



SURFACE VEHICLE RECOMMENDED PRACTICE

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Aftermarket Composite Wheels Made of Matrix Material
and Fiber Reinforcement Intended for Normal Highway Use -
Test Procedures and Performance Requirements

RATIONALE

This is a recommended practice for validating and assuring structural quality of composite wheels. Wheels made of matrix material and fiber reinforcement are termed composite wheels. These wheels can optionally have a metallic center section, which is termed hybrid composite wheel. These wheels have fasteners that secure the center section to the rim section that is termed functional fasteners.

Material characterization of composites, similar to that of low carbon steels, A356-T6 and 6061-T6, are not widely published. Additionally, steels and aluminums used previously in wheels are isotropic. Conversely, the fiber orientation to the stress is paramount in composites, thus unique to a wheel design. Thus, a fully processed wheel must be validated in its most service-like manner, i.e., the SAE J2562 biaxial wheel fatigue test.

It has been found that composite materials degrade over service that would include millions of cycles and exposure to sun, moisture, etc.; therefore, the wheel manufacturer and/or the vehicle manufacturer must provide a strength reduction factor that accounts for expected degradation of strength and/or fatigue life over the intended service life of the wheel.

The matrix materials of composite wheels have a property referred to as glass transition temperature above which the matrix materials diminish stiffness. The maximum operating temperature (MOT) should be below the glass transition temperature.

Road potholes and debris above road surface cause flange denting, which is exacerbated by the presence of lower aspect ratio tires. Flange damage is dominantly found on the inboard flange, yet it can affect both flanges depending on the shape of the pothole or debris.

A methodology is developed for measuring and comparing to assess the wheel reduction of stiffness as found on a cornering fatigue machine. This test defines a change of stiffness that can precede the end of service life of wheel, similar to a crack in steel and aluminum wheels. A 20% increase of deflection has been used for the acceptance criteria of steel and aluminum wheels.

A wheel design validation procedure is provided that uses biaxial fatigue per SAE J2562 with some allowances for material differences. A wheel design structural assurance procedure is provided for ongoing quality assurance testing with less costly equipment and in less time.

Electrical static charges on a motor vehicle need to be dissipated through a wheel/tire assembly. Electrical resistance inversely measures the ability of the wheel/tire assembly to dissipate static charge from the vehicle. A test of electrical resistance of tire/wheel assembly has been developed.

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1. SCOPE

This SAE Recommended Practice provides minimum performance requirements and uniform procedures for fatigue and impact testing, electrical resistance, and maximum operating temperature (MOT) of wheels intended for normal highway use on passenger cars, light trucks, and multipurpose vehicles.

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 J175	Wheels - Lateral Impact Test Procedure - Road Vehicles
SAE J267	Wheels/Rims - Truck and Bus - Performance Requirements and Test Procedures for Radial and Cornering Fatigue
SAE J1204	Wheels - Recreational and Utility Trailer Fatigue Test Procedure and Performance Requirements
SAE J1982	Nomenclature - Wheels for Passenger Cars, Light Trucks, and Multipurpose Vehicles
SAE J2315	Wheel Nut Seat Strength
SAE J2316	Wheel Nut Seat System Test Procedures and Performance Requirements for Passenger Cars and Light Trucks
SAE J2530	Aftermarket Wheels - Passenger Cars and Light Truck - Performance Requirements and Test Procedures
SAE J2562	Biaxial Wheel Fatigue Test
SAE J3010	Registration and Conformity Assessment Process for Passenger Cars and Light Trucks Wheels

Archibald, K., Schnaidt, W., Wallace, R., and Archibald, K., "Minimum Cycle Requirement for SAE J2562," SAE Technical Paper 2014-01-0073, 2014, <https://doi.org/10.4271/2014-01-0073>.

Kinstler, J., "The Science and Methodology of SAE Wheel Fatigue Test Specifications," SAE Technical Paper 2005-01-1826, 2005, <https://doi.org/10.4271/2005-01-1826>.

