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SURFACE VEHICLE RECOMMENDED PRACTICE

Submitted for recognition as an American National Standard

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(R) SPOKE WHEELS AND HUB FATIGUE TEST PROCEDURES

1. ***Scope***—This SAE Recommended Practice provides uniform laboratory procedures for fatigue testing of spoke wheels and hubs intended for normal highway use on trucks, buses, truck trailers, and multipurpose passenger vehicles. The hubs included have bolt circle diameters from 165.1 to 335.0 mm (6.50 to 13.19 in). The tests described in this document are not to be construed as the only tests required or permitted to assure that a spoke wheel or a hub will perform satisfactorily for its intended use.

2. ***References***

2.1 Applicable Documents—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J393—Nomenclature—Wheels, Hubs and Rims for Commercial Vehicles

SAE J694—Disc Wheel/Hub or Drum Interface Dimensions—Commercial Vehicles

SAE J851—Dimensions—Wheels for Demountable Rims, Demountable Rims, and Rim Spacers—Commercial Vehicles

SAE J1835—Fastener Hardware for Spoke Wheels

3. ***Test Procedures***

3.1 Spoke Wheels and Hubs for Test—Use only fully processed spoke wheels or hubs which are representative of production parts intended for vehicle installation. New spoke wheels or hubs and related parts shall be used for each test. If the spoke wheel or hub application is always used with a brake drum or rotor, the spoke wheel or hub may be tested with a brake drum or rotor attached. If the spoke wheel or hub application is ever to be used without a brake drum or rotor, the spoke wheel or hub must be tested without a brake drum or rotor attached.

3.2 Hub Dynamic Fatigue Test—The dynamic fatigue test may be conducted by one of the following methods:

3.2.1 CORNERING FATIGUE, 90 DEGREE LOADING METHOD

3.2.1.1 *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.

3.2.1.2 *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. Exces-

TABLE 1—TEST FIXTURE ADAPTOR DIMENSIONS

Hub Bolt Circle Diameter mm	(in)	X; Plate Thickness mm	(in)	Y; Plate Outside Bolt Circle Diameter mm	(in)
165.1	(6.500)	22.22	(0.875)	317.50	(12.50)
170.0	—	22.22	(0.875)	317.50	(12.50)
205.0	(8.000)	20.00	(0.787)	317.50	(12.50)
222.25	(8.750)	19.05	(0.750)	317.50	(12.50)
275.00	—	22.22	(0.875)	444.50	(17.50)
285.75	(11.250)	22.22	(0.875)	444.50	(17.50)
335.00	(13.188)	17.16	(0.675)	444.50	(17.50)

NOTE—These steel plate thickness selections give 131 to 145 MPa (19 000 to 21 000 psi) radial bending stress at the inner bolt circle of the adaptor plate when loaded with the typical test loading for each specified bolt circle.

sively 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 in) total indicator reading normal to the shaft axis at the point of loading. The system shall maintain the specified load within +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.

3.2.1.3 *Test Load and Bending Moment Determination*—The test load is determined by Equation 1:

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

M is determined by the formula:

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

where:

