Hub/Spoke Wheel and Axle Interface Dimensions – Truck and Bus

SAE J2475 Wheel End Assembly and Axle Spindle Interface Dimensions – Truck and Bus

2.1.2 Tire and Rim Association Publications

Available from The Tire and Rim Association, Inc., 4000 Embassy Parkway, Suite 390, Akron, OH 44333, www.us-tra.org.

Engineering Design Information

3. TEST PROCEDURES

3.1 Wheels for Demountable Rims and Hubs for Test

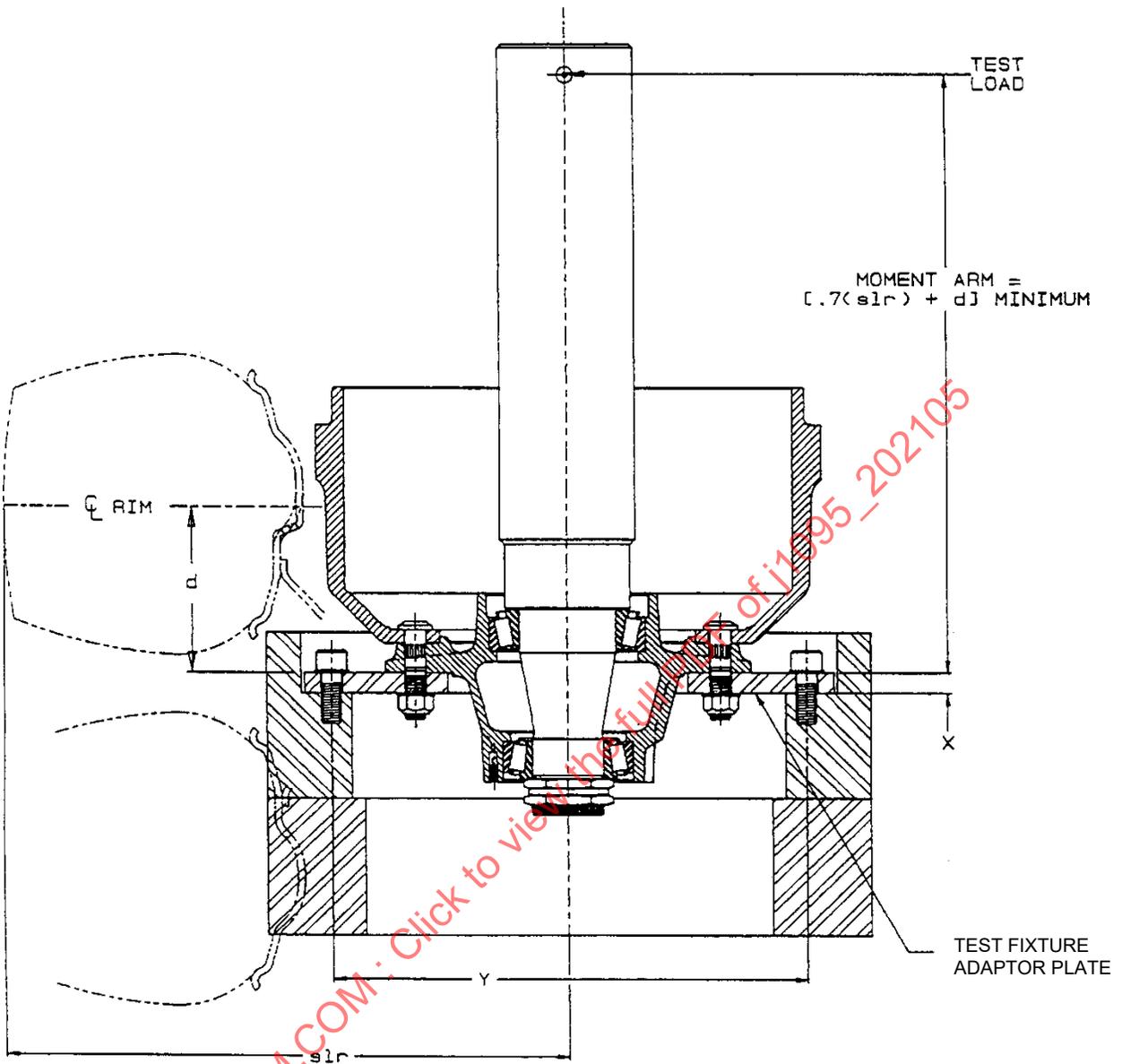
Use only fully processed wheels for demountable rims or hubs which are representative of production parts intended for vehicle installation. New wheels for demountable rims or hubs and related parts shall be used for each test. If the wheel for demountable rims or hub application is ever to be used without a brake drum or rotor, the wheel for demountable rims or hub must be tested without a brake drum or rotor attached. The drum or rotor is optional in other instances. If a drum, rotor, or representative substitute is used for testing, the worst case scenario should be tested. This is typically achieved by use of the thinnest drum or rotor mounting cross section.