Nurkala, L. and Wallace, R., "Development of the SAE Biaxial Wheel Test Load File," SAE Technical Paper 2004-01-1578, 2004, <https://doi.org/10.4271/2004-01-1578>.

2.1.2 ISO Publications

Copies of these documents are available online at <http://webstore.ansi.org/>.

ISO 3006	Road Vehicles - Passenger Car Road Wheels - Test Methods
ISO 3911	Wheels/Rims - Nomenclature, Designation, Marking, and Units of Measurement
ISO 16392:2007	Tyres, Electrical Resistance, Test Method for Measuring Electrical Resistance of Tyres on a Test Rig

2.1.3 Related Publications

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

2.1.4 Tire and Rim Association Publications

Available from The Tire and Rim Association, Inc., 175 Montrose West Avenue, Suite 150, Copley, OH 44321, Tel: 330-666-8121, www.us-tra.org.

Yearbook, The Tire & Rim Association Inc.

3. DEFINITIONS

3.1 ELECTRICAL RESISTIVITY TEST

A measure of the wheel/tire assembly's electrical resistance.

3.2 HYBRID COMPOSITE WHEEL

Wheel comprised of a metallic center attached to a composite rim with functional fasteners

3.3 MAXIMUM OPERATING TEMPERATURE (MOT)

It is understood that the strength of composite materials is diminished substantially when the material goes through an onset of glass transition temperature. The wheel manufacturer must understand and rate the wheel design with a MOT. The MOT will be tested by using a cornering fatigue machine with elevated temperature capability. The wheel is to be mounted in machine the same as for cornering fatigue. A test load of $S = 1$ of cornering fatigue test load to be imposed on the wheel while rotating at 400 rpm. Monitor the wheel load, cycles, and stiffness. The MOT is to be the temperature at which lateral rotating wheel stiffness decreases 20% from original.

3.4 NORMAL HIGHWAY USE

A wheel intended for sustained use on a motor vehicle on improved surfaces with no special restrictions as to speed or distance traveled. Service not to include motorsport service as found on racetracks.

3.5 PRESSURE RESISTANCE TEST

Inflating the wheel/tire combination to a pressure beyond that intended for normal service could conceivably be applied by mistake. The wheel must be fully serviceable after being exposed to 760 MPa (110 psi). Test site must protect from personal and physical damage with a solid restraining device that will keep the shards from vacating the specific area. Addition of water is accepted.

3.6 STRENGTH REDUCTION FACTOR FATIGUE (SRFF)

It is understood that the strength of composite materials could be reduced over years of service. The wheel manufacturer must understand this material feature and declare per wheel design as a percentage of initial strength, the anticipated reduction of fatigue due to all environmental effects foreseen of the wheel in its intended service. SRFF is always equal to or less than one.

3.7 STRENGTH REDUCTION FACTOR IMPACT (SRFI)

It is understood that the strength of composite materials could be reduced over years of service. The wheel manufacturer must understand this material feature and declare per wheel design as a percentage of initial strength, the anticipated reduction of impact strength due to all environmental effects foreseen of the wheel in its intended service. SRFI is always equal to or less than one.

3.8 STRUCTURAL MAINTENANCE TEST PROTOCOL

A subset of the design validation test protocol that can be performed in less time and more frequently. This protocol is intended to assure wheel structural maintenance while in production.

3.9 WHEEL LATERAL STIFFNESS

The static wheel stiffness is the slope of the moment vs angle measured while the spoke and window are aligned with the direction of force of the machine expressed in kN-m/rad. Stiffness reduction is the change from initial stiffness to after test termination.

3.10 WHEELS FOR TEST

Use only fully processed new wheels, which are representative of wheels intended for the vehicle and ready for road use. In the case of hybrid composite wheels with functional fasteners, stripe the fasteners for later determination of potential rotation of the functional fasteners.

4. WHEEL MARKINGS

Wheels that comply with this specification must be permanently marked with the following information. The characters shall be legible, and the character size shall not be less than 3.0 mm. Other permanent marking methods are acceptable.