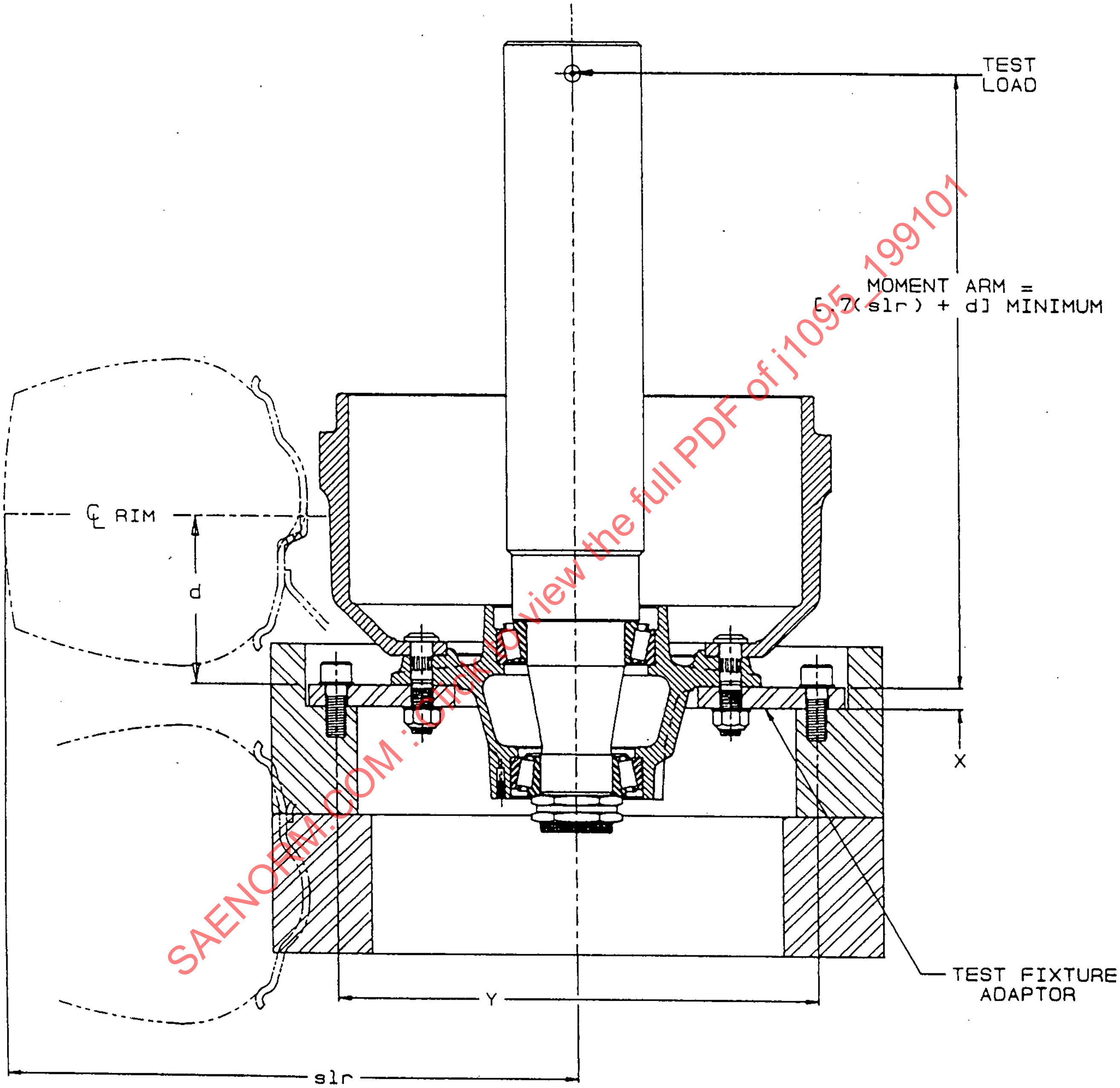
- M = Bending moment, N.m (lbf-in)
- μ = Coefficient of friction developed between tire and road (0.7)
- slr = Static loaded radius of the largest tire to be used with the hub as specified by the vehicle manufacturer, millimeters, (in $\times 10^{-3}$). Refer to Table 3 for static loaded radius.
- d = Inset of disc wheel; millimeters (in $\times 10^{-3}$) 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 both dual and single wheels with d values other than zero, use the largest absolute value. See Figure 4 in SAE J393 to determine if d is positive or negative.
- S = Accelerated test load factor.
- L = Load rating of the hub as specified by the hub manufacturer, N (lbf)

3.2.1.4 *Accelerated Test Load Factor*—See Table 4.

3.2.2 CORNERING FATIGUE, ANGULAR LOADING METHOD

3.2.2.1 *Equipment*—The test machine shall be one with a means to impart constant rotating bending moment and axial and radial load to the hub (see Figure 2). Test fixture adaptor dimensions are shown in Table 1.

3.2.2.2 *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



d = INSET OF WHEEL
X = ADAPTOR PLATE THICKNESS
Y = ADAPTOR PLATE BOLT CIRCLE (B.C.)
slr = STATIC LOADED RADIUS OF TIRE

FIGURE 1—90 DEGREE CORNERING FATIGUE TEST (TYPICAL SET-UP)

