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An American National Standard

Standard Test Methods for Bicycle Frames[1]

This standard is issued under the fixed designation F2711; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These test methods establish procedures for conducting tests to determine the structural performance properties of bicycle frames.

1.2 These test methods describe mechanical tests for determining the following performance properties:

1.2.1 Frame Fatigue—Horizontal Loading,

1.2.2 Frame Fatigue—Vertical Loading, and

1.2.3 Frame Impact Strength.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *This standard does not purport 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E4 Practices for Force Verification of Testing Machines

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *bicycle, n*—two-wheeled, single track, articulated vehicle that is solely human powered.

3.1.2 *bicycle fork, n*—structural connection between the front wheel and the frame.

3.1.2.1 *Discussion*—The fork transmits steering torque from the handlebars to the front wheel.

3.1.3 *bicycle frame, n*—structural member that supports the seat with rear connection for the rear wheel, front connection via the head tube for the fork and lower connection for the crank/pedal assembly.

3.1.4 *bottom bracket shell, n*—structural member of the frame that houses the assembly that supports the bearings, which support the cranks.

3.1.5 *crank, n*—lever arm that receives human energy as torque to convert into bicycle motion.

3.1.6 *crown race seat, n*—position on the fork where the lower steering axis bearing sits.

3.1.7 *down tube, n*—lower structural connection between the head tube and the bottom bracket shell.

3.1.8 *dropout centerline, n*—hub-mounting axis that passes through both right and left dropouts.

3.1.9 *front dropout, n*—area where the front wheel hub connects to the fork.

3.1.10 *head tube, n*—forward most structural member of the frame, which provides an interface through top, and bottom bearings for the fork.

3.1.10.1 *Discussion*—The head tube is connected to the seat tube through the top tube and the down tube.

3.1.11 *initial running displacement, n*—average displacement between approximately 500 and 1000 cycles during a durability fatigue test.

3.1.12 *normal attitude, n*—intended position of the bicycle frame when in continuous straight-line motion on a flat surface.

3.1.13 *rake, n*—straight-line distance from the front axle center to the perpendicular of the steering axis.

3.1.14 *rear dropout, n*—area where the rear wheel hub connects to the lower rear and the upper rear frame members.

3.1.15 *sag, n*—amount of compression in a suspension unit, given in a percentage.

3.1.16 *seat post, n*—structural component that connects the seat to the seat tube.

3.1.17 *seat tube, n*—structural member of the frame into which the seat post inserts.

3.1.18 *steerer tube, n*—section of the bicycle fork that is housed within the head tube and bearing assemblies.

3.1.19 *top tube, n*—upper structural connection between the head tube and the seat tube.

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[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports Equipment, Playing Surfaces, and Facilities and is the direct responsibility of Subcommittee F08.10 on Bicycles.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

3.2 *Acronyms:*

3.2.1 *OEM, n*—original equipment from manufacturer

3.3 *Symbols:*

L = fork length, a straight-line measure from the crown race seat to the center of the front axle.

δ = deflection of test fork.

4. Summary of Test Methods

4.1 *Horizontal Loading Durability Fatigue Test*—This test method restrains the frame at the rear dropouts (see Fig. 1). A cyclic load is applied along the x-axis at the front dropouts. The number of cycles is measured. The magnitude of the load, and the minimum number of cycles, are determined by the specification standard.

4.2 *Vertical Loading Durability Fatigue Test*—This test method restrains the frame at the rear dropouts, and allows free rolling at the fork (see Fig. 2). A cyclic load is applied along the Z-axis behind the seat post. The number of cycles is measured. The magnitude of the load, and the minimum number of cycles, are determined by the specification standard.

4.3 *Impact Strength Test*—This test method restrains the frame vertically at the rear dropouts (see Fig. 3). A mass is dropped onto a roller assembly attached to the fork. Permanent set is measured. The height of the drop is determined by the specification standard.

5. Significance and Use

5.1 These tests are used to verify the durability and strength of a bicycle frame.

6. Apparatus

6.1 *Requirements for Test Forks:*

6.1.1 The test forks shall be designed to mount in a manner similar to the OEM fork, or in a manner using typical bicycle assembly procedures.

6.1.2 The test forks, when mounted, shall be the same length, L, as the longest fork designed for use with the frame and have a rake of 45 ± 6 mm. When the test fork is used in place of an OEM Suspension fork, the length is determined by the dropout position when the suspension fork is compressed no more than 20 % of its maximum amount of travel.