- a. Wheel manufacturer's name, trademark, symbol, or brand.
- b. Date of manufacture of the wheel, indicating the month and year, which may be either coded or specifically indicated.
- c. Wheel manufacturer's part number or code.
- d. Country of manufacture of finished assembly.
- e. Rim size designation: rim diameter, width, rim profile (e.g., 16 x 7J or a 16 diameter, 7 wide, J profile).
- f. The manufacturer's wheel load rating as established by design validation testing to this specification, expressed in pounds or kilograms.
- g. Manufacturer's maximum operating temperature (MOT) degree Celsius rating (optional)
- h. The symbol "DOT," constituting a certification by the manufacturer that the rim complies with all applicable motor vehicle safety standards.

Following the symbol "DOT," a designation which indicates the source of rim's published nominal dimensions as follows:

1. "T" indicates The Tire and Rim Association, Inc.
2. "E" indicates The European Tyre and Rim Technical Organization.
3. "J" indicates Japan Automobile Tyre Manufacturers Association, Inc.
4. "D" indicates Deutsche Industrie Norm.
5. "B" indicates British Standards Institution.
6. "S" indicates Scandinavian Tire and Rim Organization.
7. "A" indicates Tyre and Rim Association of Australia.

- i. When a wheel design meets or exceeds all the acceptance criteria of this document, the wheel manufacturer may label the wheel with "SAE J3204." Marking can be cast in, stamped on, or labeled in other permanent methods.
- j. If the wheel manufacturer recommends restricting wheel use with certain types of tires, then the finished wheel must be permanently marked with the restriction; for example, "Not for Use with Bias Tires" (optional).

5. WHEEL NUTSEAT STRENGTH

5.1 Performance Requirements

Refer to SAE J2315.

5.2 Equipment

Refer to SAE J2315.

5.3 Procedure

Refer to SAE J2315.

5.4 Test Criteria/Test Termination

Refer to SAE J2315.

6. WHEEL FASTENING SYSTEM REQUIREMENTS

6.1 Performance requirements

Refer to SAE J2316.

6.2 Equipment

Refer to SAE 2316.

6.3 Procedure

Refer to SAE J2316.

6.4 Test Criteria/Test Termination

Refer to SAE J2316.

7. BIAXIAL FATIGUE PROCEDURE

7.1 Performance Requirements

Refer to SAE J2562, with following exception:

All lateral and radial loads defined per SAE J2562 to be divided by SRFF for composite materials.

7.2 Equipment

Refer to SAE J2562.

7.3 Procedure

Refer to SAE J2562.

All radial and lateral loads defined per SAE J2562 to be divided by SRFF.

7.4 Test Criteria/Test Termination

Refer to SAE J2562.

8. CORNERING FATIGUE

8.1 Performance Requirements

Refer to SAE J328.

8.2 Equipment

Refer to SAE J328.

8.3 Procedure

Refer to SAE J328.

8.4 Test Load Calculation

Refer to SAE J328. Calculate the cornering moment (force x load arm length) to be applied to the test wheel as follows in Equation 1:

$$M = W(SLR_u + d)S/SRFF \quad (\text{Eq. 1})$$

where:

M = cornering moment

Nm: use M(front) or M(rear), whichever is greater as determined by Equations 2 and 3:

$$M(\text{front}) = W(\text{front})(SLR_u + d)S(\text{front})/SRFF \quad (\text{Eq. 2})$$

and

$$M(\text{rear}) = W(\text{rear})(SLR_u + d)S(\text{rear})/SRFF \quad (\text{Eq. 3})$$

where:

W = 1/2 of the maximum vertical static load on the axle as specified in newtons by the vehicle manufacturer or the load rating of the wheel as specified by the wheel manufacturer; W(front) W(rear)

SLR = static-loaded radius (SLR) of the largest tire specified by the vehicle manufacturer and/or wheel manufacturer

NOTE: If the SLR is not specified, use the formula:

$$(Dr/2) + 0.77((\text{tire width (mm)} \times \text{tire section height ratio}) - 17.5) + 17.5 \text{ (mm)}$$

where Dr = nominal rim diameter in inches; needs to be converted to millimeters for use in formula.