United States
Consumer Product Safety Commission

Summary of Electric and Non-Powered Bicycle Standards

Frederick deGrano

Division of Mechanical and Combustion Engineering

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This report was prepared by the CPSC staff. It has not been reviewed or approved by, and may not represent the views of, the Commission.

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Introduction

This report accomplishes milestone EXHR-M09 of the Consumer Product Safety Commission (CPSC) Fiscal Year 2024 Operating Plan.[1] This report provides a summary and comparison of federal mandatory and voluntary standards applicable to non-powered and electric bicycles (e-bikes). In the United States, federal law requires consumer level non-powered bicycles and certain electric bicycles to comply with the mandatory safety standard 16 CFR part 1512, *Requirements for Bicycles*, which provides performance requirements to reduce the risk of hazards associated with the use of bicycles. Additionally, the American Society for Testing and Materials (ASTM) offers multiple voluntary standards with performance requirements for bicycles which were developed by committees primarily composed of bicycle manufacturers. Internationally, the European Committee for Standardization (CEN) and the International Organization for Standardization (ISO) have multiple voluntary standards developed by international stakeholders, such as regulators and bicycle manufacturers. These standards specify requirements to establish minimum strength, durability, and performance for various bicycle components, such as brakes, wheels, tires, and drive system.

This document summarizes and compares each standard and is intended to highlight the different requirements on the various bicycle related product standards that have been developed since the CPSC's initial regulation from 1975. While the CPSC standard specifies the bare minimum requirements for bicycles, these additional voluntary standards have been developed to address changes in bicycle design, use patterns, materials, and safety considerations over the last 50 years, and the combination of these voluntary and mandatory standards has largely led to safer products. CPSC staff is also currently conducting contracted product testing on multiple electric and non-powered bicycles to identify performance characteristics for the different types of bicycles. The data will inform staff of the fundamental differences between electric and non-powered bicycles such as achievable speed, acceleration, and stopping performance. This report serves as a steppingstone, combined with future testing and data gathering and assessment, to progress towards developing a notice of proposed rulemaking (NPR) to update the current regulation or other regulatory options as appropriate to address the emerging mechanical hazards of e-bikes.

Background

On March 15, 2024, the Commission published an Advanced Notice of Proposed Rulemaking (ANPR), to initiate a rulemaking proceeding under the Consumer Product Safety Act (CPSA) and the Federal Hazardous Substances Act (FHSA), and to notify the public of the Commission's consideration to develop a rule to address the risk of injury associated with e-bikes. The ANPR invited comments from the public concerning the risk of injury associated with

[1] CPSC FY24 Operating Plan, https://www.cpsc.gov/s3fs-public/FY2024OperatingPlan.pdf?VersionId=N46Kg9oFJtn_Slys4cdzuQYza29oFynS

mechanical hazards of e-bikes, potential regulatory alternatives, the economic impacts of various approaches, existing voluntary standards, and plans to develop new standards to address these risks. This study complements that rulemaking, providing a review of the applicable standards.

CPSC staff identified an increasing trend of injuries and deaths from falls and collisions associated with e-bikes with an estimated 53,200 total emergency department (ED)-treated injuries from 2017 to 2022[2] associated with e-bikes based on the incident data from the National Electronic Injury Surveillance System (NEISS).[3] Staff estimated that ED-treated injuries for e-bikes increased from 3,500 to 24,400 injuries during that timeframe and that e-bike related incidents comprise 15 percent of the overall micromobility injury estimate in that timeframe. Additionally, staff is aware of at least 100 fatalities associated with mechanical hazards involving e-bikes that occurred from 2017 through 2022, increasing from zero deaths in 2017 to 42 deaths in 2022. Staff's review of the 100 fatalities indicates that most of the fatalities involved collisions with motor vehicles. Other causes of fatalities included collisions with pedestrians, collisions with fixed objects, falls and control issues, and rider ejection.

The Product

The CPSC mandatory safety standard 16 CFR part 1512, *Requirements for Bicycles*, defines bicycles as follows:

1. A two-wheeled vehicle having a rear drive wheel that is solely human-powered; or
2. A two- or three-wheeled vehicle with fully operable pedals and an electric motor of less than 750 watts (1 horsepower), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden by an operator who weighs 170 pounds, is less than 20 mph.

A wide variety of bicycles on the market are designed and intended for different purposes, terrains, speeds, cargos, and demographics. ASTM F2043-13 (2018), *Standard Classification for Bicycle Usage*, categorizes non-powered bicycles based on their intended usage condition. The following are the bicycle conditions as defined by the standard:

[2] U.S. Consumer Product Safety Commission, Micromobility Products-Related Deaths, Injuries, and Hazard Patterns: 2017–2022, (Sept. 2023), https://www.cpsc.gov/Safety-Education/Safety-Education-Centers/Micromobility-Information-Center.

[3] NEISS is the source of the injury estimates. It is a statistically valid injury surveillance system. NEISS injury data are gathered from emergency departments of about 100 hospitals, with 24-hour emergency departments and at least six beds, selected as a probability sample of all U.S. hospitals. The surveillance data gathered from the sample hospitals enable the CPSC to make timely national estimates of the number of injuries associated with specific consumer products.

- Condition 0 – Sidewalk bicycles: This category covers children's bicycles under appropriate parental supervision in a manner consistent with the child's bicycling skills. These bicycles are intended for riders of at least three years of age and weighing less than 36 kg (80 lb).
- Condition 1 – Road bicycles: This category covers bicycles whose intended operation is on a regular paved surface where the tires are intended to maintain ground contact.
- Condition 2 – Hybrid & Trekking bicycles: This category covers bicycles whose intended operation is on Condition 1 surfaces as well as unpaved and gravel roads and trails with moderate grades.
- Condition 3 – Mountain bicycles: This category covers bicycles whose intended operation is on Conditions 1 and 2 surfaces as well as rough trails, rough unpaved roads, rough terrain, and unimproved trails that require technical skills.
- Condition 4 – Downhill bicycles: This category covers bicycles whose intended operation is on Conditions 1, 2, and 3 surfaces or downhill grades on rough trails at speeds less than 40 km/h (25 mph), or both.
- Condition 5 – Extreme riding: This category covers bicycles whose intended operation is on Conditions 1, 2, 3, and 4 surfaces, extreme jumping, and downhill grades on rough trails at speeds in excess of 40 km/h (25 mph); or a combination thereof.

Other types of bicycles not covered by ASTM's classifications include BMX bicycles, young adult bicycles, and electric bicycles, also referred to as Electrically Power Assisted Cycles (EPACs). BMX stands for bicycle motorcross and is a specialized type of bicycle used for sporting events. BMX covers a wide range of sporting events held on dirt, flatland, or park which features ramps, walls, jumps, and rails. The ISO standard, ISO 4210-1:2023, defines young adult bicycles as designed for use on public roads by a young adult whose mass is less than 40 kg and has a saddle height between 635 mm and 750 mm from the ground.

Electric Bicycles

16 CFR § 1512.2 defines a bicycle to include a two- or three-wheeled vehicle with fully operable pedals and an electric motor of less than 750 watts (1 horsepower), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden by an operator who weighs 170 pounds, is less than 20 mph. Alternatively, the standards from CEN and ISO define e-bikes as bicycles equipped with an auxiliary electric motor while not specifying a maximum motor power limit, and also states that it cannot be propelled exclusively by means of this auxiliary electric motor, except in the start-up assistance mode. E-bikes in the US market typically have a pedal assist function, a throttle, or both, for engaging the electric motor. An e-bike with pedal assistance activates the electric motor while the rider is pedaling to provide more torque than the rider would normally create on their own. An e-bike with a throttle activates the electric motor when the rider actuates the throttle mechanism to propel the bike forward without relying on pedaling. Typical throttle mechanisms are thumb-operated levers, twist throttles integrated into the handlebar grip, and trigger-style levers operated by index finger.

Similar to non-powered bicycles, manufacturers design and market their e-bikes for specific applications, such as use in a city, for commuting, for hauling small cargo, and for off-road use on bike paths and trails. Some manufacturers sell e-bikes intended for use by children. These include electric balance bikes, which are a type of e-bike that falls outside of the definition given in 16 CFR part 1512 and are mostly marketed for younger children. Although an electric balance bike does not have pedals, the electric motor assists the rider with propulsion, which is accomplished by the rider pushing their feet against the ground instead of pedaling. These e-bikes are marketed to help children learn balance and coordination, and some are used competitively by children and as training towards off-road motorcycle racing.

Although not defined in any standard, the market and many states[4] categorize e-bikes into three different classes:

1) Class 1: These e-bikes require riders to pedal in order for the electric motor to activate and assist with propelling the bicycle. These e-bikes operate similar to a non-powered bicycle except the electric motor assists with adding power to the rear wheel in addition to the effort exerted by the rider. The electric motor stops assisting the rider once the e-bike's speed reaches 20 mph.
2) Class 2: These e-bikes operate with an electric motor that is controlled by a throttle. The rider does not have to pedal in order for the electric motor to propel the bicycle. The electric motor stops providing acceleration to the e-bike once the speed reaches 20 mph.
3) Class 3: These e-bikes are similar to Class 1 e-bikes which require riders to pedal in order for the electric motor to assist with propelling the bicycle but continues to assist the rider at speeds exceeding 20 mph. The electric motor stops assisting the rider once the e-bike's speed reaches 28 mph.

Bicycle Standards

This section summarizes the mandatory and voluntary standards applying to bicycles including e-bikes. Although e-bikes do not specifically fall within the scope of some of the following standards, the standards specify mechanical requirements that may apply to e-bikes because e-bikes often have similar characteristics and components as non-powered bicycles.

CPSC Mandatory Standard

- 16 CFR part 1512 Requirements for Bicycles

ASTM International

- F2043-13 (2018) Standard Classification for Bicycle Usage
- F2273-11 (2016) Standard Test Methods for Bicycle Forks

[4] Electric Bike Laws – State by State, https://www.peopleforbikes.org/electric-bikes/state-laws

- F2899-11 (2016) Standard Specification for Condition 1 Bicycle Forks
- F2274-11 (2016) Standard Specification for Condition 3 Bicycle Forks
- F2711-19 (2019) Standard Test Methods for Bicycle Frames
- F2843-19 (2019) Standard Specification for Condition 0 Bicycle Frames
- F2802-19 (2019) Standard Specification for Condition 1 Bicycle Frames
- F2868-19 (2019) Standard Specification for Condition 2 Bicycle Frames
- F2614-19 (2019) Standard Specification for Condition 3 Bicycle Frames
- F2680-17 (2017) Standard Specification for Manually Operated Front Wheel Retention Systems for Bicycles
- F2268-03 (2015) Standard Specification for Bicycle Serial Numbers
- F2918-11 (2015) Standard Test Method for Weighing a Bicycle
- F2793-14 (2023) Standard Specification for Bicycle Grips
- F2917-12 (2018) Standard Specification for Bicycle Trailer Cycles Designed for Human Passengers

European Committee for Standardization (CEN)

- EN 14765:2008 – Bicycles for Young Children – Safety requirements and Test Methods (Condition 0)
- EN 14781:2005 – Racing Bicycles – Safety Requirements and Test Methods (Condition 1)
- EN 14764:2005 – City and trekking bicycles – Safety requirements and test methods (Condition 2)
- EN 14766:2005 – Mountain Bicycles – Safety Requirements and Test Methods (Condition 3)
- EN 15194:2017+A1:2023 – Cycles – Electrically power assisted cycles – EPAC Bicycles
- EN 17404:2022 – Cycles – Electrically power assisted cycles – EPAC Mountain bikes
- EN 16054:2012 - BMX Bicycles – Cat 1 (riders <= 45 kg) and Cat 2 (riders > 45 kg)

International Organization for Standardization (ISO)

- ISO 4210:2023 – Cycles – Safety requirements for bicycles
- ISO 4210-10:2020 Cycles – Safety requirements for bicycles – Part 10: Safety requirements for electrically power assisted cycles (EPACs).
- ISO 8098:2023 – Cycles – Safety requirements for bicycles for young children
- ISO 9633:2001 – Cycle chains – Characteristics and test methods

Mandatory Standard 16 CFR Part 1512

CPSC codified its mandatory standard for bicycles, part 1512, in 1974 (39 FR 26100, Jul. 16, 1974), with amendments in 1978 (43 FR 60034, Dec. 22, 1978), 1980 (45 FR 82625, Dec. 16, 1980), 1981 (46 FR 3203, Jan. 14, 1981), 1995 (60 FR 62989, Dec. 8, 1995), 2003 (68 FR 7072, Feb. 12, 2003 and 68 FR 52690, Sept. 5, 2003), and 2011 (76 FR 27882, May 13, 2011). Part 1512 sets requirements for the manufacture and assembly of bicycles and low-speed e-bikes sold to consumers to reduce the risk of injury from mechanical hazards as specified in the following sections:

- 1512.5 Braking system
- 1512.6 Steering system
- 1512.7 Pedals
- 1512.8 Drive chain
- 1512.9 Protective guards
- 1512.10 Tires
- 1512.11 Wheels
- 1512.12 Wheel hubs
- 1512.13 Front fork
- 1512.14 Fork and frame assembly
- 1512.15 Seat
- 1512.16 Reflectors

Part 1512 sets basic requirements for mechanical and safety systems found on all bicycles and low-speed e-bikes. The requirements apply to the following products:

1) two-wheeled vehicles with human powered rear wheel drive; and
2) two- or three-wheeled bicycles with an electric motor of less than 750 watts (1 h.p.) fully operational pedals, and a maximum speed of less than 20 mph (32 kph) when operated solely on electric power.

“Track” bicycles and “one-of-a-kind” bicycles are not subject to this regulation.[5] With the exception of these two types of bicycles, part 1512 specifies requirements regardless of the bicycle’s usage condition or type, and thus, bicycles must meet the same performance. The CPSC has only made minor revisions since part 1512 was originally codified; therefore, the standard does not address recent technological advances in bicycle design such as disc brakes and components made from composite materials such as carbon fiber.

Domestic Voluntary Standards

The ASTM standards listed above contain requirements for bicycle frames and front forks based on the use condition of the bicycle, but e-bikes do not fall within the scope of this standard because their scopes are limited to bicycles that are ‘‘solely human powered,’’ as defined in ASTM F2043–13 (2018), *Standard Classification for Bicycle Usage*. Because these standards were developed solely for non-powered bicycles, they may not be adequate to address characteristics that are unique to e-bikes. Furthermore, these standards are limited in scope as

[5] 16 CFR part 1512 defines track bicycles as designed and intended for sale as a competitive velodrome machine having no brake levers or calipers, single crank-to-wheel ratio, and no free-wheeling feature between the rear wheel and the crank. Part 1512 defines one-of-a-kind bicycles as uniquely constructed to the order of an individual consumer other than by assembly of stock or production parts.

they do not specify any requirements for other bicycle components such as brakes, handlebars, wheels, tires, and drive system, among others.

International Voluntary Standards

ISO standard 4210 contains multiple parts specifying requirements for bicycles. ISO 4210-10, *Safety requirements for electrically power assisted cycles (EPACs)*, specifies the safety and performance requirements for the design, marking, assembly, and testing unique to two-wheeled e-bikes. ISO defines an EPAC as a cycle equipped with pedals and an auxiliary electric motor, which cannot be propelled exclusively by means of the auxiliary electric motor. Therefore, ISO 4210-10 applies only to pedal-assisted e-bikes. The standard specifies mechanical requirements unique to e-bikes pertaining to the following:

- 7.2 Brakes – Heat-resistance test
- 7.3 Handlebar and stem assembly – Lateral bending test
- 7.4 Handlebar stem – Forward bending test
- 7.5 Handlebar to handlebar stem – Torsional security test
- 7.6 Handlebar and stem assembly – Fatigue test
- 7.7 Frame – Impact test (falling mass)
- 7.8 Frame and front fork assembly – Impact test (falling frame)
- 7.9 Frame – Fatigue test with horizontal forces
- 7.10 Frame – Fatigue test with a vertical force
- 7.11 Front fork – Static bending test
- 7.12 Front fork – Rearward impact test
- 7.13 Front fork – Bending fatigue test plus rearward impact test
- 7.14 Seat-post – Fatigue test

The above sections are modifications of the requirements for non-powered bicycles specified in ISO 4210 parts 1 through 9. All other mechanical requirements for bicycles apply.

CEN provides two standards, also referred to as European Norms (EN), for e-bikes titled EN 15194:2017+A1:2023, *Cycles – Electrically power assisted cycles – EPAC Bicycles*, and EN 17404:2022, *Cycles – Electrically power assisted cycles – EPAC Mountain bikes*. These standards apply to e-bikes that have a maximum continuous rated power of 0.25 kW, which is progressively reduced and finally cut off as the e-bike reaches a speed of 25 kph (15.5 mph), or sooner, if the cyclist stops pedaling. As such, similar to the ISO standard above, the EN standards only apply to pedal-assisted e-bikes. The EN standards specify mechanical requirements unique to e-bikes pertaining to the following:

- 4.3.5 Brakes
- 4.3.6 Steering
- 4.3.7 Frames
- 4.3.8 Front fork
- 4.3.9 Wheels and wheel/tyre assembly

- 4.3.10 Rims, tyres and tubes
- 4.3.12 Pedals and pedal/crank drive system
- 4.3.13 Drive-chain and drive belt
- 4.3.15 Saddles and seat-posts
- 4.3.18 Road-test of a fully-assembled EPAC

All other non-powered bicycle requirements apply to e-bikes per the EN standards.

Summary of Mechanical Requirements

This section summarizes the mechanical performance requirements across all the standards for each e-bike component. As noted previously, e-bikes do not fall within the scope of some of the above standards, but because they share similar components and construction as non-powered bicycles, the following sections include all relevant requirements.

The following sections contain a quick description of each component and the relevant mechanical performance requirements and tests from the above standards. The standards specify requirements based on the use condition of the bicycle as defined in the respective standards, and the following tables summarize the different performance requirements for each type of bicycle between the different standards. The above sections summarize each bicycle use condition and type. For reference, Figure 1 below labels each component by name and location on the e-bike.

Figure 1. Electric bicycle components

Brake System

The brake system consists of components whose operation is intended to slow or stop the motion of the bicycle. The brake system typically consists of a mechanism for the rider to apply a force to activate the brakes, a mechanism that transfers the rider's input to the brakes, and the braking mechanism that applies the stopping force to the bicycle's wheels. The mechanism for the rider to activate the brakes typically comes in two forms: handbrakes which consist of a lever adjacent to the handlebar grips where the rider applies a pulling force using their fingers; or footbrakes (coaster brakes) where the rider can apply the brakes by pedaling in the reverse direction. The mechanisms that transfer the rider's input to the brakes for handbraking systems are typically either Bowden cables or hydraulic cables. Bowden cables transmit the rider's input to the brakes by way of a flexible cable that transfers the pull force applied to the handbrake lever to the brake system. Similarly, hydraulic cables transmit the rider's input via a fluid contained in a hose connecting the braking system. For coaster brakes, the bicycle chain transfers the energy applied to the pedals to the rear wheel to both accelerate and stop the bicycle.

Common braking mechanisms in the market are rim brakes, disc brakes, and drum brakes. The braking mechanisms create friction by pushing a braking surface with a fixed surface on the wheel. As a rider applies pressure to the brake lever or pedals, the force of friction on the braking surface also increases. For rim-brake systems, the brake pads, which are typically made out of a high friction material such as rubber, apply force to the rim of the wheel. Bicycle disc-brake systems function similarly to automotive brakes. This brake system consists of a metal disc, or rotor, that is fixed to the wheel hub and rotates with the wheel, and the braking force is applied via brake pads that squeeze the sides of the rotor. For drum braking systems, brake pads apply an outward, radial force from the center of the wheel against the inside surface of a drum at the wheel hub. Figure 2 below shows examples of the above braking systems.

Figure 2. Common brake types: rim brake (left) and disc brake (right)

The CPSC, EN, and ISO standards specify requirements and performance tests for the braking performance of all in-scope bicycles. The standards require that all bicycles be equipped with front- and rear-wheel brakes or rear-wheel brakes only. The ASTM voluntary standard does not specify requirements for brake systems. The following section describes the Handbrake or Footbrake strength requirements followed by the minimum Stopping Distance requirements.

Handbrakes

The CPSC, EN, and ISO standards subject the brake lever(s) of bicycles equipped with handbrakes to multiple strength tests. The first test applies a force on the hand lever sufficient to cause the lever to contact the handlebar or a maximum force, as shown below in Table 1, depending on the intended use condition of the bicycle. The performance requirement repeats the loading condition 10 times and requires that no visible fractures, failures, misalignments, and non-compliant clearances form on any components of the brake system. This test ensures that the brake hand levers and mounting hardware are structurally and mechanically adequate to withstand applied forces from normal use. The CPSC, EN, and ISO standards have similar acceptance criteria.

Table 1. Handbrake Lever Strength Test

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO</th></tr>
<tr><td>0 – Sidewalk</td><td rowspan="8">445 N (100 lbf)</td><td>-</td><td>300 N (67 lbf)</td><td>300 N (67 lbf)</td></tr>
<tr><td>1 – Road</td><td>-</td><td>450 N (101 lbf)</td><td>450 N (101 lbf)</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>450 N (101 lbf)</td><td>450 N (101 lbf)</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>450 N (101 lbf)</td><td>450 N (101 lbf)</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td><td>450 N (101 lbf)</td></tr>
<tr><td>BMX</td><td>-</td><td>450 N (101 lbf)</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>450 N (101 lbf)</td><td>450 N (101 lbf)</td></tr>
</table>

The second strength requirement is referred to as the rocking test. This test adds a weight representative of a rider on the bicycle seat. The CPSC standard specifies a weight of 68.1 kg (150 lb) added to the bicycle seat, and the EN and ISO standards specify adding weight on the seat that would result in a combined weight of 100 kg (220.5 lb) for bicycle and simulated rider. The EN standard for EPACs, specifies a combined weight of 120 kg. The test subjects the bicycle to a rocking motion both forward and backward at least six times over a distance of at least 76 mm (3 in) in each direction with the brakes applied as shown below in Figure 3. Upon completion of this test, the brake system shall not exhibit loosening, fractures, failures, or misalignment of any component. This test ensures that the brake system functions as intended without any failure. Table 2 below shows the applied force on the brake lever and the mass added to the bicycle for each bicycle use condition. The CPSC standard specifies a more stringent applied force on the brake lever, but the EN and ISO standards specify a combined weight of the rider and bicycle that would result in a more stringent load.