6.1.3 The deflection of a test fork is measured at the front axle center, resulting from the application of a vertical 1200 N load at that point. The fork is fixed in position only at the steerer tube by a v-block with minimum length of 76 mm. The steerer tube is fixed horizontally with the crown race seat adjacent to the v-block.

6.1.4 The deflection ratio for the Test fork for the Horizontal Loading Fatigue test and the Vertical Loading Fatigue test shall not exceed the value of 1.0 when computed as follows:

$$\textit{Deflection ratio} = \frac{K \times 10\,000 \times \delta}{L^3}$$

Where:

K (a constant) = 1417 for L and δ in millimetres.

(For example, a fork length of 460 mm, the maximum acceptable fork deflection (δ) would be 6.9 mm. Similarly for a fork length of 330 mm, the maximum deflection is 2.5 mm.)

6.1.5 The deflection ratio for the Test fork for the Impact test shall not exceed the value of 1.0 when computed as follows:

$$\textit{Deflection ratio} = \frac{K \times 10\,000 \times \delta}{L^3}$$

Where:

K = 709 for L and δ in millimetres.

6.2 *Horizontal Loading Durability Fatigue Test:*

6.2.1 A fixture is required to restrain the frame at the rear dropouts, while allowing free rotation about the axle (see Fig. 1). In the case of a suspension frame, the suspension must be locked in a position equivalent to the manufacturer's recommendation for sag, or 25 % sag if none was recommended. If the suspension does not permit locking, then replace the suspension unit with a solid link providing the equivalent sag geometry.