TABLE 2—MOUNTING NUT TORQUES FOR LABORATORY WHEEL/RIM TESTS

Application[1]	Thread Size	Torque (dry)[2] +10% −0% N-m	(lbf-ft)
Disc Wheels	M12 × 1.5	110	(80)
Passenger type light truck mounting	7/16-20	110	(80)
	1/2-20	110	(80)
	9/16-18	150	(110)
	5/8-18	170	(125)
In-out coined mounting cone seat nut	9/16-18	240	(175)
	5/8-18	240	(175)
In-out coined mounting flange nut	5/8-18	370	(275)
Hub piloted mounting 1-pc nut	9/16-18	160	(120)
	5/8-18	—	—
	11/16-16	410	(300)
	3/4-16	610	(450)
	7/8-14	—	—
	M14 × 1.5	—	—
	M18 × 1.5	—	—
	M20 × 1.5	—	—
	M22 × 1.5	—	—
	M22 × 1.5[3]	—	—
2-pc nut	9/16-18	170	(125)
	5/8-18	180	(130)
	11/16-16	340	(250)
	3/4-16	410	(300)
	7/8-14	470	(350)
	M14 × 1.5	170	(125)
	M18 × 1.5	260	(190)
	M20 × 1.5	380	(280)
	M22 × 1.5	530	(390)
	M22 × 1.5[3]	610	(450)
Hub Piloted mounting with clamp plate	9/16-18	150	(110)
	M14 × 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	5/8-11	200	(150)
	3/4-10	260	(190)

[1] For applications and sizes not shown, use torque recommendations prescribed by the wheel/rim or vehicle manufacturer.
[2] Nut torque values shall be checked and reset periodically during the course of a test in order to compensate for the "wearing in" of mating surfaces.
[3] Spring type flange.

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 in) total indicator reading normal to the shaft axis at the point of loading. The system shall maintain the specified load within +3%. The application of the test load shall be at an angle from a plane through the load centerline of the rim as shown in Figure 2.

TABLE 3—AVERAGE STATIC LOADED RADII FOR CORNERING TEST CALCULATIONS

TABLE 3A—Light Truck Tires

Size	slr mm	slr in
6.50-16 LT	356	14.0
6.70-15 LT	348	13.7
7.00-15 LT	356	14.0
7.50-16 LT	381	15.0
Tubeless-5 degree		
LT175/75-14	292	11.5
LT185/75-14	282	11.1
LT195/75-14	300	11.8
LT195/75-15	312	12.3
LT215/75-14	312	12.3
LT205/75-15	305	12.0
LT215/75-15	325	12.8
LT235/75-15	338	13.3
LT225/75-16	345	13.6
LT245/75-16	358	14.1
LT265/75-16	371	14.6
LT285/75-16	384	15.1
LT215/85-16	361	14.2
LT235/85-16	373	14.7
LT255/85-16	389	15.3
9-15 LT	351	13.8
10-15	361	14.2
11-15 LT	384	15.1
12-15 LT	394	15.5
Tubeless-15 degree		
7-17.5 LT	361	14.2
8.00-16.5 LT	340	13.4
8-17.5 LT	373	14.7
8.75-16.5 LT	356	14.0
9.50-16.5 LT	366	14.4
10-16.5 LT	361	14.2
10-17.5 LT	368	14.5
12-16.5 LT	386	15.2

TABLE 3B—Heavy Truck Tires

Size	slr mm	slr in
7.50-15 TR	381	15.0
7.50-17	404	15.9
7.50-18	419	16.5
7.50-20	452	17.8
8.25-15 TR	401	15.8
8.25-17	427	16.8
8.25-20	472	18.6
9.00-15 TR	419	16.5
9.00-20	488	19.2
10.00-15 TR	434	17.1
10.00-20	508	20.0
10.00-22	531	20.9
11.00-15 TR	450	17.7
11.00-20	516	20.3
11.00-22	541	21.3
11.00-24	572	22.5
12.00-20	531	20.9
12.00-24	582	22.9
13.00-20	541	21.3
14.00-20	584	23.0
14.00-24	635	25.0
16.00-20	612	24.1
Tubeless-15 degree		
8R17.5 HC	371	14.6
8-19.5	409	16.1
8-22.5	447	17.6
9R17.5 HC	391	15.4
9-22.5	465	18.3
10R17.5 HC	401	15.8
10-22.5	488	19.2
11R17.5 HC	419	16.5
11-22.5	503	19.8
11-24.5	528	20.8
12-22.5	516	20.2
12-24.5	536	21.1
12.5-22.5	518	20.4
12.75-22.5	521	20.5
245/75-22.5	437	17.2
265/75-22.5	457	18.0
295/75-22.5	480	18.9
285/75-24.5	495	19.5

NOTE—For tire sizes not shown, use the slr listed in the individual tire manufacturer's Tire Data Book.