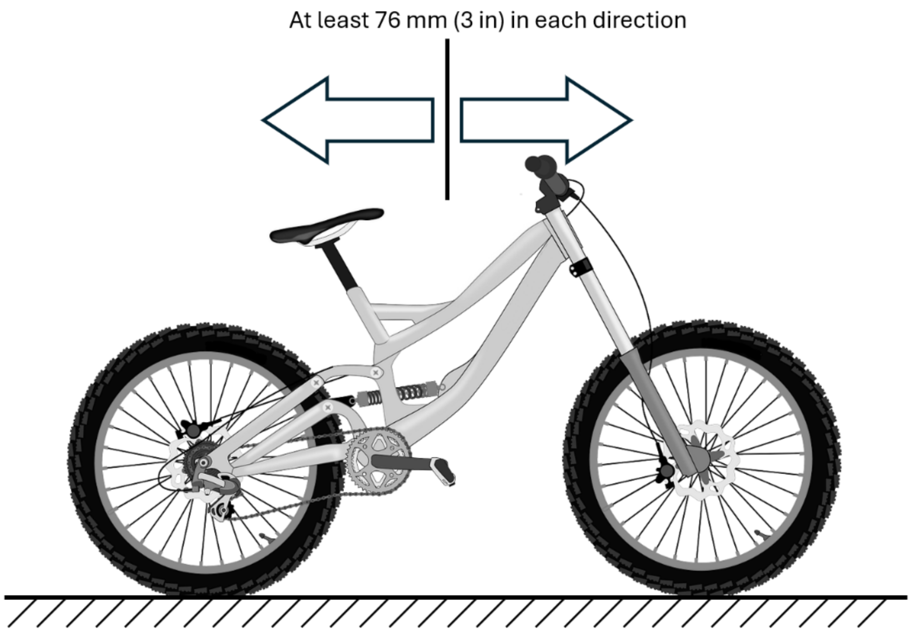

Figure 3. Test Diagram – Handbrake Rocking

Table 2. Handbrake Rocking Test (applied force on brake lever / mass added)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	445 N (100 lbf) / 68.1 kg (150 lb)	-	130 N (29 lbf) / 30 kg (66 lb)*	130 N (29 lbf) / 30 kg (66 lb)*
1 – Road		-	180 N (40 lbf) / 100 kg (220 lb)*	180 N (40 lbf) / 100 kg (220 lb)*
2 – Trekking		-	180 N (40 lbf) / 100 kg (220 lb)*	180 N (40 lbf) / 100 kg (220 lb)*
3 – Mountain		-	180 N (40 lbf) / 100 kg (220 lb)*	180 N (40 lbf) / 100 kg (220 lb)*
4 – Downhill		-	-	-
Young Adult		-	-	180 N (40 lbf) / 100 kg (220 lb)*
BMX		-	180 N (40 lbf) / **	-
EPAC		-	180 N (40 lbf) / 120 kg (265 lb)*	180 N (40 lbf) / 100 kg (220 lb)*

*Combined mass of rider and bicycle
**Tested on machine driven at 12.5 kph (7.8 mph) with sufficient downward force to prevent tire skidding

The CPSC standard has an additional requirement for hand lever operating force intended to limit the force required to pull the brake levers in order to apply the brakes, ensuring that only a reasonable force must be used to stop the bicycle. The standard requires the force to be no more than 44.5 N (10 lbf) to cause the brake pads to contact the braking surface of the wheel when applied to the hand lever at a point 25 mm (1.0 in) from the open end of the hand lever. Table 3 below shows the maximum applied force to the brake levers for each bicycle use condition.

Table 3. Hand Lever Operating Force

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	44.5 N (10 lbf)	-	-	-
1 – Road		-	-	-
2 – Trekking		-	-	-
3 – Mountain		-	-	-
4 – Downhill		-	-	-
Young Adult		-	-	-
BMX		-	-	-
EPAC		-	-	-

Footbrakes

The CPSC, EN, and ISO standards specify requirements for footbrake systems, also known as coaster brakes or back-pedal brakes. The standards require that all footbrakes have a minimum brake force on the rear wheel given an applied force on the pedals to ensure that an appropriate amount of stopping power is applied to the brakes with a reasonable applied force on the pedals. Table 4 below shows the minimum required forces from each standard. The CPSC standard specifies a more stringent brake force for sidewalk bicycles than the EN and ISO standards and also specifies requirements for all other bicycle use conditions whereas the other standards do not.

Table 4. Footbrake Operating Force Test (brake force / minimum applied force)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	225 N (50 lbf) / 112 N (25.2 lbf)	-	100 N (22.5 lbf) / 50 N (11.2 lbf)	100 N (22.5 lbf) / 50 N (11.2 lbf)
1 – Road	310 N (70 lbf) / 178 N (40 lbf)	-	-	-
2 – Trekking		-	-	-
3 – Mountain		-	-	-
4 – Downhill		-	-	-
Young Adult		-	-	-
BMX		-	-	-
EPAC		-	-	-

The EN and ISO standards require a strength test for footbrakes to ensure that the brake system is able to withstand the significant forces often exerted on the pedals without failure. With the pedal crank arms oriented in the horizontal position, the test applies a vertically downward force to the left-side pedal as shown below in Figure 4. After maintaining the force fully for 1 minute, the brake system or any component thereof shall not experience any failure. Table 5 below shows the magnitude of the applied forces for each bicycle use condition.

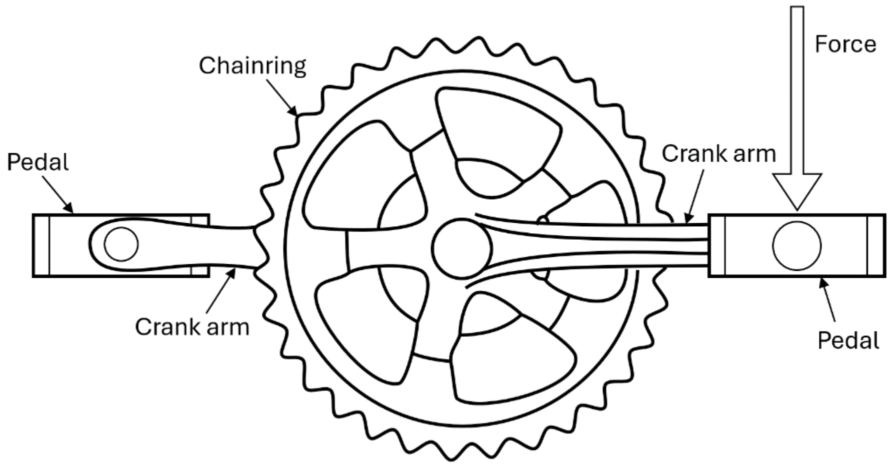

Figure 4. Test Diagram – Footbrake strength

Table 5. Footbrake Strength Test - applied force

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	600 N (135 lbf)	600 N (135 lbf)
1 – Road	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
2 – Trekking	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
3 – Mountain	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
4 - Downhill	-	-	-	-
Young Adult	-	-	-	1,500 N (337 lbf)
BMX	-	-	-	-
EPAC	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)

Track-based Stopping Distance

The CPSC, EN, and ISO standards subject all bicycles within scope to braking performance requirements to ensure that they provide enough braking power to stop within a specified distance. The brake systems must pass the above strength tests before the following performance tests with no adjustments made between tests. The braking performance test evaluates the brake system's stopping distance from a specified initial velocity. The test procedure states that the performance tests must be conducted over a dry, clean, smooth, and paved test course with a test rider of a specified weight. The CPSC standard specifies that the rider must be at least 68 kg (150 lb) or the combined weight of the rider and bicycle must be no more than 91 kg (200 lb). The EN and ISO standards specify only a combined weight of 100 kg (220 lb). The operator must accelerate to and maintain a ground speed of at least 24 ± 1.5 kph (15 ± 0.9 mph) at the bicycle's highest gear ratio while pedaling at approximately 60 revolutions per minute. When the bicycle has attained the specified ground speed, the operator must apply a force no greater than 178 N (40 lbf) on the braking mechanism (*i.e.*, lever or pedal) and come to a complete stop. The performance test measures the distance the bicycle travels from the moment the brake is applied to when the bicycle comes to a complete stop. The bicycle must stop within a specified distance based on the use condition of the bicycle specified below in Table 6 for handbrake systems and Table 7 for footbrake systems (rear-only brake test). The EN and ISO standards specify separate stopping distance requirements for bicycles equipped with brakes on both the front and rear wheels or only rear wheel, with the rear-only stopping distance being twice the required distance as both the front and rear brake systems. The CPSC standard only specifies a single stopping distance requirement. Note that the EN standard for EPACs requires the machine-based test as detailed below rather than a track-based test. Although the CPSC standard specifies a more stringent distance, the standard allows for greater stopping distances when adjusted for heavier test operators at a rate of 0.30 m per 4.5 kg (1.0 ft per 10 lb). This translates to a stopping distance of approximately 6 m (20 ft) for the maximum allowable weight in the CPSC standard, which is roughly equivalent to the EN and ISO standards.

Table 6. Handbrake Stopping Distance Test – Dry (stopping distance / rider weight)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	4.57 m (15 ft) / 68 kg (150 lb) or combined weight of rider and bicycle less than 91 kg (200 lb)	-	6 m (20 ft) / 100 kg (220 lb)*	6 m (20 ft) / 100 kg (220 lb)*
2 – Trekking		-	7 m (23 ft) / 100 kg (220 lb)*	7 m (23 ft) / 100 kg (220 lb)*
3 – Mountain		-	6 m (20 ft) / 100 kg (220 lb)*	6 m (20 ft) / 100 kg (220 lb)*
4 – Downhill		-	-	-
YA		-	-	7 m (23 ft) / 100 kg (220 lb)*
BMX 1		-	**	-
BMX 2		-	4.5 m (15 ft)*** / 100 kg (220 lb)*	-
EPAC		-	-	Same as non-powered bicycle requirements based on use condition

*Combined weight of rider and bicycle
**BMX 1 uses a machine-based test method for brake performance
***From 20 kph ground speed

Table 7. Footbrake Stopping Distance Test – Dry (stopping distance / mass added)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	4.57 m (15 ft) / 68 kg (150 lb) or combined weight of rider and bicycle less than 91 kg (200 lb)	-	-	15 m (49 ft) / 100 kg (220 lb)*
2 – Trekking		-	15 m (49 ft) / 100 kg (220 lb)*	15 m (49 ft) / 100 kg (220 lb)*
3 – Mountain		-	-	15 m (49 ft) / 100 kg (220 lb)*
4 – Downhill		-	-	-
Young Adult		-	-	15 m (49 ft) / 100 kg (220 lb)*
BMX 1		-	**	-
BMX 2		-	8.5 m (28 ft)*** / 100 kg (220 lb)*	
EPAC		-	-	15 m (49 ft) / 100 kg (220 lb)*

*Combined mass of rider and bicycle
**BMX 1 uses a machine-based test method for brake performance
***From 20 kph ground speed

The EN and ISO standards perform stopping distance tests for both dry and wet brake conditions, whereas the CPSC standard only requires a dry brake test. For the wet condition tests, the test rider must maintain a ground speed of at least 16 kph (10 mph) prior to applying the brakes. The test procedure specifies that the bicycle must be equipped with a water spray system with a nozzle at the front wheel and a pair of nozzles at the rear wheel. The water spray system wets the brakes at least 25 m prior to the application of the brakes and continuously until the bicycle comes to a complete stop. Table 8 and Table 9 show the required stopping distance for each use condition for handbrakes and footbrakes (rear-only brakes) respectively.

Table 8. Handbrake Stopping Distance Test – Wet (stopping distance / mass added)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	5 m (16.4 ft) / 100 kg*	5 m (16.4 ft) / 100 kg*
2 – Trekking	-	-	5 m (16.4 ft) / 100 kg*	5 m (16.4 ft) / 100 kg*
3 – Mountain	-	-	5 m (16.4 ft) / 100 kg*	5 m (16.4 ft) / 100 kg*
4 – Downhill	-	-	-	-
Young Adult	-	-	-	5 m (16.4 ft) / 100 kg*
BMX 1	-	-	**	-
BMX 2	-	-	3 m (9.8 ft)*** / 100 kg*	-
EPAC	-	-	-	5 m (16.4 ft) / 100 kg*

*Combined mass of rider and bicycle
**BMX 1 uses a machine-based test method for brake performance
***From 13 kph ground speed

Table 9. Footbrake Stopping Distance Test – Wet (stopping distance / mass added)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	10 m (33 ft) / 100 kg*
2 – Trekking	-	-	10 m (33 ft) / 100 kg*	10 m (33 ft) / 100 kg*
3 – Mountain	-	-	-	10 m (33 ft) / 100 kg*
4 – Downhill	-	-	-	-
Young Adult	-	-	-	10 m (33 ft) / 100 kg*
BMX 1			**	
BMX 2	-	-	6 m (19.7 ft)*** / 100 kg*	-
EPAC	-	-	-	10 m (33 ft) / 100 kg*

*Combined mass of rider and bicycle
**BMX 1 uses a machine-based test method for brake performance
***From 13 kph ground speed

Machine-based Stopping Distance

The EN and ISO standards specify an alternative machine-based test method for the braking performance requirement. The EN standard requires e-bikes to be tested with the machine-based test, but the ISO standard gives the option for either the track-based test or the machine-based test for e-bikes. The machine-based test evaluates the braking performance by measuring the resulting braking force from the wheels by the brake system while mounted onto a test rig. Consequently, this test verifies that the braking forces are sufficient to stop the bicycle within the required distance as specified above in the track-based test by calculating the predicted stopping distance using a formula that is a function of the maximum braking force from the test. Table 10 and Table 11 below show the required minimum braking performance values for each usage condition in dry and wet conditions respectively with a wheel speed of 12.5 kph ± 5% (7.8 mph). A greater value represents better braking performance. The values below directly correlate with the stopping distances from the track-based test in Table 6 though Table 9 above. The test rig can be any machine which maintains contact with the tires by means of a roller or tread belt. Next, the machine-based test evaluates the relationship between the measured braking force and the operating force, or the applied force on the braking mechanism (*e.g.*, brake levers or pedals). The average measured braking force must be linearly proportional, within 20 percent, to the operating force with progressively increasing speed. Therefore, the test evaluates the brake system's ability to stop at any speed rather than the specified speed from the track-based test. After completion of the machine-based test, the procedure then tests the bicycle on the track to qualitatively evaluate the braking performance. The bicycles must demonstrate the ability to stop smoothly without any excessive juddering, wheel locking, or loss of control. The ISO standard notes that the machine-based test improves on the repeatability and reproducibility of the brake performance evaluation over the track-based method by removing the influence of the operator and other environmental factors.

Table 10. Machine-based Braking Performance Test – Dry (front only / rear only)

Use	CPSC	ASTM	EN*	ISO*
0 – Sidewalk	-	-	-	-
1 – Road	-	-	**	350 / 220
2 – Trekking	-	-	**	300 / 200
3 – Mountain	-	-	**	350 / 260
4 – Downhill	-	-	-	-
Young Adult	-	-	-	180 / 120
BMX	-	-	-	-
EPAC	-	-	340 / 220	Same as non-powered bicycle requirements based on use condition
EPAC Mtn	-	-	425 / 280	Same as non-powered bicycle requirements based on use condition

*Performance values are unitless
**Stopping distance calculated from maximum measured brake force, required to meet stopping distances from track-based test method

Table 11. Machine-based Braking Performance Test – Wet (front only / rear only)

Use	CPSC	ASTM	EN*	ISO*
0 – Sidewalk	-	-	-	-
1 – Road	-	-	**	160 / 120
2 – Trekking	-	-	**	150 / 120
3 – Mountain	-	-	**	180 / 120
4 – Downhill	-	-	-	-
Young Adult	-	-	-	90 / 80
BMX	-	-	-	-
EPAC	-	-	220 / 140	Same as non-powered bicycle requirements based on use condition
EPAC Mtn	-	-	280 / 140	Same as non-powered bicycle requirements based on use condition

*Performance values are unitless
**Stopping distance calculated from maximum measured brake force, required to meet stopping distances from track-based test method

Heat Resistance Test

The EN and ISO standards specify brake heat-resistance requirements for all disc- and drum-brake systems and only rim-brake systems that consist of thermoplastic materials. This requirement ensures that the brake materials can withstand the heat generated from the friction generated by the brakes without failure and reduced performance. The test procedures state that the heat-resistance test is conducted on a test rig similar to that described above for the machine-based stopping distance test. The procedures include a drag test which involves driving the wheels at a speed of 12.5 kph (7.8 mph) with the brakes continuously applied such that they develop a specified total braking energy based on the type of brake for a total of 300 seconds and repeated through three trials. After completing the drag test, the brakes must maintain at least 60 percent of their original braking performance values obtained from the machine-based stopping distance test in both dry and wet conditions. Table 12 below shows the required braking performance for each bicycle use condition.

Table 12. Brake Heat Resistance Test (percentage of brake performance)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	60%	60%
2 – Trekking	-	-	60%	60%
3 – Mountain	-	-	60%	60%
4 – Downhill	-	-	-	-
Young Adult	-	-	-	60%
BMX	-	-	-	-
EPAC	-	-	60%	60%

Control Cable Ends

For brake systems that use Bowden cables, the internal wire may consist of wound strands of smaller gauge wires. If any ends of the internal wire are accessible or exposed, the CPSC, EN, and ISO standards require the ends to be protected by caps or any other method to prevent unravelling of the strands, which tend to be sharp and may cut skin or grab onto materials. The requirements subject the caps to a pull test to ensure that they remain in place during normal use of the bicycle. Table 13 below shows the required pull forces for each bicycle use condition. The CPSC standard specifies a less stringent pull force compared to the EN and ISO standards.

Table 13. Control Cable End Removal Force Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	8.9 N (2 lb)	-	20 N (4 lbf)	20 N (4 lbf)
1 – Road	8.9 N (2 lb)	-	20 N (4 lbf)	20 N (4 lbf)
2 – Trekking		-	20 N (4 lbf)	20 N (4 lbf)
3 – Mountain		-	20 N (4 lbf)	20 N (4 lbf)
4 – Downhill		-	-	-
Young Adult		-	-	20 N (4 lbf)
BMX		-	20 N (4 lbf)	-
EPAC		-	20 N (4 lbf)	20 N (4 lbf)

Steering System

The bicycle's steering system provides control to the rider for the direction of the bicycle. It consists of the handlebar, stem, and fork. The drop-out slots at the ends of the fork hold the front wheel, and the steerer tube end of the fork passes through the head tube of the bicycle frame and connects to the stem. The stem connects the handlebar to the steerer tube and the whole assembly allows the rider to rotate the front wheel by turning the handlebar, thus giving the ability to steer the bicycle. Figure 5 below shows a diagram of the typical arrangement of steering system components.

Figure 5. Bicycle steering system components

There are two primary types of bicycle stems: threaded and threadless. Threaded quill stems are mostly found in older model bicycles and insert inside the top of the fork steerer tube. A single bolt expands a part of the stem against the inner diameter of the steerer tube. This friction between the stem and inner diameter of the steerer tube maintains the positive retention of the two components. Threadless stems are found on most modern bicycles because they are typically lighter and allow easier adjustment of the handlebar height and reach. A threadless stem clamps around the outer diameter of the fork steerer tube and is held in compression by stem bolts. The friction between the stem and outer diameter of the steerer tube maintains the positive retention of the two components. Handlebar height can be adjusted by using spacers on the steerer tube below or above the stem, and handlebar reach can be adjusted by using different length stems. Figure 6 below shows examples of threadless and threaded handlebar stems.

Figure 6. Types of handlebar stems: threaded (left) and threadless (right)

There are two primary types of handlebars: drop bars and flat bars. Curved drop bars are typically used on road bikes which do not require severe steering inputs and allow riders to tuck into an aerodynamic riding position to maximize speed. Flat bars are typically used on mountain, hybrid, and cruiser bicycles; they provide wider hand placement and a more upright body position for better control and comfort. Other types of handlebars include riser bars, bullhorn bars, and BMX bars, among others. Figure 7 below shows examples of common types of bicycle handlebars.