6.2.2 A test fork meeting the requirements for this test (see 6.1) shall be used.

6.2.3 The fork shall be attached to the bicycle frame head tube using typical bicycle assembly practices.

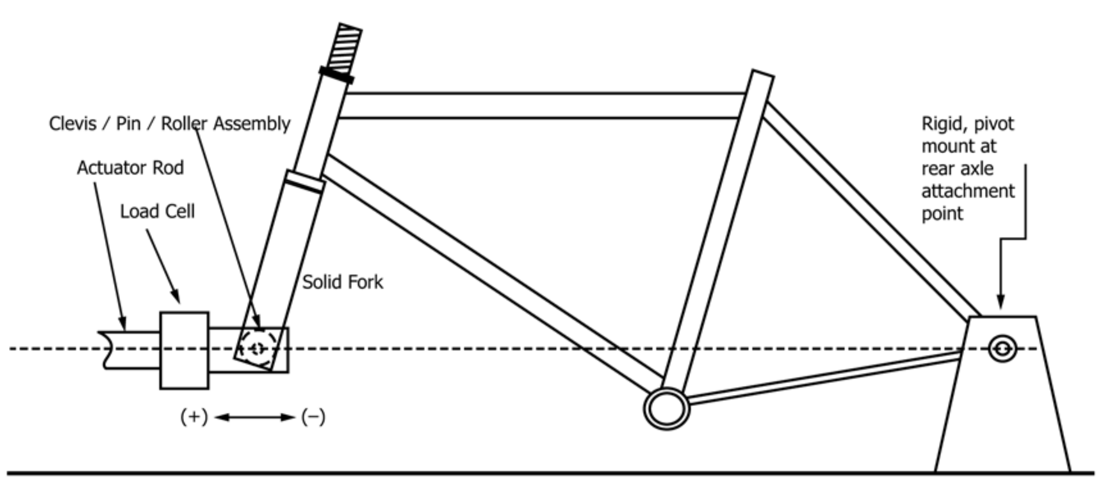

FIG. 1 Horizontal Fatigue Test

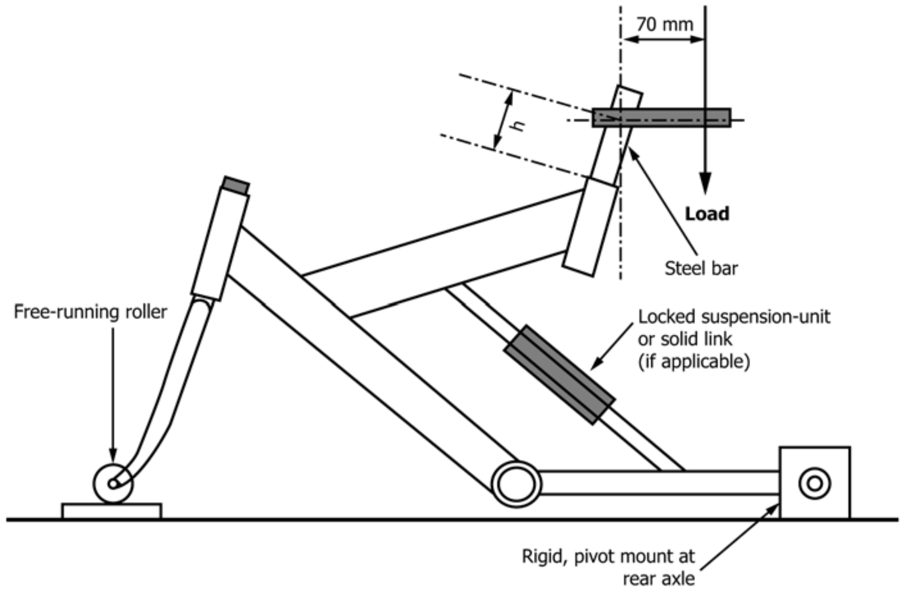

FIG. 2 Vertical Fatigue Test

6.2.4 The fork assembly shall be restrained at the dropouts in such a way that allows translation along the X-axis, and rotation about the Y-axis.

6.2.5 The front and rear dropouts are to be equal in height when the frame and fork assembly is fixtured.

6.2.6 An actuator mounted load cell or equivalent apparatus that is capable of providing a reversible load of constant amplitude shall be attached to the front dropouts or front axle, without constricting the rotational freedom of the fork assembly.

6.2.7 This apparatus shall allow cyclic load application to the front dropouts in a longitudinal direction along the bicycle centerline.

6.3 *Vertical Loading Durability Fatigue Test:*

6.3.1 A fixture is required to restrain the frame at the rear dropouts, while allowing free rotation about the rear axle (Fig. 2). In the case of a suspension frame, the suspension must be locked in a position equivalent to the manufacturer's recommendation for sag, or 25 % sag if none was recommended. If the suspension does not permit locking, then replace the suspension unit with a solid link providing the equivalent sag geometry.

6.3.2 A test fork meeting the requirements for this test (see 6.1) shall be used.

6.3.3 The fork shall be attached to the bicycle frame head tube using typical bicycle assembly practices.

6.3.4 The fork assembly shall be restrained at the dropouts in such a way that allows translation along the X-axis (see Fig. 4); and free rotation of the fork assembly about the front axle; while movement in the Y-axis and Z-axis is constrained.

6.3.5 The front and rear dropouts are to be equal height when the frame and fork assembly is fixtured.

6.3.6 A round solid steel loading bar equivalent to a seat post shall be inserted into the top of the seat tube, and secured to the seat tube by the manufacturers instructions using the normal clamp. A horizontal rearward extension shall be securely attached to the top of this bar such that its height, h, is equal to the maximum saddle height for that particular frame, as shown in Fig. 2. The extension bar shall permit loading with a 70 mm rearward offset.

6.3.7 An actuator mounted load cell or equivalent apparatus that is capable of providing a reversible load, is attached to the rearward extension and aligned in the vertical, downward, direction.

6.4 *Impact Strength Test:*

6.4.1 A fixture is required to restrain the frame at the rear dropouts, while holding the frame securely in a vertical orientation (Fig. 3). In the case of a suspension frame, the suspension must be locked in a position equivalent to the manufacturer's recommendation for sag, or 25 % sag if none was recommended. If the suspension does not permit locking, then replace the suspension unit with a solid link providing the equivalent sag geometry.

6.4.2 A test fork meeting the requirements for this test (see 6.1) shall be used.

6.4.3 The fork shall be attached to the bicycle frame head tube using typical bicycle assembly practices.

6.4.4 The front and rear dropouts of the frame are to be on the same vertical centerline when the frame and fork assembly is set into the fixture.

6.4.5 A free-running low-mass roller, 1 kg maximum, and with a maximum diameter of 55 mm, shall be attached to the fork axle (Fig. 3).

6.4.6 A free-falling, guided 22.5-kg weight shall be used to impact the low-mass roller at a point in-line with the wheel centerline and against the direction of bicycle motion in normal attitude.