TABLE 4—TYPICAL "S" FACTORS FOR HUBS

J1095 Paragraph	Load Angle	Reference Arm	"S" Factor
3.2.1	90 degrees with respect to the load shaft axis	See Figure 1	1.0 1.2 1.4
3.2.2	40 degrees with respect to the adaptor plate plane	See Figure 2	1.6
	10 degrees with respect to the adaptor plate plane	See Figure 2	2.0 2.5
3.2.3	Camber Angle 0 degrees Steer Angle 0 degrees		1.4 1.6 1.9 2.0 2.8

3.2.2.3 *Test Load and Reference Arm Determination*—The test load and reference arm are determined as follows:

$$D = \frac{(L) \times (S)}{\cos \phi} \qquad \text{(Eq.3)}$$

where:

D = Diagonal test load resultant; N (lbf)

L = Load rating of the hub as specified by the hub manufacturer; N (lbf)

S = Accelerated test load factor

ϕ = Test load angle

$$\text{Reference Arm} = (\text{slr}) \tan \phi + d \qquad \text{(Eq.4)}$$

where:

slr = Static loaded radius of the largest tire to be used with the hub as specified by the vehicle manufacturers, millimeters (in). Refer to Table 3 for static loaded radius.

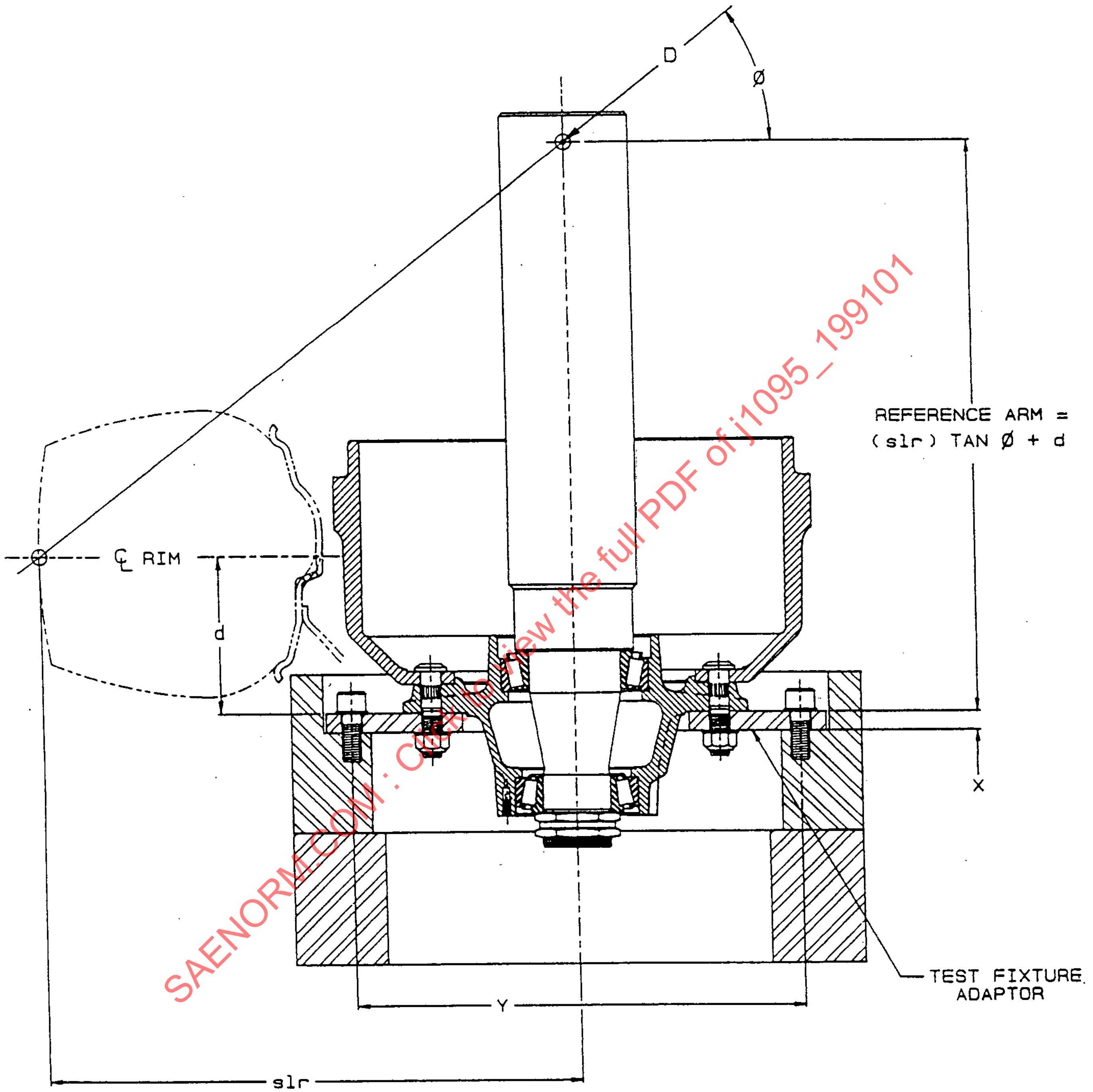
d = Inset of disc wheel; millimeters (in $\times 10^{-3}$) as measured from the centerline of the rim to the wheel mounting surface of the hub assembly. For hubs used only with dual wheels, d is zero. For hubs used with both dual and single wheels with d values other than zero, use the largest absolute value. See Figure 4 in SAE J393 to determine if d is positive or negative.