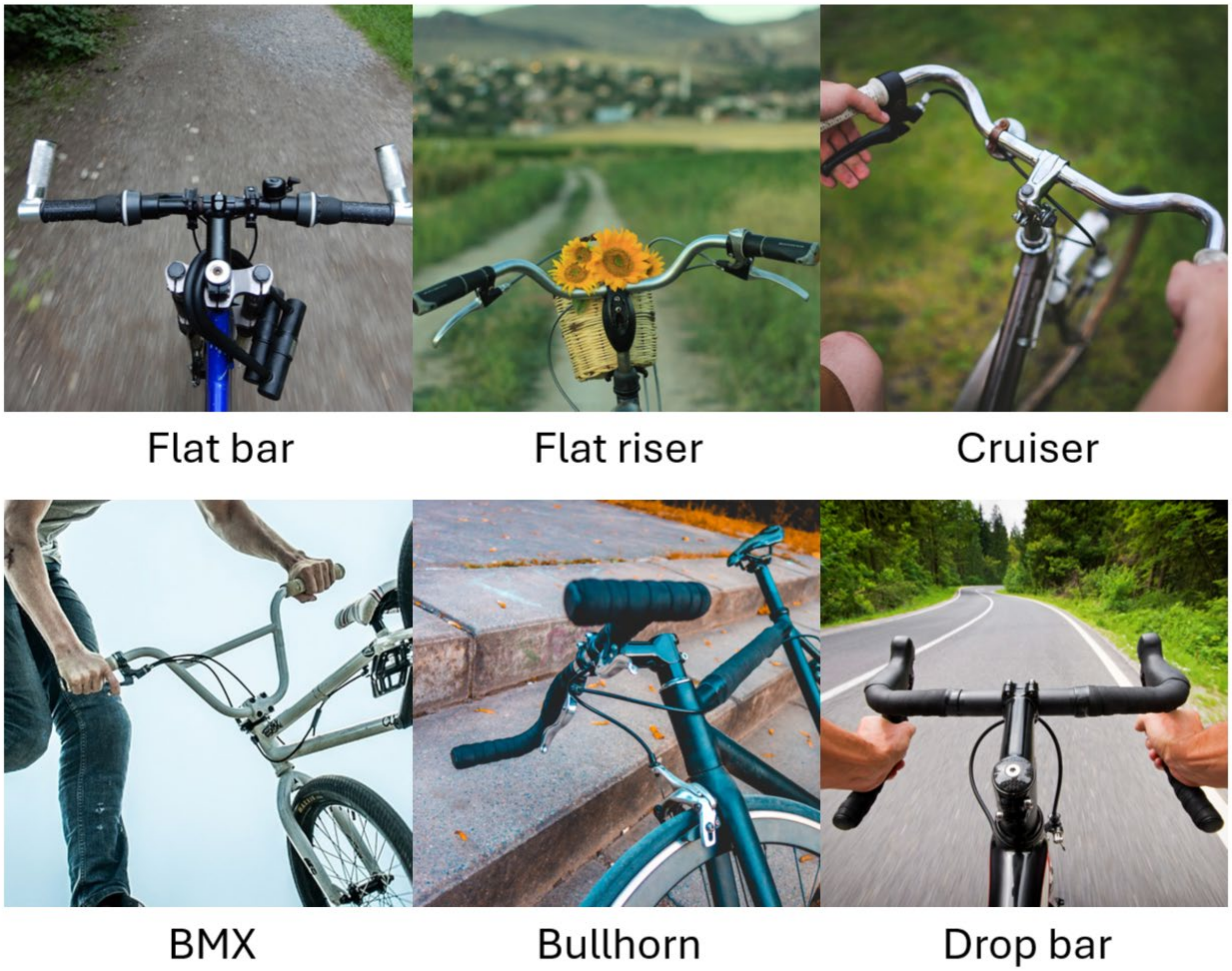

Figure 7. Common types of handlebars

Strength Tests

The CPSC, EN, and ISO standards specify performance requirements for the strength of the handlebar stem. The stem may encounter significant stresses from the weight of the rider leaning on the handlebars and momentum from sudden stops. The requirements test the stem with the end that connects with the steerer tube fixed with a rigid clamp or equivalent fixture to prevent any relative movement as shown below in Figure 8. The test applies a force angled in the forward direction, 45˚ below the horizontal, maintaining for 1 minute. After application of the force, the stem must have no visible cracks or fractures. The EN and ISO standards specify that the stem shall also not have any permanent set greater than 10 mm, whereas the CPSC standard does not specify any permanent set limitation. If the stem meets these criteria, the EN and ISO standards subject the stem to a stage 2 test. With the same setup as in stage 1, the stage 2 test applies a gradually increasing force in the same direction on the stem until the force reaches a specified magnitude or until the stem deflects 50 mm. If the stem does not yield, the force maintains for a duration of 1 minute. After the stage 2 force is released, the stem must not have any visible cracks or fractures. Table 14 below shows the magnitude of the applied force for each bicycle use condition. Although the CPSC standard specifies a more stringent applied force on the stem, it only requires the force to be applied once whereas the EN and ISO standards require a second stage to the test which applies an equivalent or greater force than the CPSC standard depending on the use condition of the bicycle. Therefore, overall, the CPSC standard is less stringent than the requirements from EN and ISO.

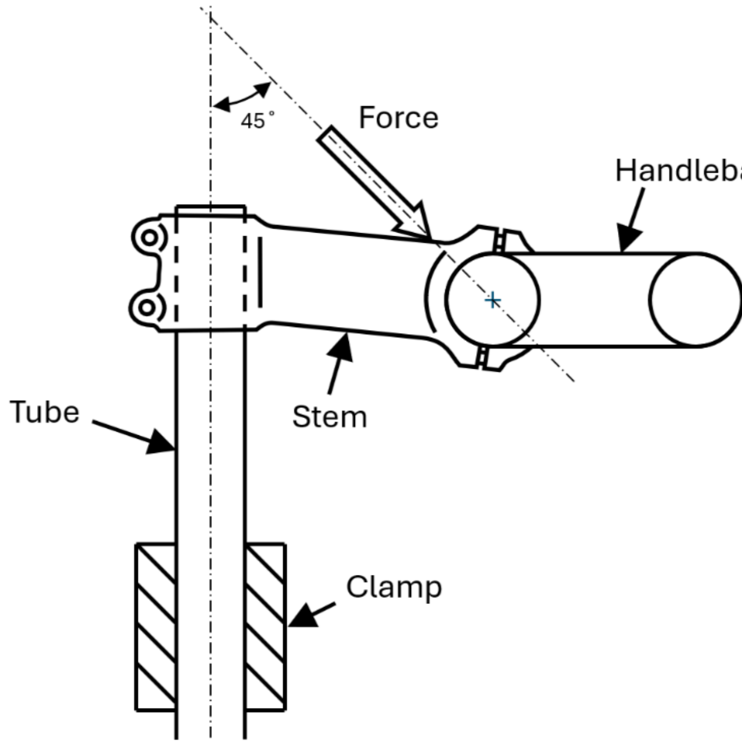

Figure 8. Test Diagram – Handlebar Stem Forward Bending Strength

Table 14. Handlebar Stem Forward Bending Strength Test (stage 1 force / stage 2 force)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	1,000 N (225 lbf) / NA	-	500 N (112 lbf) / NA	500 N (112 lbf) / NA
1 – Road	2,000 N (450 lbf) / NA	-	1,600 N (360 lbf) / 2,300 N (517 lbf)	1,600 N (360 lbf) / 2,300 N
2 – Trekking		-	1,600 N (360 lbf) / 2,000 N (450 lbf)	1,600 N (360 lbf) / 2,000 N (450 lbf)
3 – Mountain		-	1,600 N (360 lbf) / 2,600 N (585 lbf)	1,600 N (360 lbf) / 2,600 N (585 lbf)
4 – Downhill		-	-	-
Young Adult		-	-	1,600 N (360 lbf) / 2,000 N (450 lbf)
BMX 1		-	1600 N (360 lbf) / NA	-
BMX 2		-	3000 N (674 lbf) / NA	-
EPAC		-	1,600 N (360 lbf) / 2,600 N (585 lbf)	Same as non-powered bicycle requirements based on use condition, except use condition 2 is 1,600 N / 2,600 N

The EN and ISO standards contain an additional bending strength requirement for the handlebar stem. The lateral bending requirements' test setup is similar to the forward bending strength test detailed above. If the manufacturer of the stem produces both the stem and handlebar, the requirements test the handlebar clamped to the stem; otherwise, the stem shall clamp a rigid bar as a surrogate handlebar. The test applies a vertically downward force on the handlebar at a specified location. If the test is conducted on a handlebar and stem assembly, the force applies 50 mm from the end of the handlebar, and if the test is conducted with a rigid bar in lieu of a handlebar, the force applies at a prescribed distance from the center of the stem. Figure 9 below shows a diagram of the test procedure. The stem and/or handlebars shall not have any visible cracks, fractures, or permanent set exceeding 10 mm for the stem or 15 mm for the handlebar when measured at the point of force application. Table 15 shows the magnitude of the applied force for tests conducted on a stem and handlebar assembly, and Table 16 below shows the magnitude of the applied force and the distance from the center of the stem for tests conducted with the stem only.

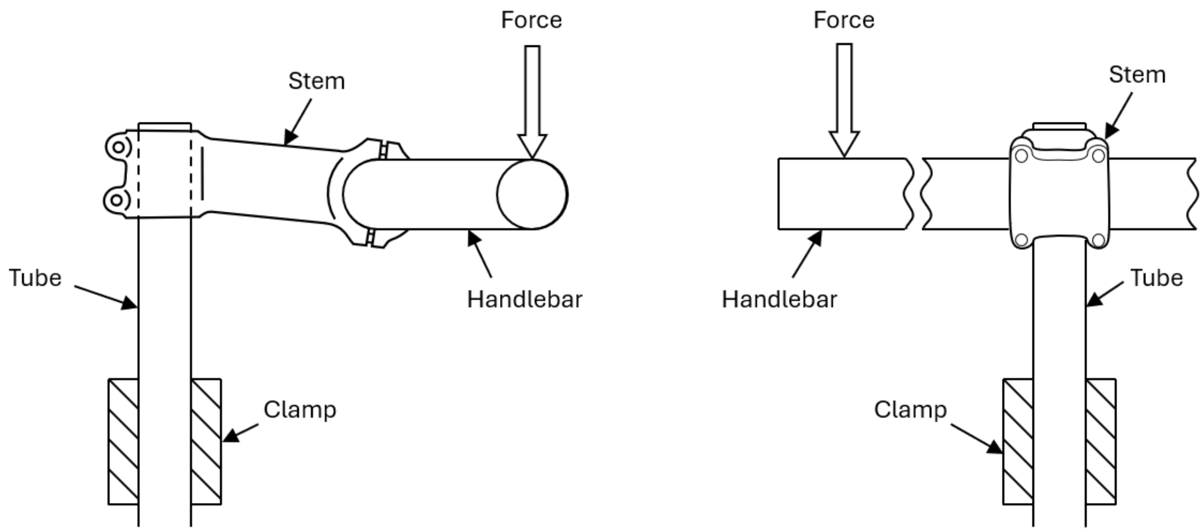

Figure 9. Test Diagram – Handlebar and Stem Lateral Bending

Table 15. Handlebar and Stem Assembly Lateral Bending Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	450 N (101 lbf)	450 N (101 lbf)
1 – Road	-	-	1,000 N (225 lbf)	1,000 N (225 lbf)
2 – Trekking	-	-	600 N (135 lbf)	600 N (135 lbf)
3 – Mountain	-	-	1,000 N (225 lbf)	1,000 N (225 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	600 N (135 lbf)
BMX 1	-	-	600 N (135 lbf)	-
BMX 2	-	-	1,000 N (225 lbf)	-
EPAC	-	-	800 N (180 lbf)	Same as non-powered bicycle requirements based on use condition, except use condition 2 is: 800 N (180 lbf) / 300 mm
EPAC Mtn	-	-	1,000 N (225 lbf)	1,000 N (225 lbf)

Table 16. Handlebar Stem Lateral Bending Strength Test (applied force / distance from center)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	1000 N (225 lbf) / 230 mm	1000 N (225 lbf) / 230 mm
2 – Trekking	-	-	600 N (135 lbf) / 300 mm	600 N (135 lbf) / 300 mm
3 – Mountain	-	-	1000 N (225 lbf) / 300 mm	1000 N (225 lbf) / 300 mm
4 – Downhill	-	-	-	-
Young Adult	-	-	-	600 N (135 lbf) / 300 mm
BMX	-	-	-	-
EPAC	-	-	-	-

The CPSC, EN, and ISO standards specify a torsional security requirement for the stem to fork clamp to prevent misalignment of the handlebars to the front fork/wheel. The requirements test the stem assembled with the fork steerer tube through the head tube of the bicycle frame and the clamp tightened to the manufacturer's recommended torque. A rigid bar replaces the handlebars in the clamp of the stem. The test applies a torque about the axis of the stem and steerer tube by applying a force on the rigid bar in the plane perpendicular to that axis and maintaining for 1 minute. Figure 10 below shows a diagram of the test procedure. The stem shall not have any relative movement relative to the fork. Table 17 below shows the applied torque to the stem and fork assembly for each bicycle use condition. The CPSC standard specifies a more stringent torque to the stem for sidewalk bicycles compared to the EN and ISO standards, but the torque for all other use conditions are equivalent.

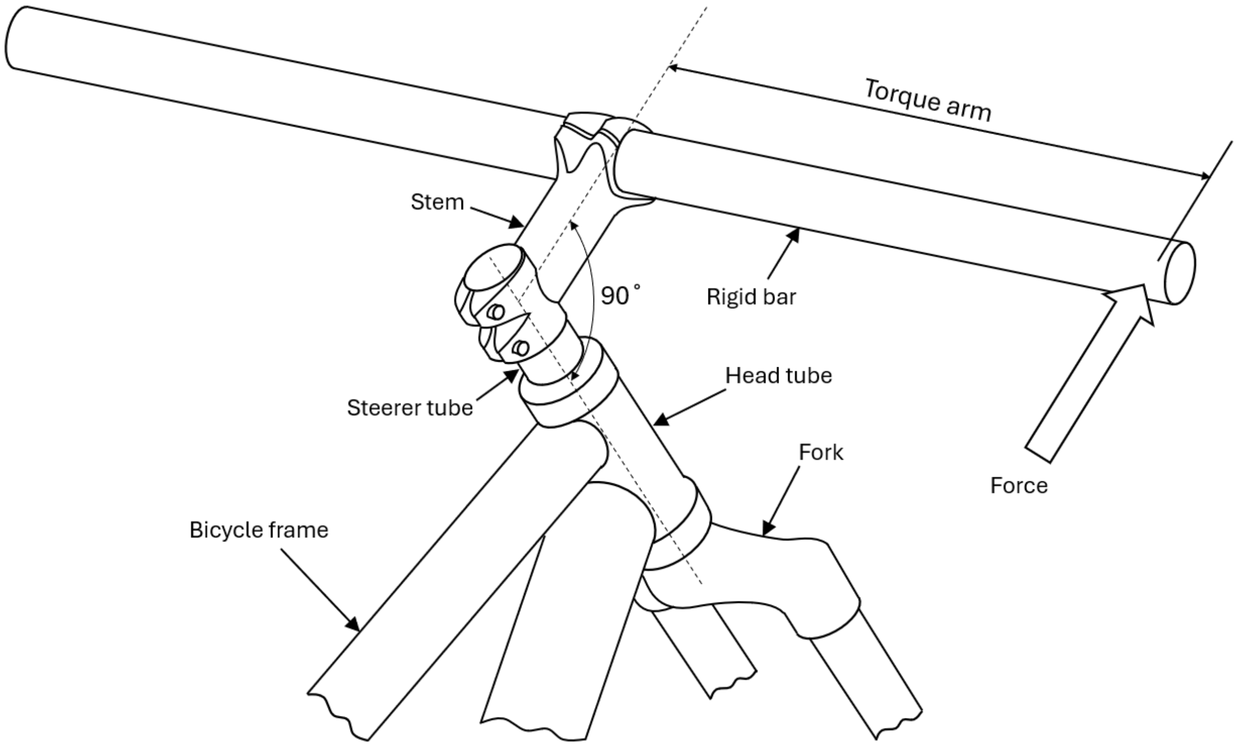

Figure 10. Test Diagram – Handlebar Stem to Fork Torsional

Table 17. Handlebar Stem to Fork Torsional Security Test

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO</th></tr>
<tr><td>0 – Sidewalk</td><td>23 N-m (17 ft-lb)</td><td>-</td><td>15 N-m (11 ft-lb)</td><td>15 N-m (11 ft-lb)</td></tr>
<tr><td>1 – Road</td><td rowspan="9">50 N-m (37 ft-lb)</td><td>-</td><td>40 N-m (30 ft-lb)</td><td>50 N-m (37 ft-lb)</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>40 N-m (30 ft-lb)</td><td>50 N-m (37 ft-lb)</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>50 N-m (37 ft-lb)</td><td>50 N-m (37 ft-lb)</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td><td>50 N-m (37 ft-lb)</td></tr>
<tr><td>BMX</td><td>-</td><td>50 N-m (37 ft-lb)</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>40 N-m (30 ft-lb)</td><td>50 N-m (37 ft-lb)</td></tr>
<tr><td>EPAC Mtn</td><td>-</td><td>50 N-m (37 ft-lb)</td><td>50 N-m (37 ft-lb)</td></tr>
</table>

The CPSC, EN, and ISO standards contain a torsional security requirement for the handlebar to stem clamp to prevent the handlebars from moving relative to the stem, especially when the rider leans their weight on the handlebars. This requirement does not apply to bicycles with drop handlebars as the lateral bending test above is an equivalent test. The test setup has the handlebars clamped to the stem and tightened to the manufacturer's recommended torque, and a fixture clamps to the stem to prevent any relative movement. Depending on the use condition of the bicycle, the test procedure either specifies to apply a force on the handlebars resulting in a specified torque on the stem clamp or specifies an applied force on a location on the handlebars to create the maximum torque possible on the stem clamp. Figure 11 below shows an example diagram of how the torque may be applied to flat handlebar configurations. The method for applying the torque will vary depending on the type of handlebar. Table 18 below shows the force or torque application for each bicycle use condition. The handlebars shall not have any relative movement to the stem at any point during the test. The CPSC standard specifies a force for all bicycle use conditions, whereas the EN and ISO standards specify different magnitudes depending on the use condition. Additionally, the EN and ISO procedures vary between use conditions as some specify a force while others specify a torque. The CPSC standard also specifies an alternative impact energy in lieu of a force for the test which addresses dynamic loads on the handlebar and stem, whereas the other standards do not.

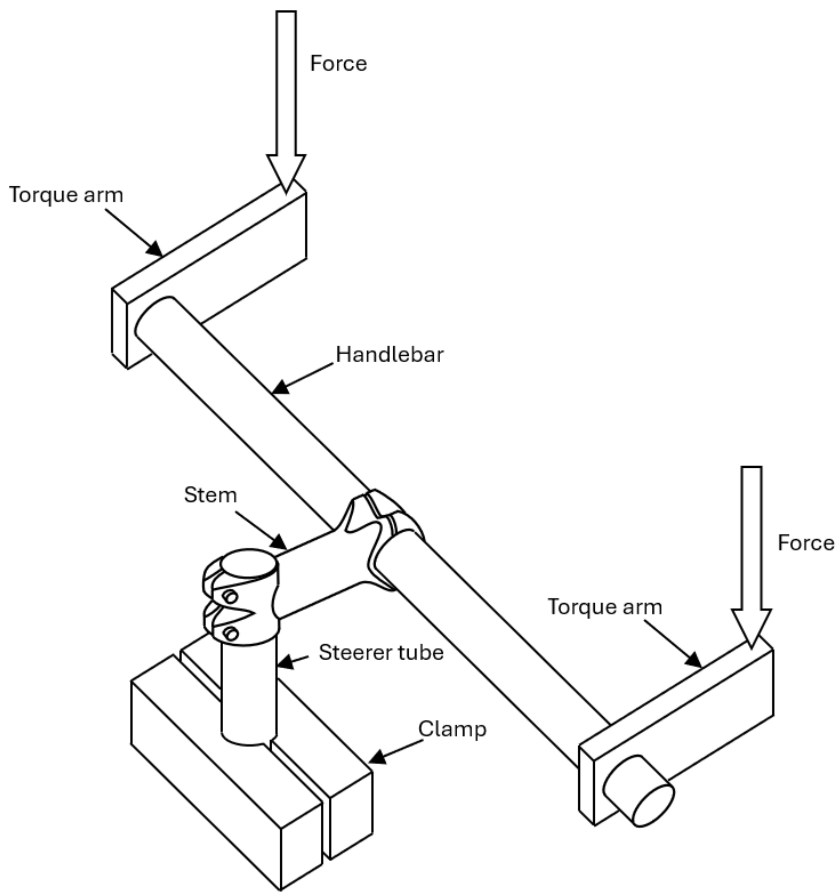

Figure 11. Test Diagram – Handlebar to Stem Torsional Security

Table 18. Handlebar to Stem Torsional Security Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	445 N (100 lbf)* or 22.6 J (200 in-lb)	-	2 x 130 N* (29 lbf)	2 x 130 N* (29 lbf)
1 – Road		-	2 x 220 N* (49 lbf)	-
2 – Trekking		-	60 N-m (44 ft-lb)	60 N-m (44 ft-lb)
3 – Mountain		-	80 N-m (59 ft-lb)	80 N-m (59 ft-lb)
4 – Downhill		-	-	-
Young Adult		-	-	60 N-m (44 ft-lb)
BMX 1		-	2 x 400 N* (90 lbf)	-
BMX 2		-	2 x 800 N* (180 lbf)	-
EPAC		-	70 N-m (52 ft-lb)	70 N-m (52 ft-lb)
EPAC Mtn		-	80 N-m (59 ft-lb)	80 N-m (59 ft-lb)

*Apply forces to locations on handlebars to create maximum torque on stem clamp

The EN and ISO standards contain a fatigue test to simulate the effects of alternating load on the handlebar such as when a rider's weight shifts between the grips when pedaling. The requirements test the handlebar and stem assembly in two stages. The test setup is with the stem fixed to prevent any relative movement at the steerer tube end and the handlebars clamped to the stem per the manufacturer's instruction as shown in Figure 12 below. Stage 1 of the fatigue test applies a vertical, fully reversed, cyclic load 50 mm from each end of the handlebar for 100,000 cycles. The forces at each end are out-of-phase with each other; in other words, as the force on one end of the handlebar is vertically downward, the force on the other end of the handlebar is vertically upwards. At the end of stage 1, the handlebar and stem assembly shall not have any visible cracks or fracture. If the assembly passes the criteria, stage 2 of the fatigue test applies another vertical, fully reversed, cyclic load at the same location for 100,000, but this time, the loads are in phase with each other, or both forces are applied in the same direction at the same time. At the end of stage 2, the assembly shall not have any visible cracks or fractures. Table 19 below shows the magnitude of the applied forces for each stage for each bicycle use condition.