3.2 Hub Dynamic Cornering Fatigue Test

3.2.1 Equipment

The test machine shall be one with a means to impart a constant rotating bending moment and radial load to the hub (see Figure 1). Test fixture adaptor dimensions are described in Table 1. Several characteristics related to the adaptor will impact the overall test results. For consistency, it is recommended the adaptor be fabricated from plate steel. Furthermore, the plate thicknesses are most representative of drive and trailer axle configurations. Steer axles will typically use a thinner plate, representative of a single wheel. Consideration should be given to ensuring the test support hardware, such as the adapter plate, bolts, washers, etc., represent the worst-case condition expected in service. Using hardware which alters the system stiffness will result in misleading data.

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d = INSET OF WHEEL FROM TEST FIXTURE ADAPTOR PLATE
 x = TEST FIXTURE ADAPTOR PLATE THICKNESS
 y = TEST FIXTURE ADAPTOR PLATE BOLT CIRCLE (B.C.)
 slr = STATIC LOADED RADIUS OF TIRE

Figure 1 - Hubs: cornering fatigue test (typical set-up)

Table 1 - Test fixture adaptor dimensions

| Mounting System | Hub Bolt Circle Diameter mm | Hub Bolt Circle Diameter Inches | X Plate Thickness mm | X Plate Thickness Inches | Y Plate Outside Bolt Circle Diameter mm | Y Plate Outside Bolt Circle Diameter Inches |
|------------------|-----------------------------|---------------------------------|----------------------|--------------------------|---|---|
| I, VI | | 6.500 | 22.22 | 0.875 | 317.50 | 12.50 |
| XIII | 205.00 | | 20.00 | 0.787 | 317.50 | 12.50 |
| V, VIII, IX, XVI | 222.25 | 8.750 | 19.05 | 0.750 | 317.50 | 12.50 |
| XVII, XVIII | 225.00 | | 19.05 | 0.750 | 317.50 | 12.50 |
| II, XIV | 275.00 | | 22.22 | 0.875 | 444.50 | 17.50 |
| III, X, XI | 285.75 | 11.250 | 22.22 | 0.875 | 444.50 | 17.50 |
| XII | | 13.188 | 17.15 | 0.675 | 444.50 | 17.50 |
| IV | 335.00 | | 17.15 | 0.675 | 444.50 | 17.50 |

Mounting system per SAE J694.

3.2.2 Procedure

Mount the hub assembly to a test fixture adaptor using wheel nuts representative of those required by the application, and torqued to the limits specified in Table 2 for the appropriate application. Bearings and test speed may be adjusted so as to maximize bearing life; however, bearing adjustments may not necessarily be those recommended for commercial practice. Excessively loose bearings may change the failure mode of the hub structure. The mating surfaces of the test adaptor and hub shall be free of paint, dirt, or foreign matter. The final clamped position of the hub without load must not exceed an eccentricity of 0.25 mm (0.010 inch) total indicator reading normal to the shaft axis at the point of loading. The system shall maintain the specified load within $\pm 3\%$. The application of the test load shall be parallel to the plane of the wheel mounting surface of the hub assembly at a specified distance (moment arm) as shown in Figure 1.

3.2.3 Test Load and Bending Moment Determination

The test load is determined by:

$$\text{Test Load} = \frac{M}{\text{Moment Arm}} \quad (\text{See Figure 1}) \quad (\text{Eq. 1})$$

M is determined by the formula:

$$M = (L)[\mu(slr) + d](S) \quad (\text{Eq. 2})$$

where:

M = bending moment, N-m (lbf-in)

μ = coefficient of friction developed between tire and road, use 0.7 for μ

slr = largest static loaded radius of the tires to be used with the hub on the wheel as specified by the current Tire and Rim Association Yearbook or the vehicle/wheel manufacturer, m (in). Use the values of slr found in Table 3.

d = inset or outset (positive for inset, negative for outset) of the wheel, m (inch), as measured from the centerline of the rim to the wheel mounting surface of the hub assembly. For hubs used only with dual wheels, d is zero. For hubs used with single wheels and d values other than zero, use the largest absolute value.