3.2.2.4 *Accelerated Test Load Factor*—See Table 4.

3.2.3 DYNAMIC RADIAL FATIGUE TEST

3.2.3.1 *Equipment*—The test machine shall be one with a driven, rotatable drum which presents a smooth surface wider than the loaded test tire section width. The suggested diameter of the drum is 1707.6 mm (67.23 in) which results in 186 revolutions per kilometer (300 revolutions per mile). The test wheel and tire fixture must provide loading normal to the surface of the drum, and in line radially with the center of the test wheel and the drum.

3.2.3.2 *Procedure*—Tires selected for this test shall be representative of a size and construction approved by the Tire and Rim Association and the wheel/rim manufacturer for the wheel/rim under test. The spoke wheel or hub assembly shall be mounted to the test fixture spindle substantially as in service. Camber and/or steer angles may be incorporated in the test; however, these angles must be noted in the test results. Bearings may be adjusted to maximize bearing life. The wheel nuts shall be torqued to the limits specified in Table 2 for the size and type of nut used. The test load and the inflation pressure are based on the wheel/rim ratings. Test inflation pressure should



D = DIAGONAL LOAD
d = INSET OF WHEEL
X = ADAPTOR PLATE THICKNESS
Y = ADAPTOR PLATE BOLT CIRCLE (B.C.)
slr = STATIC LOADED RADIUS OF TIRE

FIGURE 2—ANGULAR CORNERING FATIGUE TEST (TYPICAL SET-UP)

be selected in accordance with Table 5. The selected test inflation pressure and load shall both be maintained within ±3%.

TABLE 5—TEST INFLATION PRESSURES

Max Inflation Pressure Rating kPa	Max Inflation Pressure Rating psi	Minimum Test Pressure
0 through 310	0 through 45	450 kPa (65 psi)
Over 310	Over 45	1.2 x Max. Inflation Pressure Rating

3.2.3.3 *Radial Load Determination*—The radial load is determined as follows:

$$R = L \cdot S \qquad \text{(Eq.5)}$$

where:

R = radial load, N (lbf)

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

S = accelerated test factor

3.2.3.4 *Accelerated Test Load Factor*—See Table 4.

3.3 Spoke Wheels, Cornering Fatigue Test

3.3.1 EQUIPMENT—The test machine shall be such that either the spoke wheel rotates under the influence of a stationary bending moment, or the stationary spoke wheel is subjected to a rotating bending moment. (See Figure 3.)

3.3.2 PROCEDURE—The spoke wheel 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 spoke wheels. 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 spoke wheel 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 spoke wheel. The final clamped position of the wheel without load shall not exceed 0.25 mm (0.010 in) total indicator reading normal to the shaft axis at the point of loading. The load system must maintain the specified test load within +3%.

3.3.3 TEST LOAD AND BENDING MOMENT DETERMINATION—The test load is determined by:

$$\text{Test Load} = \frac{M}{\text{Moment Arm}} \text{ (See Figure 3)} \qquad \text{(Eq.6)}$$

M is determined by the formula:

$$M = \mu(slr)(S)(L) \qquad \text{(Eq.7)}$$

where:

M = Bending moment, N·m (lbf-in)

μ = Coefficient of friction developed between tire and road (0.7)

slr = Static loaded radius of the largest tire to be used on the spoke wheel as specified by the vehicle or wheel manufacturer, millimeters (in $\times 10^{-3}$). Refer to Table 3 for static loaded radius.