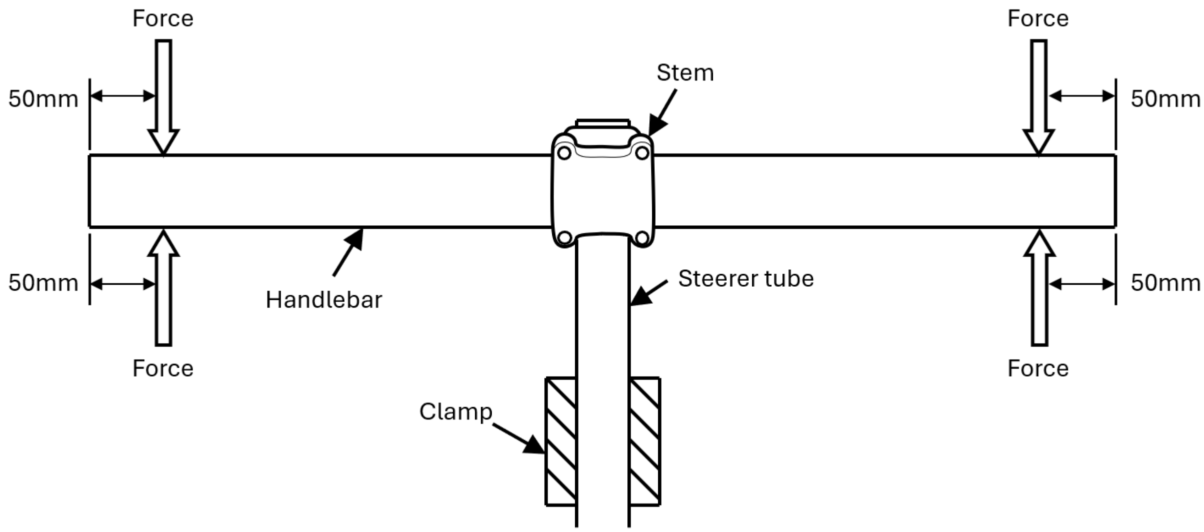

Figure 12. Test Diagram – Handlebar and Stem Fatigue

Table 19. Handlebar and Stem Fatigue Test (stage 1 cyclic force / stage 2 cyclic force)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	115 N (26 lbf) / 190 N (43 lbf)	115 N (26 lbf) / 190 N (43 lbf)
1 – Road	-	-	280 N (63 lbf) / 400 N (90 lbf)	280 N (63 lbf) / 400 N (90 lbf)
2 – Trekking	-	-	200 N (45 lbf) / 250 N (56 lbf)	200 N (45 lbf) / 250 N (56 lbf)
3 – Mountain	-	-	270 N (61 lbf) / 450 N (101 lbf)	270 N (61 lbf) / 450 N (101 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	200 N (45 lbf) / 250 N (56 lbf)
BMX 1	-	-	200 N (45 lbf) / 250 N (56 lbf)	-
BMX 2	-	-	270 N (61 lbf) / 450 N (101 lbf)	-
EPAC	-	-	220 N (49 lbf) / 280 N (63 lbf)	Same as non-powered bicycle requirements based on use condition, except use condition 2 is: 220 N (49 lbf) / 280 N (63 lbf)
EPAC Mtn	-	-	270 N (61 lbf) / 450 N (101 lbf)	270 N (61 lbf) / 450 N (101 lbf)

Pedals

The pedals are the contact points where the downward motion of the user's feet is translated by the crank arms into the circular motion that drives the chain and propels the rear wheel of the bicycle. There are two common types of bicycle pedal: clipless and flat pedals. Figure 13 below shows examples of clipless and flat pedals. Despite the name of the pedal, clipless pedals allow riders to clip their specialized shoes to the pedals similar to a ski binding via spring-loaded clips on the face of the pedal. This is beneficial with respect to maximizing power applied due to the increased efficiency of power transfer to the drive system and the control provided to the rider especially when riding fast or hopping over bumps and curbs as the rider's feet are always connected to the pedals and won't bounce off, but they require skill in use to quickly unclip when stopping to allow feet to extend to the ground. Flat pedals do not provide an attachment mechanism and provide a wider and flat surface to support the rider's feet. Flat pedals are the most common pedal type found on every type of bicycle. Mountain bikes and commuting bikes, where the rider frequently gets on and off the bike, use flat pedals. Flat pedals are typically made out of steel, aluminum, or magnesium for most bicycles, but BMX bikes typically use non-metallic pedals made out of nylon, polycarbonate, or carbon reinforced plastic.

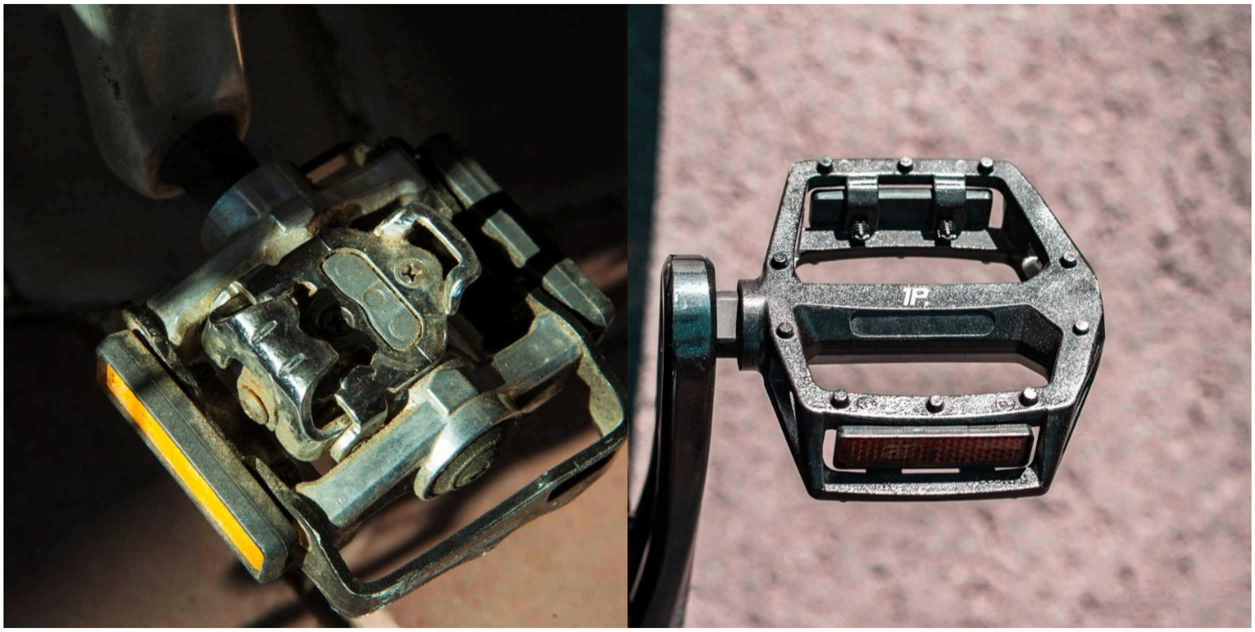

Figure 13. Example bicycle pedal types: clipless pedal (left) and flat pedal (right)

The pedals connect to the crank arms via a spindle that threads into the ends of the crank arms, and the pedals are free to rotate about the axis of the spindle via a bearing system. Because the pedals must withstand repeated downward force of the user's foot, the spindle is typically composed of a more durable material than the crank arms into which they are threaded. Standard bicycle design also specifies right-hand threads on the right-side crank arm and pedal, and left-hand (reverse) thread on the left-side crank and pedal. As such, right pedals will only thread into right side crank arms and left pedals will only thread into left side crank arms. The standardized bicycle design allows standard pairs of pedals to fit interchangeably onto any standard bicycle.

Strength Requirements

The EN and ISO standards contain performance requirements for bicycle pedals. Because the pedals are the contact point for which the rider applies force to propel the bicycle, this exerts a significant amount of stress on the pedal structure. To account for these high stresses, the static strength requirement tests the pedal with the spindle screwed and secured into a rigid fixture and applies a vertically downward force of 1,500 N on the pedal. The EN standard maintains this force for 1 minute and the ISO standard for 5 minutes. The pedal shall have no visible cracks, fractures, or distortion that could affect the operation of the pedal. Table 20 below shows the applied force for each bicycle use condition.

Table 20. Pedal Static Strength Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
2 – Trekking	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
3 – Mountain	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,500 N (337 lbf)
BMX	-	-	1,500 N (337 lbf)	-
EPAC	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)

The EN and ISO standards also specify an impact test for the pedals. Using the same test setup as the static strength test above, the impact test drops an impactor with a mass of 15 kg (33 lb) from a specified height onto the center of the pedal. The impact shall not form any visible fractures on any part of the pedal or spindle or any separation of the bearing system. Table 21 below shows the mass of the impactor and the drop height for each bicycle use condition.

Table 21. Pedal Impact Test (impactor mass / drop height)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	15 kg (33 lb) / 200 mm	15 kg (33 lb) / 200 mm
1 – Road	-	-	15 kg (33 lb) / 400 mm	15 kg (33 lb) / 400 mm
2 – Trekking	-	-	15 kg (33 lb) / 400 mm	15 kg (33 lb) / 400 mm
3 – Mountain	-	-	15 kg (33 lb) / 400 mm	15 kg (33 lb) / 400 mm
4 – Downhill	-	-	-	-
Young Adult	-	-	-	15 kg (33 lb) / 400 mm
BMX	-	-	100 J*	-
EPAC	-	-	15 kg (33 lb) / 400 mm	15 kg (33 lb) / 400 mm

*Impact force specified rather than mass and drop height, and tested with pedal and crank arm assembly

Next, the EN and ISO standards subject pedals to a fatigue test called the dynamic durability test. The test setup consists of the pedal and spindle assembly screwed into a rotatable test shaft that rotates about the axis of the pedal spindle, and a weight of a specified mass hangs off the pedal suspended by a tension spring to minimize oscillations of the load during the test. Figure 14 below shows a diagram of the test setup. The test shaft rotates for a total of 100,000 revolutions, rotating the spindle relative to the pedal and cycling the load and stress around the spindle about its axis. After completion of the test cycles, the pedal, spindle, or crank-threads shall not have any visible fractures or cracks in any part. Table 22 below shows the mass of the hanging weight and the number of cycles for each bicycle use condition.

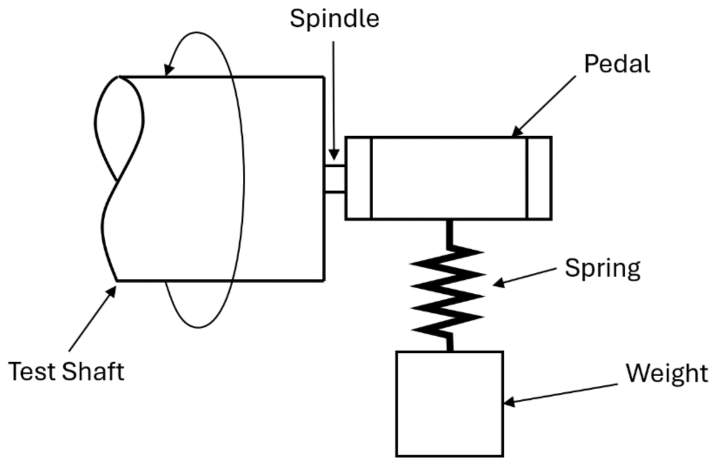

Figure 14. Test Diagram – Pedal Dynamic Durability

Table 22. Pedal Dynamic Durability Test (hanging mass / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	30 kg / 100,000	30 kg / 100,000
1 – Road	-	-	65 kg / 100,000	90 kg / 100,000
2 – Trekking	-	-	80 kg / 100,000	80 kg / 100,000
3 – Mountain	-	-	90 kg / 100,000	90 kg / 100,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	80 kg / 100,000
BMX	-	-	90 kg / 100,000	-
EPAC	-	-	80 kg / 100,000	Same as non-powered bicycle requirements based on use condition
EPAC Mtn	-	-	90 kg / 100,000	90 kg / 100,000

Drive System

The bicycle's drive system, or drive train, is the system of components which translate power from the rider or electric motor into forward propulsion, or simply, the system that moves the bicycle. The drive system typically consists of the pedals, crank arms, chainring, front and rear derailers, cassette, and chain/belt. For e-bikes, the drive system also includes the electric motor either mounted in the bottom bracket of the frame or at the rear hub. Figure 15 shows a diagram of all the components of a typical bicycle drive system.

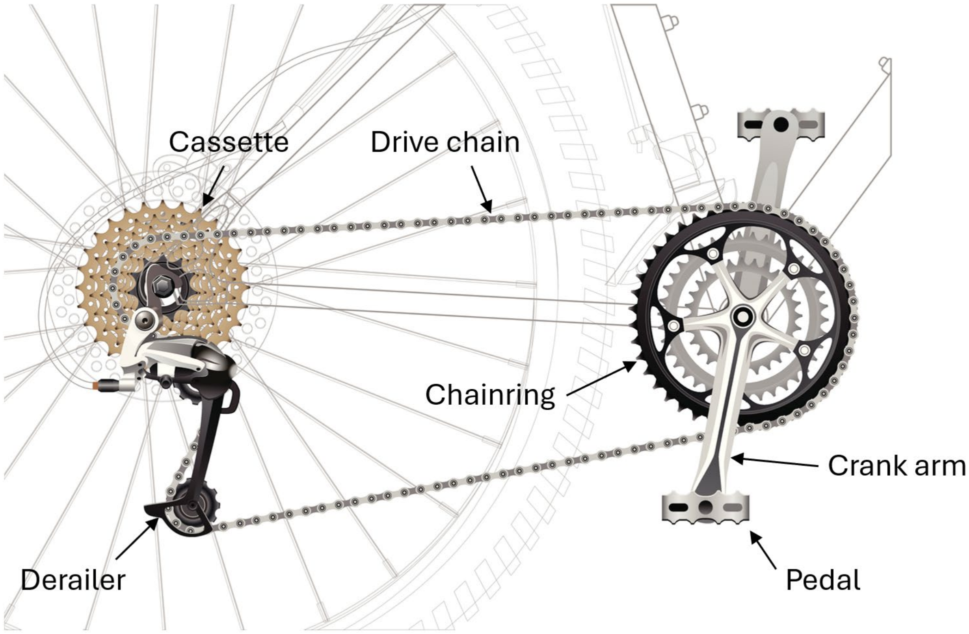

Figure 15. Components of the bicycle drive system

Bicycles transfer power from the pedals and crank arms to the rear wheel via either a drive chain or belt which, in turn, transfers the power from the crank set into forward propulsion via the rear wheel. E-bikes with mid-drive electric motors which drive the chainring directly also transfers power through the drive chain or belt. Drive chains, also known as bicycle chains or roller chains, consist of a series of links connected to each other by a pin, allowing rotation between links about only one axis. Drive belts are a recent innovation to bicycle drive systems because they are lower maintenance, lubrication free, quieter, longer lasting, and lighter. Drive belts utilize carbon reinforced belts with toothed ridges that fit directly with the teeth of the sprockets or gears of the crankset and cassette. Figure 16 below shows examples of each type of drive system.

Figure 16. Drive systems: chain (left) and belt (right)

Some e-bikes have hub motors where the motor is located at either the front or rear hub. Therefore, these e-bikes do not transfer their power through a drive-chain or -belt. There are two different types of hub motors: direct-drive motors and geared hub motors. For direct-drive motors, the motor is fixed to the wheel; therefore, the motor and wheel rotate together around the hub of the bicycle which is stationary. Geared hub motors use planetary gears to achieve higher torque than direct-drive motors. In both these types, there is no transfer of power because the motor is attached to the wheel.

Drive-Chains

The CPSC, EN, and ISO standards specify strength requirements for drive chains. The first strength requirement is a tensile load test which slowly applies a pull force on the ends of the sample drive chain until any failure occurs along the length of the chain. Table 23 below shows the minimum required tensile strength that drive chains must meet for each bicycle use condition. The CPSC standard specifies an equivalent tensile load to the EN and ISO standards; however, it specifies a requirement for sidewalk bicycles, whereas the EN and ISO standards do not.

Table 23. Drive Chain Tensile Load Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	6,230 N (1,400 lb)	-	-	-
1 – Road	8,010 N (1,800 lb)	-	8,000 N (1,798 lbf)	8,000 N (1,798 lbf)
2 – Trekking		-	8,000 N (1,798 lbf)	8,000 N (1,798 lbf)
3 – Mountain		-	8,000 N (1,798 lbf)	8,000 N (1,798 lbf)
4 – Downhill		-	-	-
Young Adult		-	-	8,000 N (1,798 lbf)
BMX		-	8,000 N (1,798 lbf)	-
EPAC		-	8,000 N (1,798 lbf)	8,000 N (1,798 lbf)

The second strength requirement is a push-out force test for drive chain pins. The pins secure the links of the bicycle chain together and therefore may lead to the chain failing if a pin were dislodged from the chain. The test applies a gradually increasing push force on a single pin of a sample chain until it is pushed out the other side, and the pin-pushout resistance is measured by the minimum measured force during the test. Table 24 below shows the minimum required push-out resistance for drive chains for each bicycle use condition.

Table 24. Drive Chain Pin Push-Out Resistance Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	780 N (175 lbf)	780 N (175 lbf)
2 – Trekking	-	-	780 N (175 lbf)	780 N (175 lbf)
3 – Mountain	-	-	780 N (175 lbf)	780 N (175 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	780 N (175 lbf)
BMX	-	-	780 N (175 lbf)	-
EPAC	-	-	780 N (175 lbf)	780 N (175 lbf)

The EN and ISO standards specify a static strength test for the complete drive system assembly including the bicycle frame, drive chain, front and rear sprockets, transmission system, rear wheel, pedals, and crank arms. The requirements test the drive system assembly mounted on the bicycle frame with the rear wheel held at the rim to prevent rotation and the crank arms oriented in the horizontal position similar to Figure 4 above. The test applies a 1,500 N (337 lbf) in the vertically downward direction and maintains for 1 minute. Throughout the duration of the test, there shall be no fracture of any component of the drive system assembly and no drive capability lost. The strength test repeats for each pedal. Table 25 below shows the minimum applied force to the pedals that the drive system assembly must withstand without failure for each bicycle use condition.

Table 25. Drive System Static Strength Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	700 N (157 lbf)	700 N (157 lbf)
1 – Road	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
2 – Trekking	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
3 – Mountain	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,500 N (337 lbf)
BMX	-	-	1,500 N (337 lbf)	-
EPAC	-	-	1,500 N (337 lbf)	1,500 N (337 lbf)

Drive Belts

For bicycles equipped with a belt drive system, the EN and ISO standards specify separate requirements. The first requirement subjects drive belts to a tensile strength test. A test fixture with a drive belt affixed to two drive pulleys, as shown below in Figure 17, applies a gradually increasing force to one drive pulley up to 16,000 N, which in turn increases the tension load of the drive belt to 8,000 N. The drive belt shall be able to withstand this tension load with no evidence of cracking, fracture, or delamination. Table 26 below shows the required minimum tensile load for each bicycle use condition.

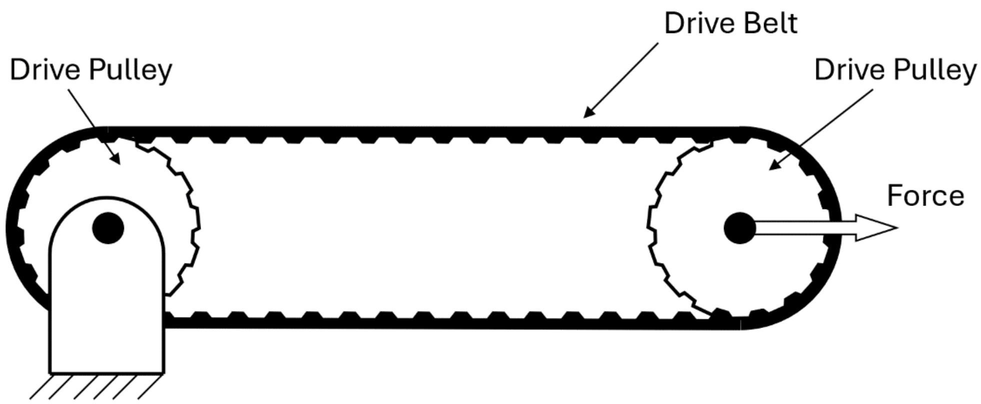

Figure 17. Test Diagram – Drive Belt Tensile Strength

Table 26. Drive Belt Tensile Strength Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	8,000 N (1,798 lbf)
2 – Trekking	-	-	-	8,000 N (1,798 lbf)
3 – Mountain	-	-	-	8,000 N (1,798 lbf)
4 - Downhill	-	-	-	-
Young Adult	-	-	-	8,000 N (1,798 lbf)
BMX	-	-	-	-
EPAC	-	-	4,000 N (899 lbf)	8,000 N (1,798 lbf)

The ISO standard specifies a strength test similar to the drive-chain system test detailed above. This strength test requires drive belts to be pre-conditioned with a water spray for a duration of 10 minutes, and the strength test shall be conducted within 20 minutes of pre-conditioning. This requirement tests the drive belt installed in the complete drive system assembly, including the bicycle frame, front and rear sprockets, transmission system, rear wheel, pedals, and crank arms. The test setup has the rear wheel held at the rim to prevent rotation and crank arms oriented in the horizontal position. The test applies a 1,500 N force (337 lbf) in the vertically downward direction and maintains for 1 minute. Throughout the duration of the test, there shall be no fracture of any component of the drive system assembly, no drive capability lost, and no evidence of cracking, fracture, or delamination of the drive belt. The strength test repeats for each pedal. Table 27 below shows the minimum applied force to the pedals that the drive system assembly must withstand without failure for each bicycle use condition.