S = accelerated load factor:

| COMMONLY USED |
|---------------|
| 1.0 |
| 1.2 |
| 1.4 |

L = load rating of the hub as specified by the hub manufacturer, N (lbf)

Table 2 - Mounting nut torques for laboratory wheel/rim tests

| Application ⁽¹⁾ | Thread Size | Dry Torque ⁽²⁾ +10%-0% N-m | Dry Torque ⁽²⁾ +10%-0% lbf-ft |
|---|-----------------------|---|--|
| Disc Wheels Light Truck 60 degrees Cone Nuts | M12 x 1.5 | 110 | 80 |
| | 7/16-20 | 110 | 80 |
| | 1/2-20 | 110 | 80 |
| | 9/16-18 | 170 | 125 |
| | 5/8-18 | 170 | 125 |
| Hub Piloted Mounting 1-piece Nut | 9/16-18 | 160 | 120 |
| | 11/16-16 | 410 | 300 |
| Hub Piloted Mounting 2-piece Nut | 9/16-18 | 170 | 125 |
| | 5/8-18 | 180 | 130 |
| | 3/4-16 | 410 | 300 |
| | 7/8-14 ⁽³⁾ | 480 | 350 |
| | 7/8-14 | 610 | 450 |
| | M12 x 1.75 | 115 | 85 |
| | M14 x 1.75 | 180 | 130 |
| | M14 x 2.0 | 150 | 110 |
| | M18 x 1.5 | 260 | 190 |
| | M20 x 1.5 | 380 | 280 |
| M22 x 1.5 | 610 | 450 | |
| Hub Piloted Mounting with Clamp Plate and 90 degree Cone Nuts | 9/16-18 | 150 | 110 |
| | M14 x 1.5 | 150 | 110 |
| | 5/8-18 | 180 | 130 |
| Ball Seat Mounting | 3/4-16 | 610 | 450 |
| | 1-1/8-16 | 610 | 450 |
| Heavy-Duty Ball Seat Mounting | 15/16-12 | 1020 | 750 |
| | 1-5/16-12 | 1020 | 750 |
| Demountable Rims Studs and Nuts | 3/4-10 | 270 | 200 |
| | | | |

(1) For applications and sizes not shown, use torque recommendations prescribed by the wheel/rim or vehicle manufacturer.

(2) Dry torque means no additional lubricants are applied to the fasteners in new condition.

(3) Bus front.

Nut torque values shall be checked and reset periodically during the course of a test in order to compensate for “wearing in” of mating surfaces.

Table 3 - Static loaded radii for bending moment calculations

| Size | slr m | slr Inches | Size | slr m | slr Inches |
|------------------------------|----------|---------------|--|----------|---------------|
| 5 degrees | | | Tubeless - 15 degrees (continued) | | |
| 8.25R20 | 0.452 | 17.8 | 9R22.5 | 0.460 | 18.1 |
| 9.00R20 | 0.480 | 18.9 | 10R22.5 | 0.480 | 18.9 |
| 10.00R20 | 0.495 | 19.5 | 11R22.5 | 0.506 | 19.9 |
| 11.00R20 | 0.513 | 20.2 | 12R22.5 | 0.513 | 20.2 |
| 12.00R20 | 0.523 | 20.6 | 255/70R22.5 | 0.439 | 17.3 |
| 14.00R20 | 0.569 | 22.4 | 275/70R22.5 | 0.452 | 17.8 |
| 365/80R20 | 0.503 | 19.8 | 305/70R22.5 | 0.465 | 18.3 |
| | | | 365/70R22.5 | 0.498 | 19.6 |
| 11.00R22 | 0.539 | 21.2 | 245/75R22.5 | 0.447 | 17.6 |
| | | | 265/75R22.5 | 0.462 | 18.2 |
| 11.00R24 | 0.559 | 22.0 | 295/75R22.5 | 0.485 | 19.1 |
| 12.00R24 | 0.572 | 22.5 | 235/80R22.5 | 0.442 | 17.4 |
| | | | 255/80R22.5 | 0.455 | 17.9 |
| | | | 275/80R22.5 | 0.478 | 18.8 |
| | | | 295/80R22.5 | 0.493 | 19.4 |
| | | | 315/80R22.5 | 0.511 | 20.1 |
| | | | 11R24.5 | 0.531 | 20.9 |
| Tubeless - 15 degrees | | | 12R24.5 | 0.539 | 21.2 |
| 9R17.5 | 0.391 | 15.4 | 285/75R24.5 | 0.500 | 19.7 |
| 10R17.5 | 0.399 | 15.7 | 305/75R24.5 | 0.508 | 20.0 |
| 10R17.5HC | 0.409 | 16.1 | 275/80R24.5 | 0.490 | 19.3 |
| 215/75R17.5 | 0.363 | 14.3 | Wide Base - Tubeless - 15 degrees | | |
| | | | 445/65R19.5 | 0.495 | 19.5 |
| 8R19.5 | 0.406 | 16.0 | | | |
| 225/70R19.5 | 0.389 | 15.3 | 445/50R22.5 | 0.483 | 19.0 |
| 245/70R19.5 | 0.399 | 15.7 | 455/55R22.5 | 0.495 | 19.5 |
| 265/70R19.5 | 0.404 | 15.9 | 385/65R22.5 | 0.506 | 19.9 |
| 285/70R19.5 | 0.414 | 16.3 | 425/65R22.5 | 0.526 | 20.7 |
| 305/70R19.5 | 0.424 | 16.7 | 445/65R22.5 | 0.539 | 21.2 |