7. Calibration and Standardization

7.1 *Durability Fatigue Tests:*

7.1.1 The test apparatus shall be calibrated to meet Practices E4, for accuracy within ±1 % of specified load.

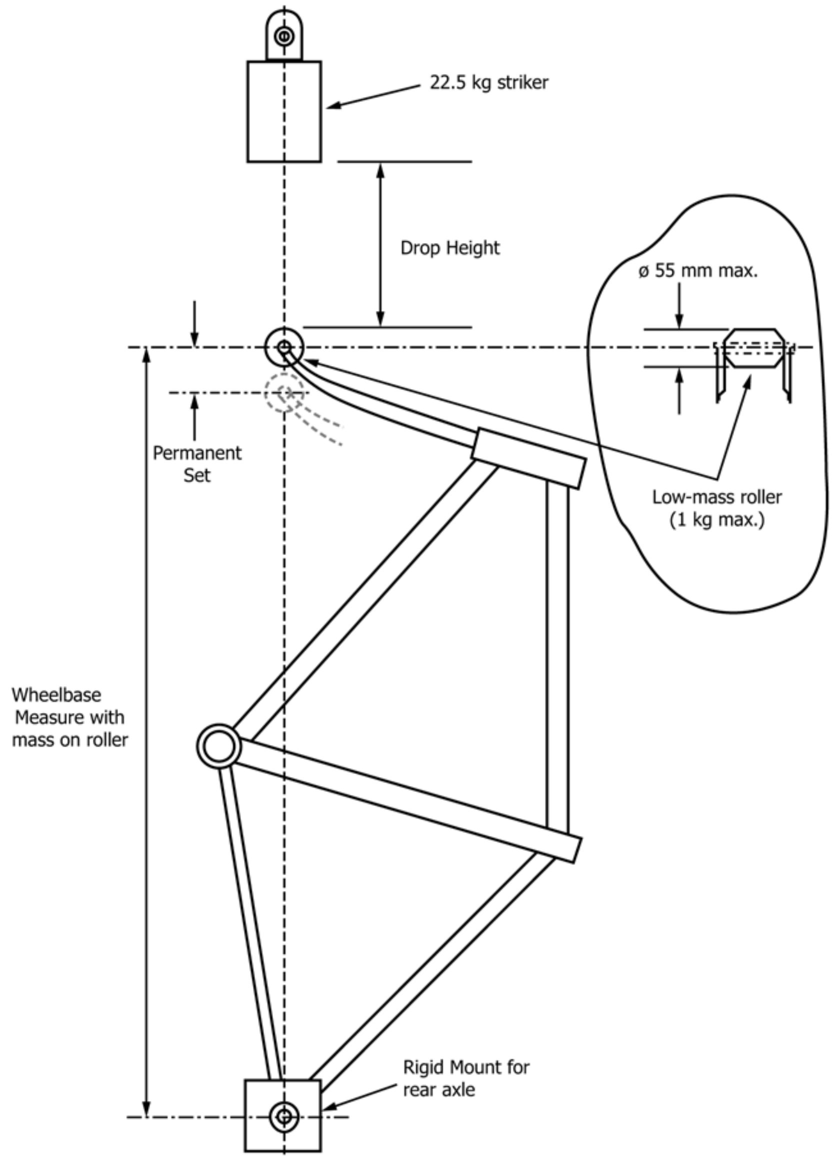

FIG. 3 Frame Impact Test

7.1.2 The load shall be monitored to an accuracy of ±2.5 % through a load cell or other suitable load-measuring device.

7.1.3 The displacement shall be monitored to within ±2.5 %.

7.1.4 Rearward force is defined as compression (denoted with minus (–) sign); forward force is defined as tension (denoted with plus (+) sign). The number of cycles is measured.

7.1.5 All tolerances on the test fixture shall be within ±1 %.

7.2 *Impact Test:*

7.2.1 The test weight shall be accurate to within ±2 % of specified weight.

8. Conditioning

8.1 Tests are to be performed at room temperature of 18 to 35°C.

8.2 All tests are to be performed on initially unused frames.

8.3 The same frame may be used in successive tests of this standard, except as noted in 8.5. If it does not pass a subsequent test after passing its first test, then that particular test is inconclusive and must be repeated with an unfailed frame.

8.4 No frame shall be used for the same test more than once.

8.5 No frame shall be used for successive testing after being impact tested, as described in 9.3.

9. Procedure

9.1 *Horizontal Durability Fatigue Test:*

9.1.1 Assemble the frame onto the test apparatus, as described in 6.2.

9.1.2 Begin applying the specified cyclic load at 1 Hz. To exceed a 1 Hz load application rate, the following criteria must be met. The running displacement shall be within ±3 % of the displacement at 1 Hz.