Table 27. Drive Belt Static Strength Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	1,500 N (337 lbf)
2 – Trekking	-	-	-	1,500 N (337 lbf)
3 – Mountain	-	-	-	1,500 N (337 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,500 N (337 lbf)
BMX	-	-	-	-
EPAC	-	-	-	1,500 N (337 lbf)

Wheel/Tires

While the bicycle drive system transfers the rider's energy to the wheels, the wheels and tires are what transfer that effort to the ground. A bicycle wheel typically consists of three components: the rim, hub, and spokes. The rim is the outer most metal hoop of the wheel furthest away from the center that holds the tires, and for rim-brake systems, provides the braking surface. Typically, rims are composed of metal such as aluminum but can be made of carbon fiber for higher end models.

The hub is at the center of the wheel where the axle attaches the wheel to the bicycle fork or frame. The most common types of wheel hubs are quick-release, thru-axle, and bolt-on hubs as shown below in Figure 18. Quick release hubs are most common on road bicycles and have a cam-lever locking device that can be used without tools for quick removal of the wheel from the bicycle. Thru-axle hubs are most common on mountain bicycles and have a fixed axle that goes through the hub and threads directly onto the bicycle frame. Lastly, bolt-on axles have threaded ends and a hex nut to squeeze and secure the axel to the bicycle frame.

Figure 18. Bicycle hub types: quick-release (left), thru-axle (center), bolt-on (right)

The spokes are the components which connect the rim to the hub. Spokes are most commonly made of metal wire such as steel, aluminum, magnesium, or titanium, but can also be made out of carbon fiber. The number can vary with more spokes leading to improved strength and robustness of the wheel. Nipples are the attachment points of the spokes to the rim which can be adjusted to increase or decrease spoke tension to center the hub to the rim.

Bicycles come with many different sizes and types of tires. Manufacturers typically design tires based on the intended use condition of the bicycle on which they will be used. For example, tires used for road bicycles (condition 1) will typically be skinnier with a smoother tread pattern, and tires used for mountain bicycles (condition 3) will typically have wider tires with more pronounced tread to maintain grip on rough terrain. In terms of tire size, the diameter and width of the wheel rim usually governs the size of the tire it can mount. The width of the tire has varying trade-offs in terms of the desired performance for the bicycle, with narrower tires being great for reduced weight and faster speed and wider tires sacrificing weight and speed for increased traction. Figure 19 below shows examples of common types of bicycle tires and tread patterns.

Figure 19. Common types of bicycle tires

Rim Test

The CPSC, EN, and ISO standards specify performance requirements for the strength of bicycle wheel rims. The CPSC standard's static strength requirement tests bicycle wheels with the rim circumferentially supported around the tire sidewall and a 2,000 N (450 lbf) load applied to the axle perpendicular to the plane of the wheel for at least 30 seconds. After applying the load, the wheel shall not have any missing spokes and shall turn freely without roughness when remounted on the bicycle. The EN and ISO standards' static strength requirements test bicycle wheels with the axle fixed and a load applied to the rim perpendicular to the plane of the wheel for at least 1 minute. The wheel shall not have failure of any component of the wheel or permanent set greater than a specified maximum when measured at the location of the applied load. Table 28 below shows the applied load and maximum allowable permanent set for each bicycle use condition. Because the CPSC standard's test procedure differs from the EN and ISO standards', staff cannot determine the level of stringency between the standards without conducting comparative testing.

Table 28. Wheel Rim Static Strength Test (applied load / maximum permanent set)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	200 N (45 lbf)** / 1.5 mm	200 N (45 lbf)** / 1.5 mm
1 – Road	2,000 N (450 lbf)* / NA	-	250 N (56 lbf)** / 1 mm	250 N (56 lbf)** / 1 mm
2 – Trekking		-	250 N (56 lbf)** / 1.5 mm	250 N (56 lbf)** / 1.5 mm
3 – Mountain		-	370 N (83 lbf)** / 1 mm	370 N (83 lbf)** / 1 mm
4 – Downhill		-	-	-
Young Adult		-	-	250 N (56 lbf)** / 1.5 mm
BMX 1		-	300 N (68 lbf)** / 1.5 mm	-
BMX 2		-	500 N (112 lbf)** / 1.5 mm	-
EPAC		-	250 N (56 lbf)** / 1.5 mm	Same as non-powered bicycle requirements based on use condition
EPAC Mtn		-	370 N (83 lbf)** / 1 mm	Same as non-powered bicycle requirements based on use condition

*Applied at the axle
**Applied at the rim

Impact Test

The EN standard requires an impact test for BMX bicycle wheel and tire assemblies. Because BMX bicycles are intended to experience frequent hard landings, this requirement ensures that the wheels have the required strength to withstand those impacts. The test procedure requires the tire to be inflated to the minimum pressure as indicated on the tire or 80% of the maximum tire pressure if no minimum pressure is stated and the wheel mounted in the vertical orientation. The test drops an impactor with a flat impact surface of a specified mass from a specified height and impacts the wheel and tire assembly. On impact, the inner tube of the tire shall not burst (i.e. instantaneous deflation), and no component of the wheel shall become detached or expelled outwards, no sharp or serrated surfaces shall form from any breakage, and the hub shall not become separated from the rim. Table 29 below shows the mass of the impactor and the drop height for each bicycle use condition.

Table 29. Wheel/Tire Assembly Impact Test (impactor mass / drop height)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	-
2 – Trekking	-	-	-	-
3 – Mountain	-	-	-	-
4 – Downhill	-	-	-	-
Young Adult	-	-	-	-
BMX 1	-	-	22.5 kg / 400 mm	-
BMX 2	-	-	22.5 kg / 600 mm	-
EPAC	-	-	-	-

Wheel Retention

The CPSC, ASTM, EN, and ISO standards contain performance requirements for the attachment of the wheel to the bicycle. To evaluate the effectiveness of the wheel locking mechanism securing it to the bicycle, the standards require a wheel retention test for both the front and rear wheels. The standards first evaluate the wheel retention with the locking devices secured and tightened to the manufacturer's specifications. The ASTM standard's requirement only applies to quick release locking devices that do not require a tool to operate. The test applies a force symmetrically on both ends of the axle in the direction needed to remove the wheel from the bicycle frame. The CPSC standard maintains the force for 30 seconds and the ASTM, EN, and ISO standards for 60 seconds. After application of the force, the wheels shall experience no relative motion between the axle and the frame. Table 30 below shows the magnitude of the applied force for each bicycle use condition. The CPSC standard specifies a less stringent force and duration than the ASTM, EN, and ISO standards.

Table 30. Wheel Retention Test – Locking device secured

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO</th></tr>
<tr><td>0 – Sidewalk</td><td>-</td><td>-</td><td>1,000 N (225 lbf)</td><td>1,000 N (225 lbf)</td></tr>
<tr><td>1 – Road</td><td rowspan="7">1,780 N (400 lbf)*</td><td rowspan="4">2,300 N (516 lbf)**</td><td>2,300 N (516 lbf)</td><td>2,300 N (516 lbf)</td></tr>
<tr><td>2 – Trekking</td><td>2,300 N (516 lbf)</td><td>2,300 N (516 lbf)</td></tr>
<tr><td>3 – Mountain</td><td>2,300 N (516 lbf)</td><td>2,300 N (516 lbf)</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td><td>2,300 N (516 lbf)</td></tr>
<tr><td>BMX</td><td>-</td><td>2,300 N (516 lbf)</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>2,300 N (516 lbf)</td><td>2,300 N (516 lbf)</td></tr>
</table>

*Only applicable to rear wheel
**Only applicable to quick release locking mechanisms, threaded locking mechanisms excluded

The ASTM, EN, and ISO standards have a separate retention test with the locking devices unsecured. This requirement ensures that the wheels will not detach via a secondary retention system in the event that the quick-release mechanism inadvertently opens or if the threaded locking device loosens during use. For this test, the quick-release mechanism shall be in the open position, or the threaded locking device unscrewed by at least 360 degrees from the finger tight condition. The ASTM test applies a force radially outwards from the hub in the direction to remove the wheel as well as a force on the rim perpendicular to the plane of the wheel. The EN and ISO tests apply a single force radially outwards in line with the drop-out slots of the bicycle frame. Figure 20 below shows a diagram of the applied loads for each standard. After application of the force for a duration of 1 minute, the wheel shall not be detached from the fork. Table 31 below shows the magnitude of the applied force for each bicycle use condition. The CPSC standard's requirement is equivalent to the EN and ISO standards is less stringent than the ASTM standard because the CPSC test procedure only applies a single radial force whereas the ASTM procedure applies two orthogonal forces to remove the wheel.

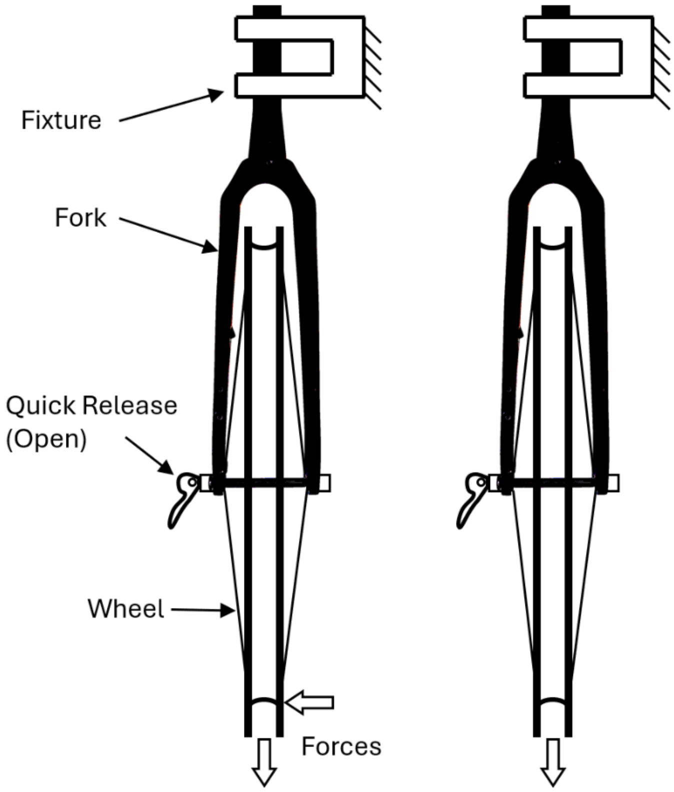

Figure 20. Test Diagram – Wheel Retention Test – Unsecured: ASTM test (left); CPSC, EN, and ISO tests (right)

Table 31. Wheel Retention Test – Locking Device Unsecured (radial / perpendicular)

Use	CPSC**	ASTM	EN	ISO
0 – Sidewalk	-	-	100 N (23 lbf)*	100 N (23 lbf)*
1 – Road	111 N (25 lbf)*	200 N (45 lbf) / 100 N (23 lbf)	100 N (23 lbf)*	100 N (23 lbf)*
2 – Trekking		200 N (45 lbf) / 100 N (23 lbf)	100 N (23 lbf)*	100 N (23 lbf)*
3 – Mountain		200 N (45 lbf) / 100 N (23 lbf)	100 N (23 lbf)*	100 N (23 lbf)*
4 – Downhill		200 N (45 lbf) / 100 N (23 lbf)	-	-
Young Adult		-	-	100 N (23 lbf)*
BMX		-	100 N (23 lbf)*	-
EPAC		-	100 N (23 lbf)*	100 N (23 lbf)*

*Only radial force applied
**Excludes front hubs with quick-release axles

The CPSC, EN, and ISO standards specify requirements for the minimum torque to remove threaded locking devices such as wheel nuts and thru-axles when tightened to the manufacturer's recommended torque, ensuring that the locking device will not loosen during use. Table 32 shows the minimum removal torque for each bicycle use condition. The CPSC standard specifies a torque value, whereas the EN and ISO standards specify a proportion of the manufacturer's recommended torque. Because of the variation of locking devices available, a single torque value may not address all designs, whereas the EN and ISO requirements can be scaled according to the design.

Table 32. Threaded Locking Device Minimum Removal Torque Test

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO</th></tr>
<tr><td>0 – Sidewalk</td><td>-</td><td>-</td><td>70%*</td><td>70%*</td></tr>
<tr><td>1 – Road</td><td rowspan="7">17 N-m (12.5 ft-lb)</td><td>-</td><td>70%*</td><td>70%*</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>70%*</td><td>70%*</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>70%*</td><td>70%*</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td><td>70%*</td></tr>
<tr><td>BMX</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>70%*</td><td>70%*</td></tr>
</table>

*Percentage of manufacturer's recommended tightening torque

Composite Wheels

The ISO standard contains separate performance requirements for wheels made from composite materials such as carbon fiber. Heat from storage, such as in a hot car, or the friction generated by braking, specifically for rim-brake systems, can melt or distort the resin which binds the carbon fibers. Therefore, the ISO standard subjects composite wheels to a "greenhouse effect" test which heats a fully assembled composite wheel and tire assembly in a chamber at 80˚C (176˚F) for a duration of 4 hours. After letting it cool at room temperature for another 4 hours, the wheel shall have no failure of any components, no tire separation, and no increase in rim width greater than 5%. The requirement then repeats the static strength tests as detailed above to ensure the structural integrity of the wheel remains. Table 33 below shows the chamber temperature and duration for each bicycle use condition.

Table 33. Composite Wheels – Greenhouse Effect Test (temperature / duration)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	80˚C / 4 hrs
2 – Trekking	-	-	-	80˚C / 4 hrs
3 – Mountain	-	-	-	80˚C / 4 hrs
4 – Downhill	-	-	-	-
Young Adult	-	-	-	80˚C / 4 hrs
BMX	-	-	-	-
EPAC	-	-	-	80˚C / 4 hrs

For bicycles with composite wheels and rim-brake systems, the ISO standard applies a heat resistance test. The test setup utilizes a test machine similar to the machine-based brake performance tests detailed above. The test machine drives the front and rear wheels separately with the brakes applied at a velocity of 25 kph (15.5 mph) for a duration of 3 minutes. Upon completion of the test, the wheels shall have no visible cracking, fracture, or permanent deformation. Table 34 below shows the test velocity and duration for each bicycle use condition.

Table 34. Composite Wheels – Heat Resistance Test (speed / duration)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	25 kph (15.5 mph) / 3 mins
2 – Trekking	-	-	-	25 kph (15.5 mph) / 3 mins
3 – Mountain	-	-	-	25 kph (15.5 mph) / 3 mins
4 – Downhill	-	-	-	-
Young Adult	-	-	-	25 kph (15.5 mph) / 3 mins
BMX	-	-	-	-
EPAC	-	-	-	25 kph (15.5 mph) / 3 mins

Lastly, the ISO standard applies an impact test for composite wheels using rim-brake systems after completing the heat resistance test above. With the tire removed from the wheel and mounted on the test fixture in the vertical orientation, a mass impacts the top of the wheel when dropped from a height sufficient to generate 40 J of energy as shown below in Table 35 for each bicycle use condition. The wheel shall have no visible cracks, fractures, or permanent deformation exceeding 1 mm.

Table 35. Composite Wheels – Impact Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	40 J
2 – Trekking	-	-	-	40 J
3 – Mountain	-	-	-	40 J
4 – Downhill	-	-	-	-
Young Adult	-	-	-	40 J
BMX	-	-	-	-
EPAC	-	-	-	40 J

Front Fork

The front fork is the part of the bicycle that holds the front wheel. The fork connects with the handlebar stem through the head tube of the bicycle frame to complete the steering system of the bicycle. A fork consists of two blades joined together at the top by the crown and the steerer tube extending above the crown which connects with the handlebar stem as shown below in

Figure 21. At the bottom of each blade are the drop-out slots where the front wheel's axle mounts via either a quick release mechanism or a threaded connection. Some forks may have suspensions on each blade to absorb impacts and provide a smoother ride. Suspension forks use either coil springs or air contained in the lowers to absorb the impact energy from the wheels to provide a smoother ride. The fork also provides mounting points for the front brakes. For rim-brake systems, the mounting point is typically at the crown or close to the top of the blades, and disc-brake systems mount close to the bottom of the blades adjacent to the wheel axle. Some bicycles have other mounting points to attach accessories such mudguards for mountain bikes.

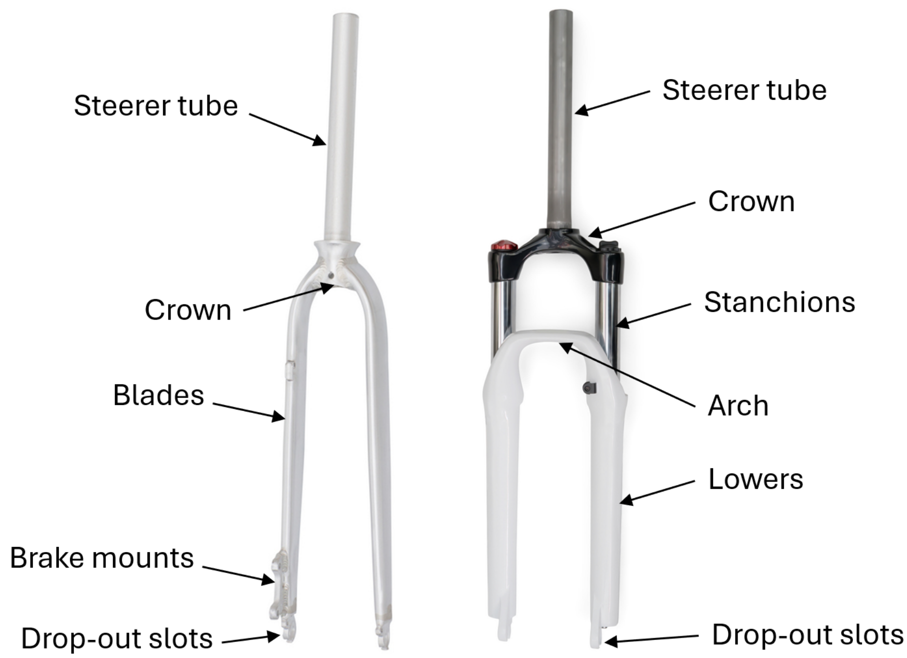

Figure 21. Parts of a bicycle fork: traditional fork (left) and suspension fork (right)

The blades often curve or angle in the forward direction of the bicycle creating an offset, or rake, relative to the axis of the steerer tube. This is beneficial for the bicycle because it moves the contact point of the front wheel forward of where the steerer tube axis intersects with the ground which results in an improved ability to turn the bicycle. The length and spacing of the blades govern the compatible size of the wheel and tires for the bicycle.

Strength Tests

The ASTM, EN, and ISO standards contain multiple performance requirements for the front fork. The first requirement subjects the front fork to a bending test. The test setup has the fork steerer tube secured to a fixture via a clamp and a free-rolling axle attached to the drop out slots of the fork where the wheel normally connects. The test applies a load on the axle perpendicular to the axis of the stem against the direction of the rake of the fork. Figure 22 below shows a diagram of the test setup from the CPSC standard for corresponding impact test. The test procedures for the bending strength tests differ between the standards as summarized below in Table 36. The front fork shall have no visible fractures, cracks, or permanent set exceeding a specified value.

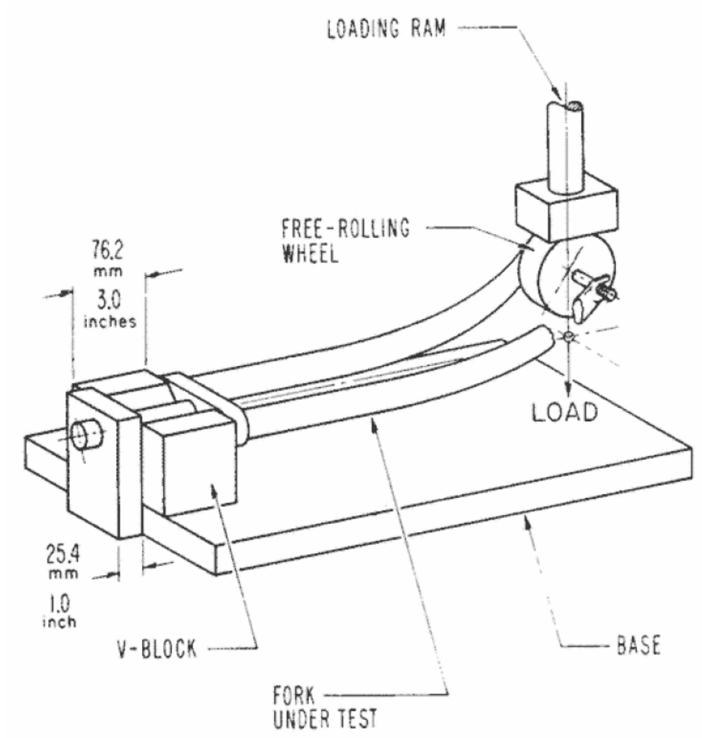

Figure 22. Test Diagram – Front Fork Cantilever Bending

Table 36. Fork Static Bending Strength Test – (applied load / max permanent set for rigid forks / max permanent set for suspension forks)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road		1,200 N (270 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	1,200 N (270 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	1,200 N (270 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)
2 – Trekking	-	-	1,000 N (225 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	1,000 N (225 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)
3 – Mountain	-	1,500 N (337 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	1,500 N (337 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	1,500 N (337 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,000 N (225 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)
BMX 1	-	-	800 N (180 lbf) / 5 mm (0.2 in) / 5 mm (0.2 in)	-
BMX 2	-	-	1,500 N (337 lbf) / 5 mm (0.2 in) / 5 mm (0.2 in)	-
EPAC	-	-	1,500 N (337 lbf) / 10 mm (0.4 in) / 10 mm (0.4 in)	1,500 N (337 lbf) / 10 mm (0.4 in) / 10 mm (0.4 in)
EPAC Mtn	-	-	1,500 N (337 lbf) / 5 mm (0.2 in) / 10 mm (0.4 in)	2,000 N (450 lbf) / 10 mm / 10 mm (0.4 in)

The ASTM, EN, and ISO standards specify an impact resistance requirement for bicycle forks. The test is similar to the static bending strength test detailed above as shown in Figure 22. The test subjects the fork to a series of drops with an impactor onto the roller depending on the material and construction of the fork. The tests from the standards vary slightly, and Table 37 summarizes the parameters for each bicycle use condition. In general, the test subjects the fork to at least one impact that is dropped from a specified height. The fork shall have no visible fractures, cracks, or permanent set greater than a specified amount. If the fork is subject to a second drop test, the fork must against show no visible fractures or cracks after the second drop test. If the fork meets the required criteria after the second drop, the test then applies a torque to the bicycle fork about the axis of the steerer tube for a duration of 1 minute. The fork shall not have any relative movement between the steerer tube and crown. The CPSC standard specifies an impact energy, whereas the ASTM, EN, and ISO standards specify a mass of the impactor and the drop height. By calculation of the impact energy from the mass and drop height, the CPSC standard specifies a less stringent impact energy than the ASTM, EN, and ISO standards. Additionally, the ASTM, EN, and ISO standards require two drop tests whereas the CPSC standard only requires one drop.