S = Accelerated test factor. Refer to Table 6.

L = Load rating of the spoke wheel as specified by the wheel manufacturer, N (lbf)

3.3.4 TEST FACTOR AND CYCLE REQUIREMENTS—Refer to Table 6.

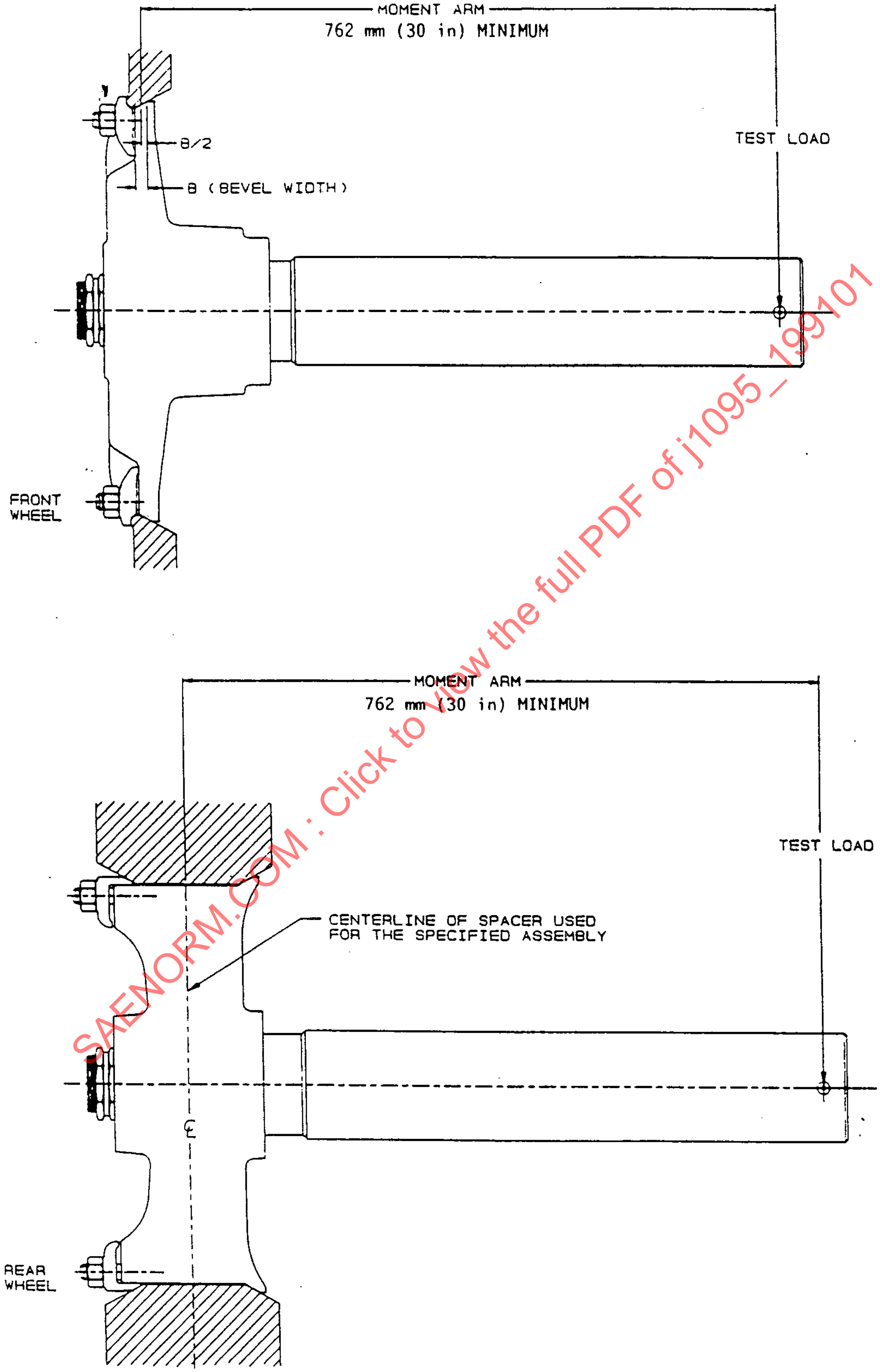


FIGURE 3—90 DEGREE CORNERING FATIGUE TEST (TYPICAL SET-UP)