For tire sizes not shown, the reference static loaded radius (slr) is determined by the equations as shown in the current Tire and Rim Association, Inc. Engineering Design Information (EDI), <http://www.us-tra.org>.

3.3 Wheels for Demountable Rims, Dynamic Cornering Fatigue Test

3.3.1 Equipment

The test machine shall be such that either the wheel for demountable rims rotates under the influence of a stationary bending moment, or the stationary wheel for demountable rims is subjected to a rotating bending moment (see Figure 2).

3.3.2 Procedure

The wheel for demountable rims shall be clamped securely to the test device using studs and nuts representative of those specified for the wheel assembly. The rim clamp nuts shall be tightened to the torque limits specified in Table 2 for the thread size listed for wheels for demountable rims. Bearings and test speed may be adjusted so as to maximize bearing life; however, bearing adjustments may not necessarily be those recommended for commercial practice. Excessively loose bearings may change the failure mode of the wheel structure. The mating surface of the test adaptor and wheel for demountable rims shall be free of excessive buildup of paint, dirt, or foreign material. A rigid load arm shaft shall be attached to the hub of the wheel for demountable rims. The final clamped position of the wheel without load shall not exceed 0.25 mm (0.010 inch) total indicator reading normal to the shaft axis at the point of loading. The load system must maintain the specified test load within $\pm 3\%$.

3.3.3 Test Load and Bending Moment Determination

The test load is determined by:

$$\text{Test Load} = \frac{M}{\text{Moment Arm}} \quad (\text{See Figure 2}) \quad (\text{Eq. 3})$$

M is determined by the formula:

$$M = (L)\mu(\text{slr})(S) \quad (\text{Eq. 4})$$

where:

M = bending moment, N-m (lbf-in)

μ = coefficient of friction developed between tire and road, use 0.7 for μ

slr = largest static loaded radius of the tires to be used on the wheel for demountable rims as specified by the current Tire and Rim Association Yearbook or the vehicle/wheel manufacturer, m (inch). Use the values of slr found in Table 3.

S = accelerated load factor. See Table 4.

L = load rating of the wheel for demountable rims as specified by the wheel manufacturer, N (lbf)

3.3.4 Accelerated Load Factor and Cycle Targets

Table 4 - Typical "S" factors and cycle life targets for ferrous wheels

| SAE J1095 Paragraph | Load Angle | Moment Arm | Accelerated Load Factor | Minimum Cycle Life Target |
|---------------------|------------|--------------|-------------------------|---------------------------|
| 3.3 | 90 degrees | See Figure 2 | 1.9 | 35000 |
| | | | 1.5 | 100000 |

A wheel design that meets or exceeds the pairing of accelerated load factor and minimum cycle life target in Table 4 should provide acceptable field performance in its intended vocation. However, these should not be used as the sole acceptance criteria. The wheel manufacturer must determine the additional validation processes and requirements appropriate for the wheel.

It should be noted that the test conditions do not consider braking loads. The wheel manufacturer should determine if additional requirements are appropriate based on the intended use.

3.4 Test Termination Definitions

3.4.1 Inability to sustain load.

3.4.2 A visually detected fatigue crack penetrating through a section.

3.4.3 Loose bearing cup.

3.4.4 Broken studs before 20000 cycles.

3.5 Test Disqualification

If any failure of the test fixture or associated parts (i.e., shaft, bearings, adaptor plate, etc.) occurs during test, the test may be disqualified if the failure is deemed to have affected the life characteristics of the wheel for demountable rims or hub under test.

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