Table 37. Fork Rearward Impact Resistance Test (impactor mass / drop height / acceptance criteria)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	39.5 J (350 in-lb) impact energy / not specified / maximum deflection 64 mm (2.5 in)	Drop 1: 22.5 kg (49.6 lb) / 640 mm / max permanent set 45 mm	Drop 1: 22.5 kg (49.6 lb) / 360 mm (640 mm for composite) / max permanent set 5 mm	Drop 1: 22.5 kg (49.6 lb) / 360 mm (640 mm for composite) / max permanent set 45 mm Drop 2**: 22.5 kg @ 600 mm / withstand 80 Nm of torque
2 – Trekking		-	Drop 1: 22.5 kg (49.6 lb) / 180 mm / max permanent set 45 mm Drop 2*: 22.5 kg (49.6 lb) / 600 mm / withstand 50 Nm of torque	Drop 1: 22.5 kg (49.6 lb) / 180 mm (320 mm for composite) / max permanent set 45 mm Drop 2**: 22.5 kg (49.6 lb) / 600 mm / withstand 50 Nm of torque
3 – Mountain		Drop 1: 22.5 kg (49.6 lb) / 360 mm / max permanent set 45 mm Drop 2: 22.5 kg (49.6 lb) / 600 mm / withstand 108.5 Nm of torque	Drop 1: 22.5 kg (49.6 lb) / 360 mm / max permanent set 45 mm Drop 2*: 22.5 kg (49.6 lb) / 600 mm / withstand 80 Nm of torque	Drop 1: 22.5 kg (49.6 lb) / 360 mm (600 mm for composite) / max permanent set 45 mm Drop 2**: 22.5 kg (49.6 lb) / 600 mm / withstand 80 Nm of torque
4 – Downhill		-	-	-
Young Adult		-	-	Drop 1: 22.5 kg (49.6 lb) / 180 mm (320 mm for composite) / max permanent set 45 mm Drop 2**: 22.5 kg / 600 mm / withstand 50 Nm of torque
BMX 1		-	Drop 1: 22.5 kg (49.6 lb) / 180 mm / max permanent set 45 mm	-
BMX 2		-	Drop 1: 22.5 kg (49.6 lb) / 360 mm / max permanent set 45 mm Drop 2*: 22.5 kg (49.6 lb) / 600 mm / withstand 80 N-m torque	-
EPAC			Drop 1: 22.5 kg (49.6 lb) / 360 mm / max permanent set 45 mm Drop 2*: 22.5 kg (49.6 lb) / 600 mm / withstand 80 Nm of torque	Same as non-powered bicycle requirements based on use condition, except drop height is 360 mm and applied torque is 80 Nm

*Forks made entirely of metal with crown/stem joint assembled welding or brazing, only conduct drop 1
**For composite forks, conduct drop 1 only and apply torque

The ASTM, EN, and ISO standards specify a fatigue test for bicycle forks. This requirement again has the same test setup as shown above in Figure 22. The test applies a fully-reversed cyclic load to the roller axle in line with the plane of the wheel and perpendicular to the steerer tube for a total of 100,000 cycles. At the completion of the test cycles, the fork shall not have any fractures or failures. Table 38 below shows that magnitude of the cyclic load for each bicycle use condition. If the fork completes the cyclic test without any observed fracture, the requirements, depending on the use condition, repeats the rearward impact test and inspected again for fractures or permanent set.

Table 38. Fork Bending Fatigue and Impact Test (applied cyclic force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	+/- 400 N (90 lb) / 100,000	+/- 400 N (90 lb) / 100,000
1 – Road	-	+/- 620 N (139 lb) / 100,000*	+/- 620 N (139 lb) / 100,000	+/- 620 N (139 lb) / 100,000*
2 – Trekking	-	-	+/- 450 N (101 lb) / 100,000	+/- 450 N (101 lb) / 100,000*
3 – Mountain	-	+/- 650 N (146 lb) / 100,000*	+/- 650 N (146 lb) / 100,000	+/- 650 N (146 lb) / 100,000*
4 – Downhill	-	-	-	-
Young Adult	-	-	-	+/- 450 N (101 lb) / 100,000*
BMX 1	-	-	+/- 450 N (101 lb) / 100,000	-
BMX 2	-	-	+/- 650 N (146 lb) / 100,000	-
EPAC	-	-	+/- 500 N (112 lb) / 100,000*	Same as non-powered bicycle requirements based on use condition, except use condition 2 is 500 N
EPAC Mtn	-	-	+/- 650 N (146 lb) / 100,000*	+/- 675 N (152 lb) / 100,000*

*If fork passes fatigue test, repeat rearward impact test

Suspension Forks

The ASTM, EN, and ISO standards contain separate performance requirements for suspension forks. The first requirement is a compression test for tire clearance on the wheel and tire assembly installed on the bicycle fork. The test applies a compressive load to the wheel in the direction towards the crown of the fork and parallel to the axis of the stem and maintains for 1 minute duration as shown below in Figure 23. The ASTM standard specifies that there shall be a minimum clearance of 3 mm between the tire and the crown at full compression, and the EN and ISO standards specify that the tire shall not make any contact with the crown. Table 39 below shows the magnitude of the compression load for each bicycle use condition.

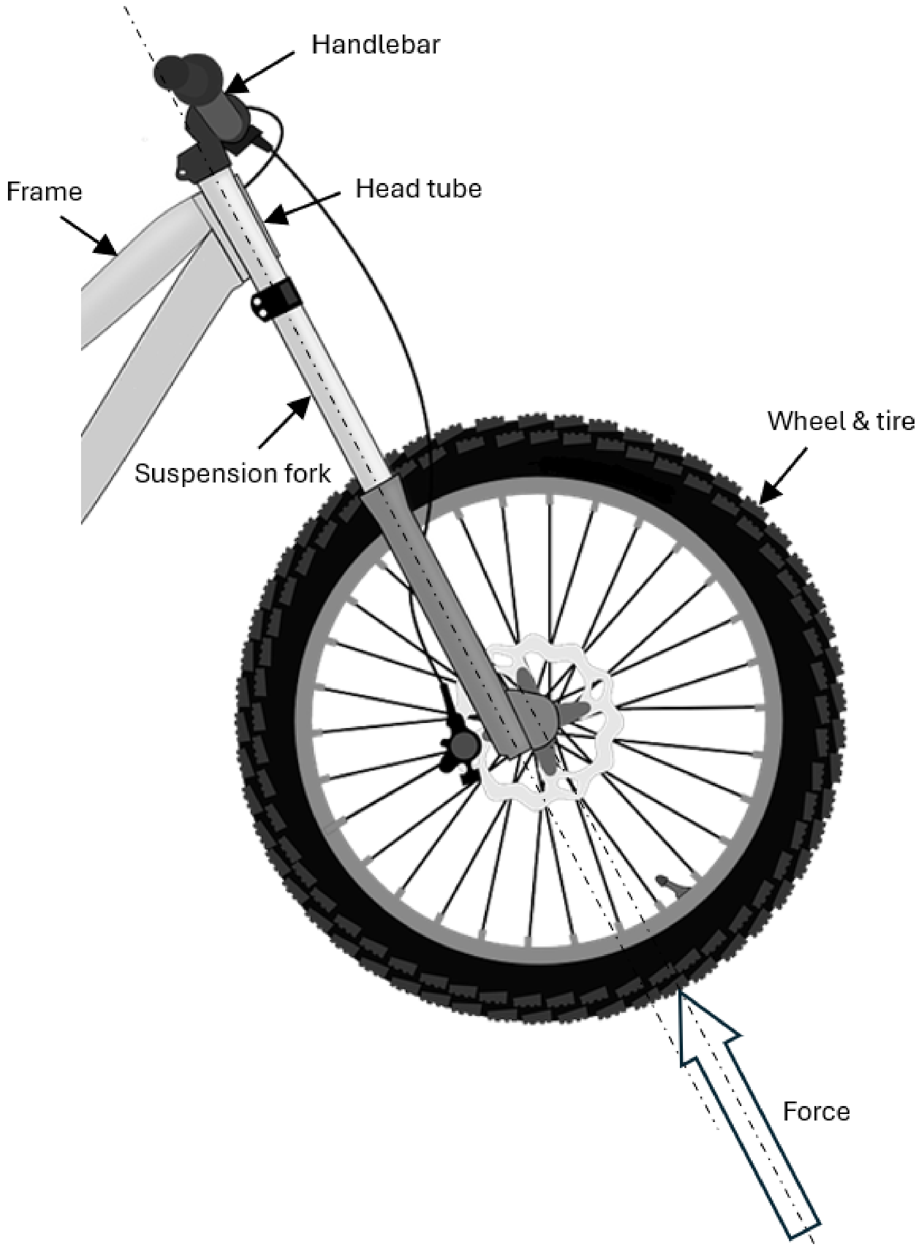

Figure 23. Test Diagram – Suspension Fork Compression & Tire Clearance

Table 39. Suspension Fork Compression & Tire Clearance Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	2,800 N (629 lbf)*	2,800 N (629 lbf)	2,800 N (629 lbf)
2 – Trekking	-	-	2,800 N (629 lbf)	2,800 N (629 lbf)
3 – Mountain	-	2,800 N (629 lbf)*	2,800 N (629 lbf)	2,800 N (629 lbf)
4 - Downhill	-	-	-	-
Young Adult	-	-	-	2,800 N (629 lbf)
BMX	-	-	-	-
EPAC	-	-	2,800 N (629 lbf)	2,800 N (629 lbf)

*3 mm minimum clearance between tire and crown at full compression

The EN and ISO standards specify a second requirement which subjects suspension forks to a tensile test. With the fork fixed at the steerer tube and an axle connected to the drop-out slots, the test applies a tensile force to the axle away from the crown and parallel to the axis of the stem and maintains for 1 minute as shown in Figure 24 below. The suspension fork shall not experience any detachment or loosening of any components of the assembly. Table 40 below shows the magnitude of the applied tensile load to the fork for each bicycle use condition.

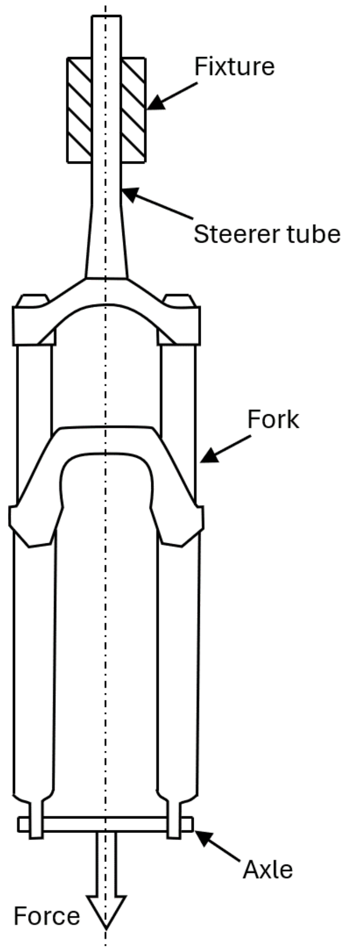

Figure 24. Test Diagram – Suspension Fork Tensile

Table 40. Suspension Fork Tensile Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	2,300 N (517 lbf)	2,300 N (517 lbf)
2 – Trekking	-	-	2,300 N (517 lbf)	2,300 N (517 lbf)
3 – Mountain	-	-	2,300 N (517 lbf)	2,300 N (517 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	2,300 N (517 lbf)
BMX	-	-	-	-
EPAC	-	-	2,300 N (517 lbf)	2,300 N (517 lbf)

Traditional Forks

For traditional forks that are secured in the crown by press-fitting, clamping, adhesives, or any method other than welding or brazing, the EN and ISO standards specify a separate tensile strength test. The standards do not subject traditional forks that are welded to any tensile requirements. The EN and ISO requirements use the same test procedure as the suspension fork tensile test as shown above in Figure 24, except that the tensile load is increased to 5,000 N. The rigid fork shall experience no detachment or loosening of any parts of the assembly. Table 41 below shows the magnitude of the tensile load for each bicycle use condition.

Table 41. Rigid Non-Welded Fork Tensile Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	5,000 N (1,124 lb)	5,000 N (1,124 lb)
2 – Trekking	-	-	-	5,000 N (1,124 lb)
3 – Mountain	-	-	-	5,000 N (1,124 lb)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	5,000 N (1,124 lb)
BMX	-	-	-	-
EPAC	-	-	5,000 N (1,124 lb)	5,000 N (1,124 lb)

Forks with Hub and Disc Brakes

The EN and ISO standards specify requirements for bicycle forks that are intended for use with hub or disc brakes. Due to the mounting position of the brakes, they may exert forces on the blades of the fork which may cause the blades to bend or brake. The first requirement is a static brake torque test. The test procedure specifies that the fork shall be mounted horizontally with the steerer tube fixed, an axle fitted to the drop-out slots, and an L-shaped torque arm mounted to the axle so that the applied force creates a torque to simulate the loading from the brake mounting points as shown below in Figure 25. The test applies a 1,000 N (225 lbf) force at the end of the torque arm at a specified distance away from the pivot point based on either the bicycle use condition or the size of the tire as shown below in Table 42. The fork shall not have any visible fractures or cracks in any part of the fork. The EN standard also specifies that the fork shall not have a permanent set greater than 5 mm.

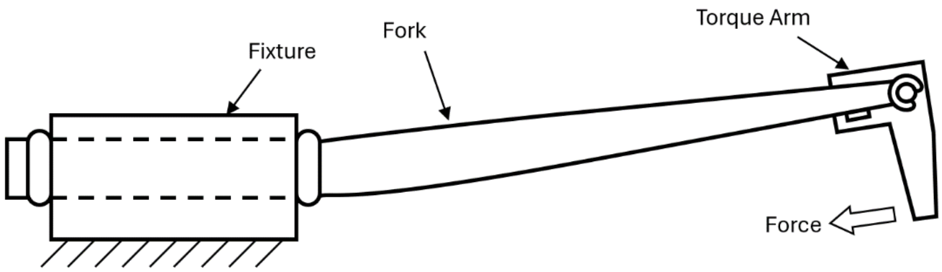

Figure 25. Test Diagram – Static Brake Torque

Table 42. Fork Hub/Disc Brake Static Torque Test (applied force / moment arm)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	1,000 N (225 lbf) / 355 mm (14 in)	1000 N (225 lbf) / based on tire size: 16” = 202 mm (8 in) 18” = 228 mm (9 in) 20” = 253 mm (10 in) 22” = 279 mm (11 in) 24” = 305 mm (12 in) 26” = 330 mm (13 in) 650b = 349 mm (13.7 in) 29” = 368 mm (14.5 in) 700c = 368 mm (14.5 in)
2 – Trekking	-	-	1,000 N (225 lbf) / 330 mm (13 in)	
3 – Mountain	-	-	1,000 N (225 lbf) / 330 mm (13 in)	
4 – Downhill	-	-	-	
Young Adult	-	-	-	
BMX	-	-	-	-
EPAC	-	-	1,000 N (225 lbf) / based on tire size: 24” = 305 mm (12 in) 26” = 330 mm (13 in) 650b = 349 mm (13.7 in) 29” = 368 mm (14.5 in) 700c = 368 mm (14.5 in)	1000 N (225 lbf) / based on tire size: 16” = 202 mm (8 in) 18” = 228 mm (9 in) 20” = 253 mm (10 in) 22” = 279 mm (11 in) 24” = 305 mm (12 in) 26” = 330 mm (13 in) 650b = 349 mm (13.7 in) 29” = 368 mm (14.5 in) 700c = 368 mm (14.5 in)

Next, the EN and ISO standards subject bicycle forks with hub or disc brake systems to a fatigue test. Using a similar test setup as the static test as shown above in Figure 25, the test applies a cyclic load of 600 N (135 lbf) only in the rearward direction to the torque arm for a specified number of cycles. Table 43 below shows the magnitude of the applied force, the moment arm, and number of cycles for each bicycle use condition. The fork shall have no visible fractures or cracks.

Table 43. Fork Hub/Disc Brake Fatigue Torque Test (applied force / moment arm / number of cycles)

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO</th></tr>
<tr><td>0 – Sidewalk</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>1 – Road</td><td>-</td><td>-</td><td>600 N (135 lbf) / 355 mm (14 in) / 20,000</td><td rowspan="5">600 N (135 lbf) /
based on tire size:
16” = 202 mm (8 in)
18” = 228 mm (9 in)
20” = 253 mm (10 in)
22” = 279 mm (11 in)
24” = 305 mm (12 in)
26” = 330 mm (13 in)
650b = 349 mm (13.7 in)
29” = 368 mm (14.5 in)
700c = 368 mm (14.5 in) /
12,000*</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>-</td><td>600 N (135 lbf) / 330 mm (13 in) / 12,000</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>-</td><td>600 N (135 lbf) / 330 mm (13 in) / 12,000</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>BMX</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>-</td><td>600 N (135 lbf) / based on tire size:
24” = 305 mm (12 in)
26” = 330 mm (13 in)
650b = 349 mm (13.7 in)
29” = 368 mm (14.5 in)
700c = 368 mm (14.5 in) /
12,000</td><td>600 N (135 lbf) /
based on tire size:
16” = 202 mm (8 in)
18” = 228 mm (9 in)
20” = 253 mm (10 in)
22” = 279 mm (11 in)
24” = 305 mm (12 in)
26” = 330 mm (13 in)
650b = 349 mm (13.7 in)
29” = 368 mm (14.5 in)
700c = 368 mm (14.5 in) /
12,000*</td></tr>
</table>

*20,000 cycles for use condition 1

Frame

The bicycle frame is the backbone of the bicycle and is the foundation for all other components, such as the wheels, brakes, drive system, handlebars, and saddle, and the battery for e-bikes. Bicycle frames are typically triangular, truss-like structures called diamond frames, but also come in a more compact design for folding bicycles, or a curved design called a cantilever frame, among others. Figure 26 below shows some common types of bicycle frames currently in the market. Bicycle frames are typically a metal material such as steel, aluminum, or titanium, but can also be made of carbon fiber, especially for high-performance bikes, due to their weight savings and stiffness. Manufacturers typically construct bicycle frames by joining an arrangement of tubes together either by welding or inserting into socketed fittings called lugs.

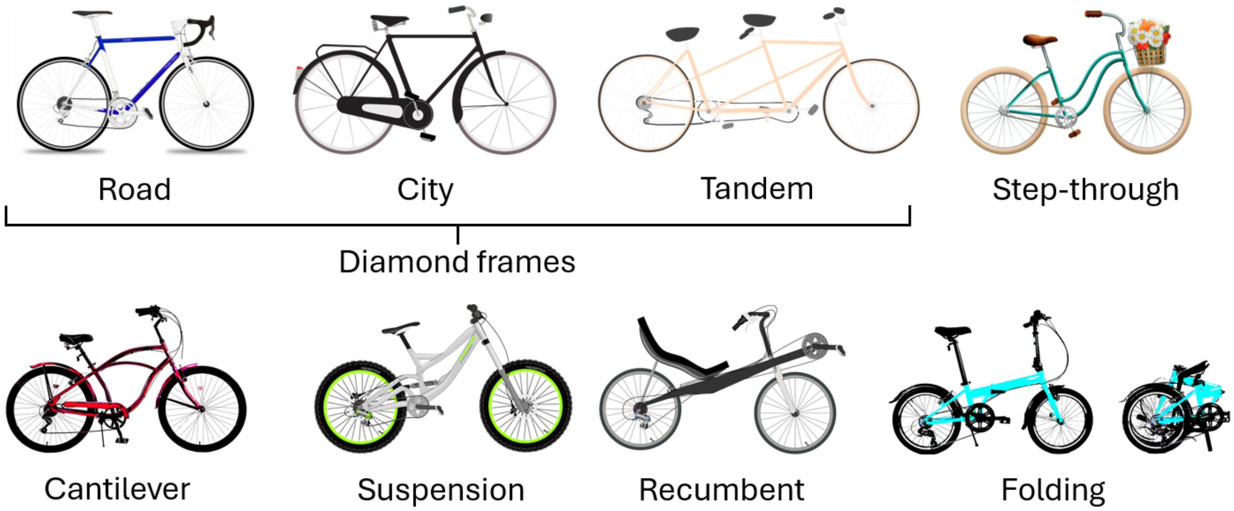

Figure 26. Common types of bicycle frames

Bicycle frames comprise of multiple components such as the top tube, down tube, steerer head tube, seat tube, seat stay, chain stay, and bottom bracket, as shown below in Figure 27. The top tube, down tube, and seat tube comprise the main triangle of the bicycle frame, and the seat stay, chain stay, and seat tube make up the rear triangle. The main triangle acts as the primary structure of the bicycle, while the rear triangle provides the structure that supports the rear wheel. The frame provides mounting interfaces for all other components of the bicycle to attach. The head tube is where the front fork and handlebar stem are located. The seat tube is where the saddle or seat post inserts into the frame. The bottom bracket is where the crank set including the chain rings, crank arms, and pedals mount (see Figure 15). Lastly, the drop-out slots at the rear tip of the rear triangle connect the rear wheel and cassette.