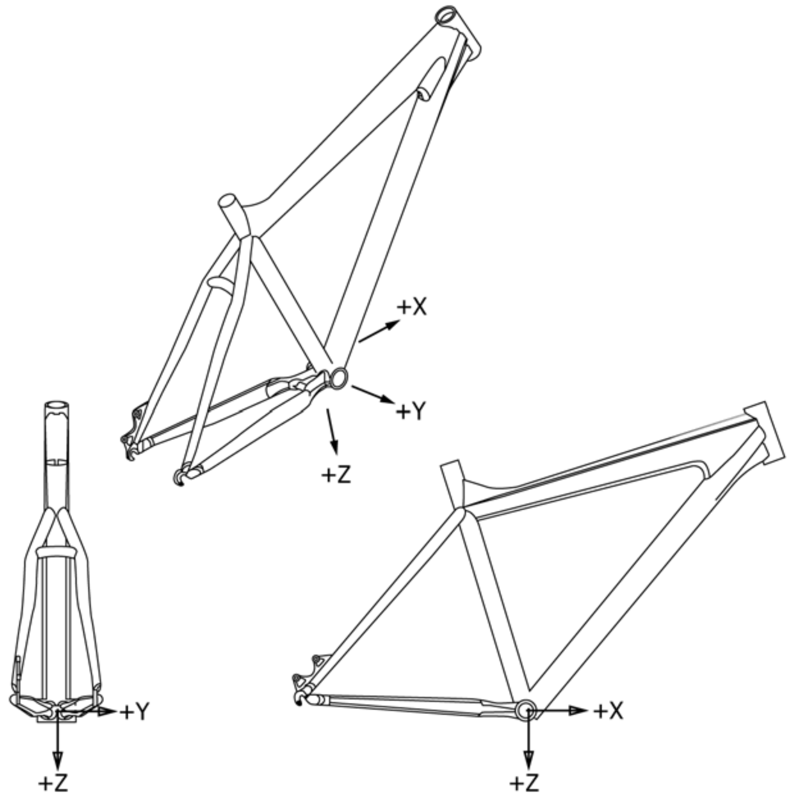

FIG. 4 Frame Coordinate System

9.1.3 Conclude the test when the specified minimum number of cycles is attained, or if/when fracture occurs. Fracture is defined as the following:

9.1.3.1 If using displacement control to perform the test, fracture is the point at which the load drops below 95 % of the maximum specified running load.

9.1.3.2 If using force control to perform the test, fracture is a crack, tear, or separation at the surface of the frame that is visible to the unaided eye. Inspection of the frame for the existence of fracture must occur when displacement exceeds 3.0 mm from initial running displacement or previous inspection.

9.2 *Vertical Durability Fatigue Test:*

9.2.1 Assemble the frame onto the test apparatus, as described in 6.3.

9.2.2 Begin applying the specified cyclic load at 1 Hz. To run the test at a greater frequency than 1 Hz, the following criteria must be met. The running displacement shall be within ±3 % of the displacement at 1 Hz.

9.2.3 Conclude the test when the specified minimum number of cycles is attained, or if/when fracture occurs. Fracture is defined as the following:

9.2.3.1 If using displacement control to perform the test, fracture is the point at which the load drops below 95 % of the maximum specified running load.

9.2.3.2 If using force control to perform the test, fracture is a crack, tear, or separation at the surface of the frame that is visible to the unaided eye. Inspection of the frame for the existence of fracture must occur when displacement exceeds 3.0 mm from initial running displacement or previous inspection.

9.3 *Impact Strength Test:*

9.3.1 Mount the frame and fork assembly in the vertical plane, as described in 6.4, with the front and rear dropouts on the same vertical centerline.

9.3.2 Connect the fork roller assembly to fork dropouts.

9.3.3 Measure the distance between the axles (wheelbase) with the weight resting on the fork roller.

9.3.4 Raise the weight to the appropriate drop height, as defined by the specification standard.

9.3.5 Release the weight onto the fork roller. The weight will bounce (this is normal and permitted).

9.3.6 After the weight comes to rest, repeat the wheelbase measurement—this is the permanent set of the frame and fork.

10. Precision and Bias

10.1 No information is presented concerning the precision or bias of these test methods for measuring the durability and strength of a bicycle frame since the test result is non-quantitative.

11. Keywords

11.1 actuator; bicycle; bicycle frame; bottom bracket shell; cyclic load; displacement; dropouts; fatigue; fork; head tube;

horizontal loading; impact strength; load; load cell; non-suspension; OEM; permanent set; rider; solid fork; suspension; vertical loading