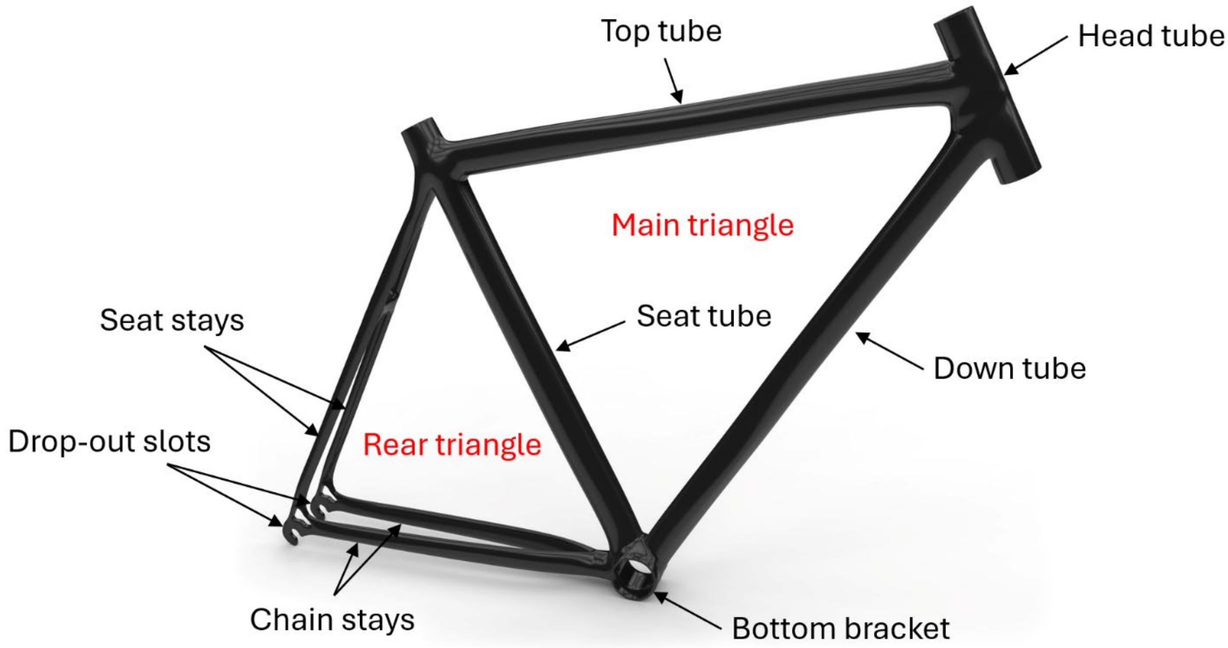

Figure 27. Parts of a typical bicycle frame

Structural Strength Tests

Because the frame acts as the main structure for the bicycle, all the loads from the wheels, drive system, pedals, and saddle transfer energy into and throughout the frame. To account for the load bearing, the CPSC, ASTM, EN, and ISO standards specify performance requirements to ensure that the structural integrity of the frame remains intact in the roughest conditions. The CPSC standard specifies a static load test to the frame and fork assembly. The test procedure requires the fork to be installed onto the frame per the manufacturer's instructions with a roller attachment connected to the front wheel drop-out slots and the rear axle fixed in place. The test applies a load of 890 N (200 lbf) or 39.5 J (350 in-lb) of energy, whichever results in a greater force, to the fork at the axle attachment point against the direction of the rake in line with the rear wheel axle. The frame and fork assembly shall not have any visible evidence of fracture or frame deformation that significantly limits the steering angle over which the wheel can be turned. Table 44 below shows the magnitude of the applied force for each bicycle use condition.

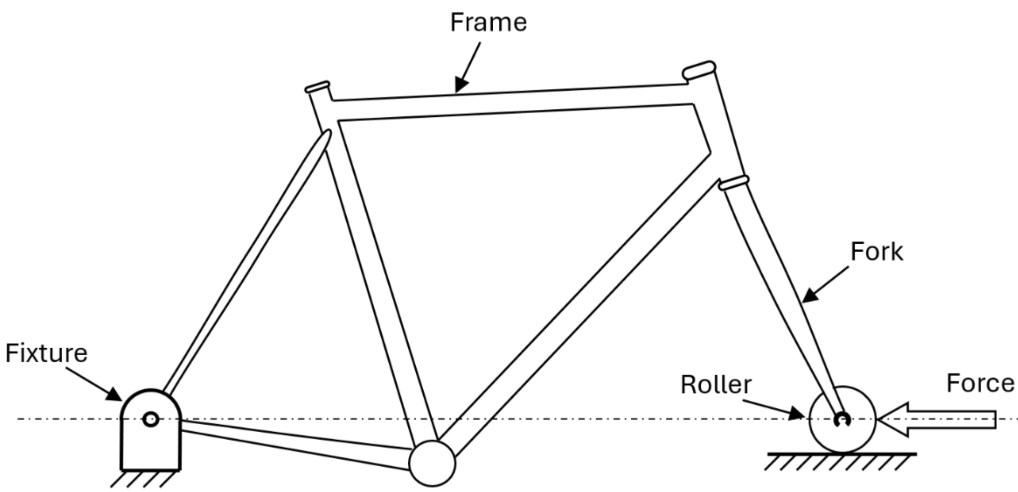

Figure 28. Test Diagram – Frame and Fork Assembly Horizontal Static Load

Table 44. Frame and Fork Assembly Horizontal Static Load Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	890 N (200 lbf) or 39.5 J (350 in-lb)	-	-	-
2 – Trekking		-	-	-
3 – Mountain		-	-	-
4 – Downhill		-	-	-
Young Adult		-	-	-
BMX		-	-	-
EPAC				

The ASTM, EN, and ISO standards specify a series of fatigue tests for the fork and frame assembly. With the bicycle frame and fork assembly set up similar to the static load test as detailed above, the first fatigue test applies a horizontal load to the axle at the drop-out slots of the fork in the forward (positive) direction and the rearward (negative) direction for a prescribed number of cycles as shown below in Table 45. After completion of the cycling loads, the frame shall have no visible fractures or cracks.

Table 45. Frame and Fork Assembly Horizontal Fatigue Test (applied force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	+600 N (135 lbf) -300 N (68 lbf) / 50,000	-	-
1 – Road	-	+/- 450 N (101 lbf) / 100,000	+/- 600 N (135 lbf) / 100,000	+/- 600 N (135 lbf) / 100,000
2 – Trekking	-	+800 N (180 lbf) -600 N (135 lbf) / 50,000	-	+/- 450 N (101 lbf) / 100,000
3 – Mountain	-	+1,200 N (270 lbf) - 600 N (135 lbf) / 50,000	+1,200 N (270 lbf) - 600 N (135 lbf) / 50,000	+1,200 N (270 lbf) - 600 N (135 lbf) / 50,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	+/- 450 N (101 lbf) / 100,000
BMX 1	-	-	+/- 450 N (101 lbf) / 50,000	-
BMX 2	-	-	+/- 650 N (146 lbf) / 50,000	-
EPAC	-	-	+/- 500 N (112 lbf)* / 100,000	+/- 500 N (112 lbf)* / 100,000
EPAC Mtn	-	-	+1,200 N (270 lbf) - 600 N (135 lbf) / 100,000	+1,200 N (270 lbf) - 600 N (135 lbf) / 100,000

*Front-wheel-driven EPACs apply a +/- 600 N (135 lbf) force

The second fatigue test applies a vertical cyclic load on the seat post of the frame to account for the stresses from the weight of the rider. The test procedures require a rearward extension attached to the top of the seat post such that the downward force can be applied a prescribed offset distance rearward from the axis of the seat post as shown below in Figure 29. A fixture shall secure the rear axle, and a roller affixed to the front drop-out slots allows for the bicycle frame to flex. The test applies a cyclic force in the vertical direction for a specified number of cycles. Upon completion of the cyclic test, the frame and seat tube clamp shall not have any visible cracks or fracture, and the suspension shall have no separation of any components. Table 46 below shows the magnitude of the applied cyclic load (positive is downward) and the number of cycles for each bicycle use condition.

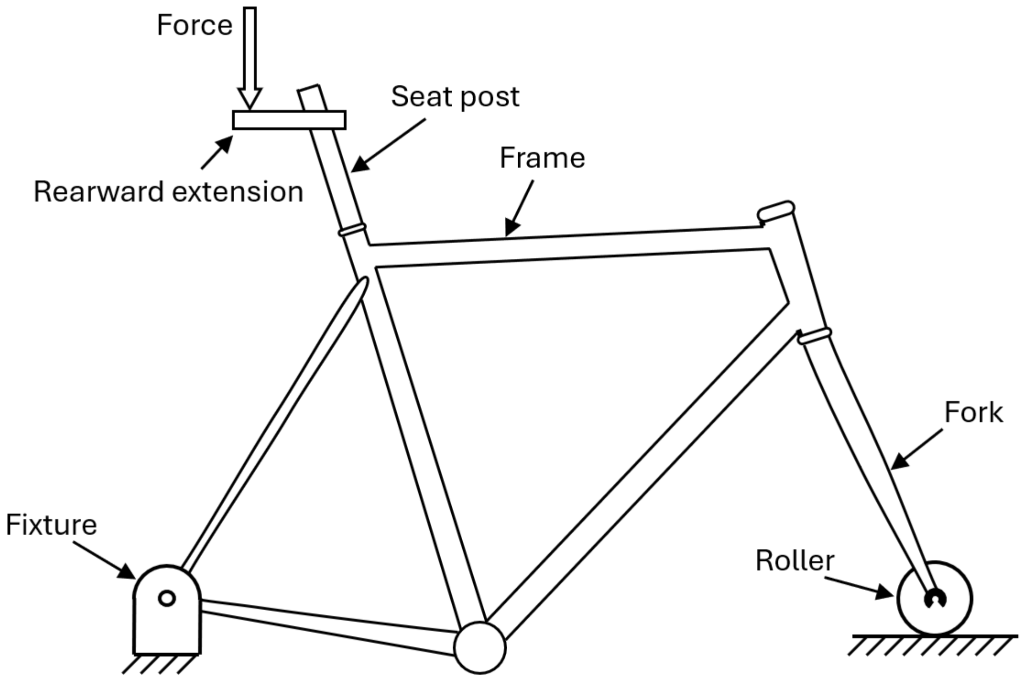

Figure 29. Test Diagram – Frame and Fork Assembly Vertical Fatigue

Table 46. Frame and Fork Assembly Vertical Fatigue Test (applied force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	+600 N (135 lbf) -60 N (14 lbf) / 50,000	-	-
1 – Road	-	+1,200 N (270 lbf) -120 N (30 lbf) / 50,000	-	+1,200 N (270 lbf) +0 N (0 lbf) / 50,000
2 – Trekking	-	+1,200 N (270 lbf) -120 N (30 lbf) / 50,000	+1,000 N (225 lbf) +0 N (0 lbf) / 50,000	+1,000 N (225 lbf) +0 N (0 lbf) / 50,000
3 – Mountain	-	+1,200 N (270 lbf) -120 N (30 lbf) / 50,000	+1,200 N (270 lbf) +0 N (0 lbf) / 50,000	+1,200 N (270 lbf) +0 N (0 lbf) / 50,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	+500 N (112 lbf) +0 N (0 lbf) / 50,000
BMX	-	-	-	-
EPAC	-	-	+1,100 N (247 lbf) +0 N (0 lbf) / 50,000	+1,100 N (247 lbf) +0 N (0 lbf) / 50,000
EPAC Mtn	-	-	+1,400 N (315 lbf) +0 N (0 lbf) / 50,000	+1,400 N (315 lbf) +0 N (0 lbf) / 50,000

The EN and ISO standards contain a third fatigue test, which accounts for the stresses on the bicycle frame from the forces exerted on the pedals and crank arms. This fatigue test evaluates the bicycle frame, fork, and drive-system assembly, which includes the crank arms, chain ring, bicycle chain, and cassette. The test procedure requires the whole assembly mounted upright, such that the front and rear drop-out slots are elevated to a height slightly greater than the radius of the wheel and tire assembly to allow for the crank arms to rotate as shown below in Figure 30. The test applies a cyclic downforce on each of the pedal spindles over 100,000 cycles, where one cycle is the application and removal of the two forces on each crank arm. Upon completion of the fatigue test, the frame shall have no visible cracks or fractures, or separation of components if it has a built-in suspension system. Table 47 below shows the magnitude of the applies forces and the number of cycles for each bicycle use condition.

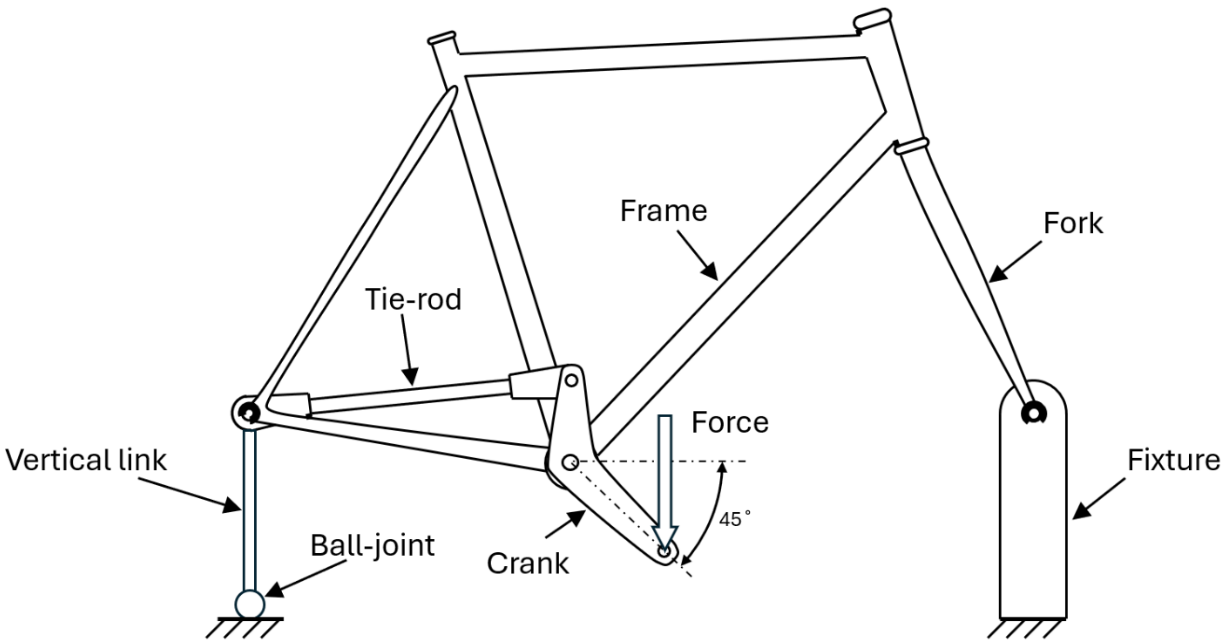

Figure 30. Test Diagram – Frame and Fork Assembly Pedaling Forces Setup

Table 47. Frame and Fork Assembly Pedaling Forces Fatigue Test (applied load / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	1,100 N (247 lbf) / 100,000	1,100 N (247 lbf) / 100,000
2 – Trekking	-	-	1,000 N (225 lbf) / 100,000	1,000 N (225 lbf) / 100,000
3 – Mountain	-	-	1,200 N (270 lbf) / 100,000	1,200 N (270 lbf) / 100,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,000 N (225 lbf) / 100,000
BMX 1	-	-	900 N (202 lbf) / 100,000	-
BMX 2	-	-	1,200 N (270 lbf) / 100,000	-
EPAC	-	-	1,000 N (225 lbf) / 100,000	Same as non-powered bicycle requirements based on use condition
EPAC Mtn	-	-	1,200 N (270 lbf) / 100,000	Same as non-powered bicycle requirements based on use condition

*Same as non-powered bicycle requirements based on use condition

The ASTM, EN and ISO standards specify a series of impact strength tests to evaluate the frame's ability to withstand horizontal impacts such as from minor head-on collisions. The first impact requirement is the falling mass test. The test setup requires the bicycle frame and fork assembly to be mounted vertically such that the front and rear axle drop-out slots are in line with a vertical axis as shown below in Figure 31. The test may use a "dummy" fork in place of the intended fork with the frame. The front drop-out slot must have a light-weight roller affixed to it, and a fixture must rigidly clamp the rear drop-out slot. The test impacts the front roller with an impactor of mass 22.5 kg (50 lb) when dropped from a specified height. After impact, the frame shall not have any visible cracks or fracture, and the permanent set shall not exceed a specified amount. Table 48 below shows the mass of the impactor, drop height, and maximum permanent set for each bicycle use condition.

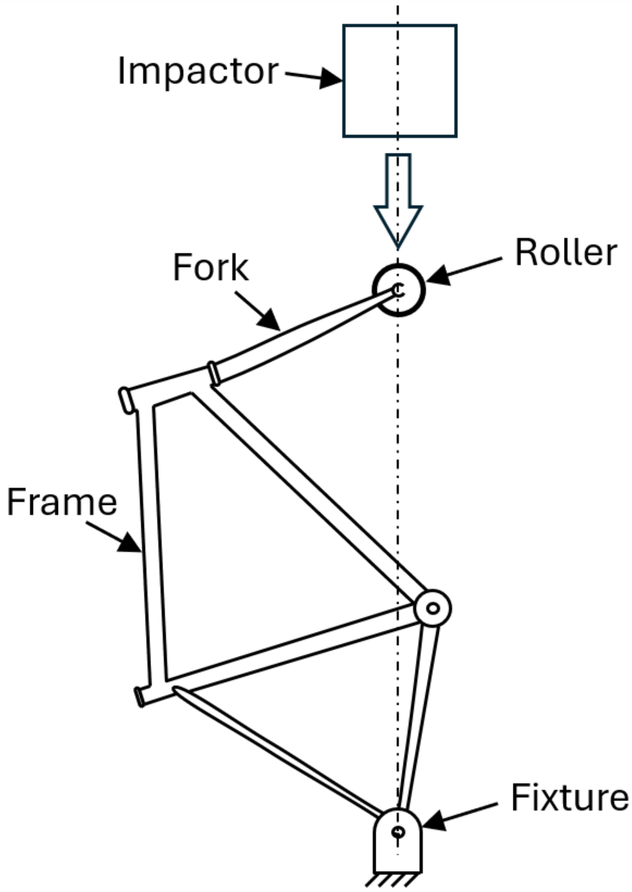

Figure 31. Test Diagram – Frame and Fork Falling Mass

Table 48. Frame and Fork Assembly Impact Strength Test – Falling Mass (impactor mass / drop height / max permanent set)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	22.5 kg (50 lb) / 180 mm (7 in) / 40 mm (1.6 in)	22.5 kg (50 lb) / 120 mm (4.7 in) / 20 mm (0.8 in)	22.5 kg (50 lb) / 120 mm (4.7 in) / 20 mm (0.8 in)
1 – Road	-	22.5 kg (50 lb) / 180 mm (7 in) / 40 mm (1.6 in)	22.5 kg (50 lb) / 212 mm (8.3 in) / 30 mm* (1.2 in)	22.5 kg (50 lb) / 212 mm (8.3 in) / 30 mm* (1.2 in)
2 – Trekking	-	22.5 kg (50 lb) / 180 mm (7 in) / 40 mm (1.6 in)	22.5 kg (50 lb) / 180 mm (7 in) / 30 mm** (1.2 in)	22.5 kg (50 lb) / 180 mm (7 in) / 30 mm** (1.2 in)
3 – Mountain	-	22.5 kg (50 lb) / 360 mm (7 in) / 40 mm (1.6 in)	22.5 kg (50 lb) / 360 mm (14.2 in) / 30 mm** (1.2 in)	22.5 kg (50 lb) / 360 mm (14.2 in) / 30 mm** (1.2 in)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	22.5 kg (50 lb) / 180 mm (7 in) / 30 mm** (1.2 in)
BMX 1	-	-	22.5 kg (50 lb) / 180 mm (7 in) / 30 mm** (1.2 in)	-
BMX 2	-	-	22.5 kg (50 lb) / 360 mm (14.2 in) / 30 mm** (1.2 in)	-
EPAC	-	-	22.5 kg (50 lb) / 360 mm (14.2 in) / 30 mm** (1.2 in)	Same as non-powered bicycle requirements based on use condition, except use condition 2 is dropped 360 mm (14.2 in)

*15 mm if a steel bar is used in place of the fork
**10 mm if a steel bar is used in place of the fork

The EN and ISO standards contain a second impact strength test called the falling frame test. The test procedure specifies that the frame and fork assembly be mounted at the rear drop-out slots so that it is free to rotate about the axle's axis, and a roller attached to the front axle drop-out slots. Additionally, depending on the bicycle use-condition, the test procedure states that masses must be added to the seat post, steering head, or bottom bracket where the chain ring would normally be attached as shown in the test setup diagram below in Figure 32. With the roller on the front fork resting on flat steel anvil surface, the test lifts and rotates the frame and fork assembly about the axis of the rear axle to a prescribed height then allowed to freefall to impact against the surface. For use condition 0, the EN standard states that the frame and fork assembly shall be rotated up so that the center of gravity of the mass mounted to the seat post is directly above the rear axle and then released. For use condition 1, the EN standard states that the frame and fork assembly shall be rotated up until the whole frame and fork assembly reaches its balance point and then released. For all other use conditions, the standards specify a specific drop height. The frame shall have no visible cracks or fractures resulting from the impact, and the frame suspension system shall not experience separation of any components. Table 49 below shows the total mass added, drop height, and the maximum allowable permanent set for each bicycle use condition.

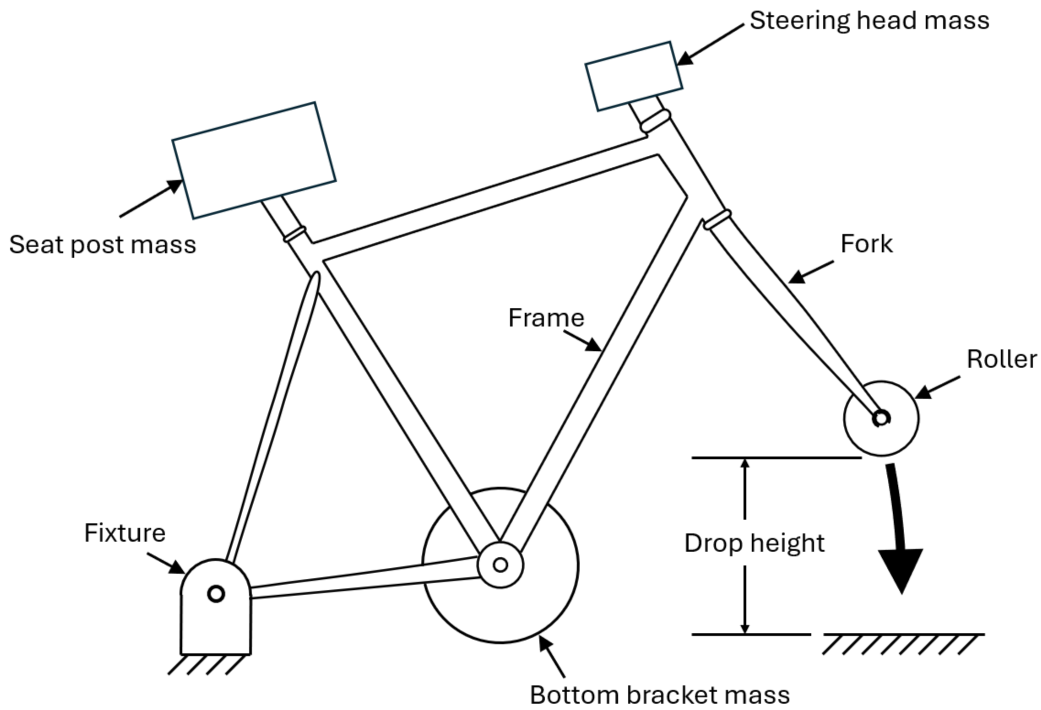

Figure 32. Test Diagram – Frame and Fork Falling Frame

Table 49. Frame and Fork Assembly Impact Strength Test – Falling Frame (mass added / drop height / maximum permanent set)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	Seat post mass: 30 kg (66 lb) Drop height: CG of seat post mass above rear axle Max permanent set: 20 mm (0.8 in)	Seat post mass: 30 kg (66 lb) Drop height: 200 mm (7.9 in) Max permanent set: 20 mm (0.8 in)
1 – Road	-	-	Seat post mass 70 kg (154 lb) Drop height: balance point of bicycle Max permanent set: 15 mm (0.6 in)	Seat post mass: 30 kg (66 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 200 mm (7.9 in) Max permanent set: 15 mm (0.6 in)
2 – Trekking	-	-	-	Seat post mass: 50 kg (110 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 30 kg (66 lb) Drop height: 200 mm (7.9 in) Max permanent set: 60 mm (2.4 in)
3 – Mountain	-	-	Seat post mass: 30 kg (66 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 300 mm (11.8 in) Max permanent set: 60 mm (2.4 in)	Seat post mass: 30 kg (66 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 300 mm (11.8 in) Max permanent set: 60 mm (2.4 in)
4 - Downhill	-	-	-	-
Young Adult	-	-	-	Seat post mass: 40 kg (88 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 20 kg (44 lb) Drop height: 200 mm (7.9 in) Max permanent set: 60 mm (2.4 in)
BMX	-	-	Seat post mass: 30 kg (66 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 300 mm (11.8 in) Max permanent set: 60 mm (2.4 in)	-
EPAC	-		Seat post mass: 30 kg (66 lb) Steering head mass: 10 kg (22 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 300 mm (11.8 in) Max permanent set: 60 mm (2.4 in)	Same as non-powered bicycle requirements based on use condition, except use condition 2 is: Seat post mass: 10 kg (22 lb) Steering head mass: 30 kg (66 lb) Bottom bracket mass: 50 kg (110 lb) Drop height: 300 mm (11.8 in) Max permanent set: 60 mm (2.4 in)

Rear Disc Brake Mounts

The ISO standard specifies a series of performance requirements for frames that are intended to have mounted disc brakes for the rear wheel. The first test is a static test which accounts for the stresses on the frame from the torque transferred from the disc brakes. The test procedure specifies that the frame and fork assembly shall be mounted upright in a fixture with either the rear axle drop-out slots secured or the bottom bracket secured. A stiff, vertical link with length equivalent to the radius of the wheel intended to be used with the bicycle shall mount to the rotor or representative disc at the rear axle. This link acts as the mechanism to apply a torque on the brake mount the same way as an actual brake caliper would. Figure 33 shows a diagram of the test setup. The test applies a force on the end of the vertical link in the forward and rearward direction and maintains for 1 minute in each direction. Table 50 below shows the magnitude of the forces for each bicycle use condition. The frame shall not have any visible fracture or cracks, and any suspension shall not have separation of any components.

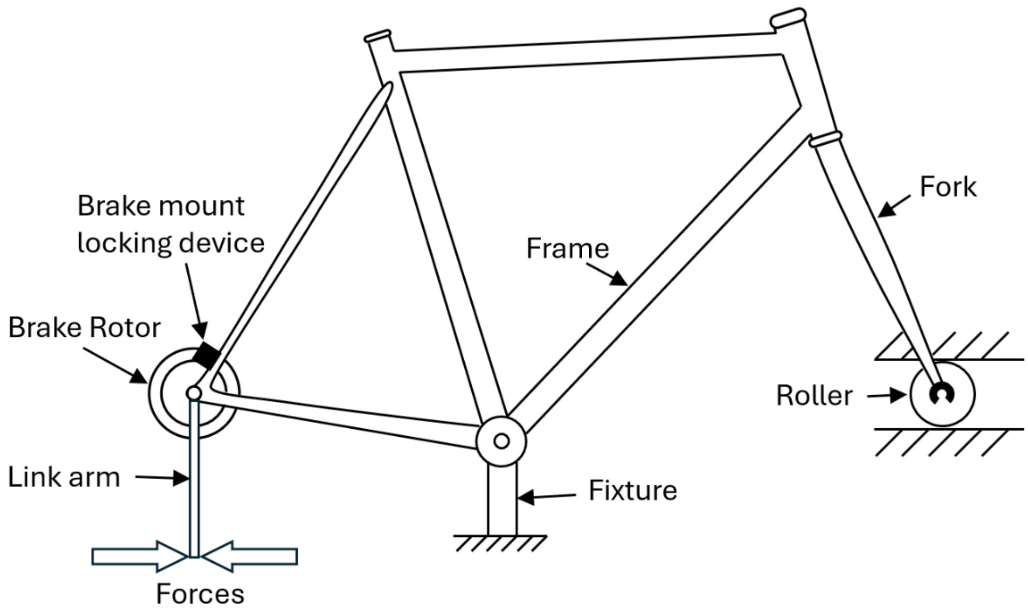

Figure 33. Test Diagram – Frame Rear Brake Mount Static Torque

Table 50. Frame Rear Brake Mount Static Torque Test (rearward force / forward force)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	700 N (157 lbf) / 300 N (67.4 lbf)
2 – Trekking	-	-	-	700 N (157 lbf) / 300 N (67.4 lbf)
3 – Mountain	-	-	-	700 N (157 lbf) / 300 N (67.4 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	700 N (157 lbf) / 300 N (67.4 lbf)
BMX	-	-	-	-
EPAC	-	-	-	700 N (157 lbf) / 300 N (67.4 lbf)

Next, the ISO standard subjects the frame and fork assembly to a fatigue test. The test setup is the same as the static torque test above. This test applies a cyclic load to the vertical link in the rearward and forward direction with one cycle being the application and release of the force in each direction. Table 51 below shows the magnitude of the applied forces and the number of cycles for each bicycle use condition.

Table 51. Frame Rear Brake Mount Fatigue Test (rearward force / forward force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	400 N (90 lbf) / 50 N (11.2 lbf) / 200,000
2 – Trekking	-	-	-	500 N (112 lbf) / 50 N (11.2 lbf) / 200,000
3 – Mountain	-	-	-	500 N (112 lbf) / 200 N (45 lbf) / 200,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	300 N (67.4 lbf) / 50 N (11.2 lbf) / 200,000
BMX	-	-	-	-
EPAC	-	-	-	Same as non-powered bicycle requirements based on use condition

Saddles/Seats

The bicycle saddle, also referred to as bicycle seat, provides the surface on which the rider may sit. Although the seat is just one of the five contact points for the rider on the bicycle including the two handlebar grips and two pedals, the saddle bears most of the weight of the rider. There are many different types of saddles suited for different riding conditions whether on the road or rough terrain. Performance saddles are typically long and narrow with minimal padding, whereas more common-use bicycles tend to be wider with more plush padding. Bicycle saddles typically comprise of the shell, cover, rails, clamp, seat post, and sometimes suspension, as shown below in Figure 34. The shell is what forms the shape of the saddle and is usually made from molded plastic or carbon fiber. The cover goes overtop the shell to add some sort of padding from foam or gel. The rails, or chassis, provide the connection point to the bicycle. Saddles typically have two parallel rails to which the seat post clamps. The seat post connects the saddle to the bicycle and is made of a shaft that inserts into the frame through the seat tube. The combination of the rails and seat post provides adjustability for forward, rearward, tilt, and height.

Figure 34. Parts of a bicycle saddle

Strength Tests

The EN and ISO standards specify strength requirements for bicycle saddles to ensure that the saddle will remain securely connected to the saddle chassis with no damage during use. The strength requirement first tests the saddle in its forward-most position with clamps tightened to the manufacturers recommended torque and applies a vertically upwards force under the nose of the saddle cover. Next, the test applies an upwards force under the rear of the saddle cover when the saddle is in the rearward-most position. The saddle chassis, saddle cover, and/or plastic molding shall not disengage at any point during or after the test, and the saddle assembly shall not have any visible cracking or permanent deformation. Table 52 below shows the magnitude of the applied force for each bicycle use condition.

Table 52. Saddle Static Strength Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	400 N (90 lbf)	400 N (90 lbf)
1 – Road	-	-	400 N (90 lbf)	400 N (90 lbf)
2 – Trekking	-	-	400 N (90 lbf)	400 N (90 lbf)
3 – Mountain	-	-	400 N (90 lbf)	400 N (90 lbf)
4 – Downhill	-	-	-	-
Young Adult	-		-	400 N (90 lbf)
BMX	-	-	400 N (90 lbf)	-
EPAC	-	-	400 N (90 lbf)	400 N (90 lbf)

Next, the EN and ISO standards subject the saddle and post assembly to a fatigue test to account for the long-term stresses over the course of the life of the saddle assembly. With the saddle post inserted and clamped to its minimum insertion depth in a rigid mount and the saddle in its rearmost position, the fatigue test applies a cyclic force vertically downwards on the saddle cover for a specified number of cycles. Upon completion of the cyclic loading, the saddle assembly shall not have visible fractures, cracks, or loosening of clamps. Table 53 below shows the magnitude of the applied force and number of cycles for each bicycle use condition.

Table 53. Saddle and Post Fatigue Test (applied force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	700 N (157 lbf) / 100,000	700 N (157 lbf) / 100,000
1 – Road	-	-	1000 N (225 lbf) / 200,000	1000 N (225 lbf) / 200,000
2 – Trekking	-	-	1000 N (225 lbf) / 200,000	1000 N (225 lbf) / 200,000
3 – Mountain	-	-	1000 N (225 lbf) / 200,000	1000 N (225 lbf) / 200,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1000 N (225 lbf) / 200,000
BMX	-	-	1000 N (225 lbf) / 100,000	-
EPAC	-	-	1000 N (225 lbf) / 200,000	1000 N (225 lbf) / 200,000

The CPSC, EN, and ISO standards contain performance requirements for the security of the saddle and post assembly to ensure that the clamping forces are sufficient to prevent movement of the saddle during normal use. The requirement tests the saddle installed onto the bicycle frame with the clamps tightened to the manufacturer recommended torque and applies a prescribed force in the downwards direction at a specified distance from the front or rear of the saddle, whichever produces the greater torque on the saddle clamp. The test then applies a horizontal force perpendicular to the vertical plane of the bicycle at the same point on the saddle. The saddle shall not experience any movement at the adjustment clamp relative to the saddle post, and the saddle post shall not experience any movement relative to the bicycle frame. Table 54 below shows the magnitude of the applied forces on the saddle for each bicycle use condition. The CPSC standard specifies a equivalent applied forces compared to the EN and ISO standards; except the EN standard has more stringent requirements just for use condition 1 bicycles.

Table 54. Seat Clamp Static Test (vertical force / horizontal force)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	334 N (75 lbf) / 111 N (25 lbf)	-	300 N (67 lbf) / 100 N (22 lbf)	300 N (67 lbf) / 100 N (22 lbf)
1 – Road	668 N (150 lbf) / 222 N (50 lbf)	-	1000 N (225 lb) / 400 N (90 lbf)	650 N (146 lbf) / 250 N (56 lbf)
2 – Trekking		-	650 N (146 lbf) / 250 N (56 lbf)	650 N (146 lbf) / 250 N (56 lbf)
3 – Mountain		-	650 N (146 lbf) / 250 N (56 lbf)	650 N (146 lbf) / 250 N (56 lbf)
4 – Downhill		-	-	-
Young Adult		-	-	650 N (146 lbf) / 250 N (56 lbf)
BMX		-	650 N (146 lbf) / 250 N (56 lbf)	-
EPAC		-	650 N (146 lbf) / 250 N (56 lbf)	650 N (146 lbf) / 250 N (56 lbf)

Saddle Post

The EN and ISO standards specify separate performance requirements for the saddle post to ensure that it has adequate structural strength to withstand the stresses from normal use. The first requirement subjects the saddle post to a fatigue test. The test procedure requires the seat post to be clamped to a fixture angled 73˚ from horizontal and an adapter connected to the attachment point of the post, so that a force can be applied offset from the axis of the saddle post as shown below in Figure 35. The test applies a cyclic load vertically downward 70 mm rearward from the saddle post for 100,000 cycles. The cyclic loading for use condition 1 in the EN standard differs slightly in that the cyclic load alternates between a downward force 70 mm rearward and 70 mm forward of the saddle post. Additionally, use condition 1 in the EN standard subjects the saddle post to a second fatigue test which applies a cyclic load of 900 N perpendicular to the post axis for 100,000 cycles. At the conclusion of the cyclic loading, the seat post shall have no visible cracks or fractures. Table 55 below shows the magnitude of the cyclic load and the number of cycles for each bicycle use condition.

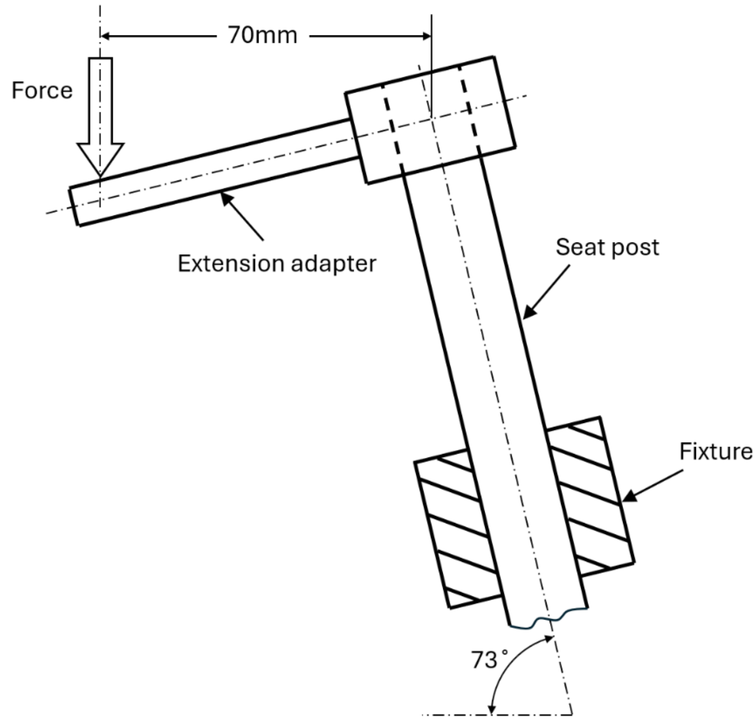

Figure 35. Test Diagram – Saddle Post Fatigue Test

Table 55. Saddle Post Fatigue Test (applied force / number of cycles)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	1,200 N (270 lbf)* / 100,000**	1,200 N (270 lbf) / 100,000
2 – Trekking	-	-	1,000 N (225 lbf) / 100,000	1,000 N (225 lbf) / 100,000
3 – Mountain	-	-	1,200 N (270 lbf) / 100,000	1,200 N (270 lbf) / 100,000
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,000 N (225 lbf) / 100,000
BMX	-	-	-	-
EPAC	-	-	1,000 N (225 lbf) / 100,000	Same as non-powered bicycle requirements based on use condition
EPAC Mtn	-	-	1,200 N (270 lbf) / 100,000	1,400 N (315 lbf) / 100,000

*Applies an alternating force of 1,200 N downward on the front and rear of the saddle post axis
**Applies a second force of 900 N (202 lbf) perpendicular to saddle post for 100,000 cycles

The ISO standard specifies an additional performance requirement for saddle posts that are made out of composite materials which subjects them to a static load test. The EN standard for EPACs references the ISO standard for this requirement, but all other EN standards for other use conditions do not require this test. This test uses the same setup as the fatigue test above and applies a vertically downward force 70 mm rearward of the saddle post for a duration of 1 minute. The saddle post shall not have any visible fractures, cracks, or permanent set exceeding 10 mm. Table 56 below shows the magnitude of the applied force for each bicycle use condition.

Table 56. Saddle Post Static Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	-	-	-	2,000 N (450 lbf)
2 – Trekking	-	-	-	2,000 N (450 lbf)
3 – Mountain	-	-	-	2,000 N (450 lbf)
4 – Downhill	-	-	-	-
Young Adult	-	-	-	1,500 N (337 lbf)
BMX	-	-	-	-
EPAC	-	-	2,000 N (450 lbf)	Same as non-powered bicycle requirements based on use condition

Visibility

Reflectors are safety devices that aid in visibility of bicycles in low light environments to alert others of the bicycle's presence and avoid collisions. Reflectors typically consist of a transparent plastic outer casing with an arrangement of internal prisms or beads. The design of the reflector redirects any light in the same direction it enters; thus, it reflects the light back towards the source of the light, regardless of where it is relative to the reflector as shown below in Figure 36. This is unlike a flat mirror where unless the light source is directly perpendicular to the mirror's surface, the light will be reflected in a direction away from the source. This unique design of reflectors aids in visibility by reflecting a vehicle's headlights back in the general direction of the driver's eyes therefore making the driver aware of the bicycle's presence at any angle within the reflector's range.

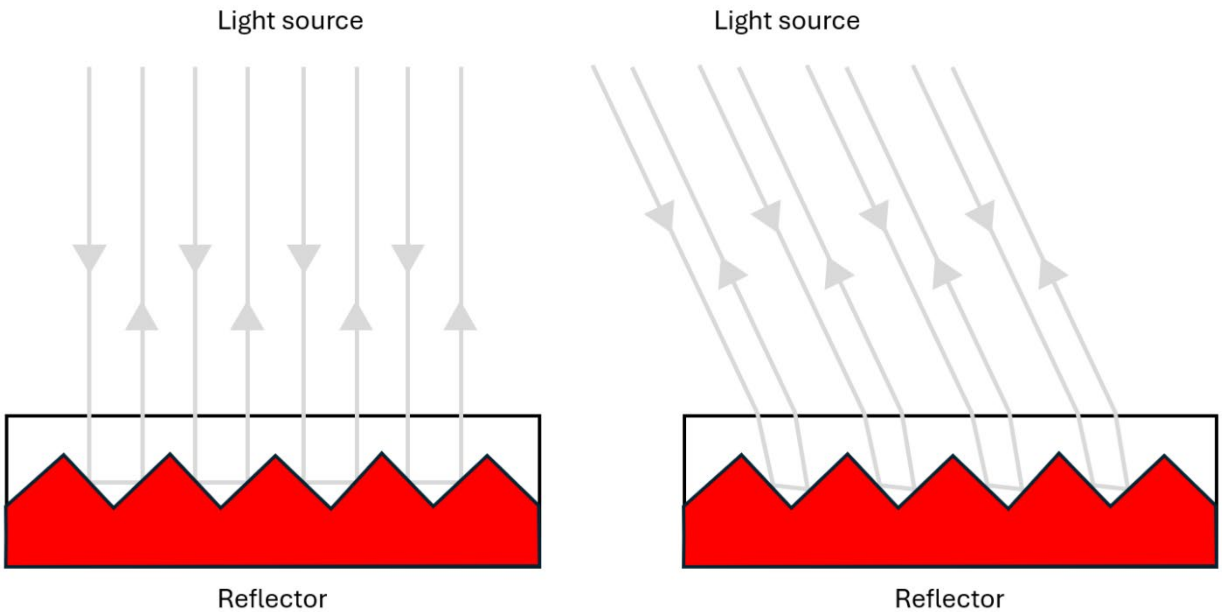

Figure 36. Reflector redirects light back in direction of source

Reflectors

The CPSC and ISO standards contain requirements to establish the minimum performance of bicycle reflectors. The reflectance test ensures that reflectors have minimum level of reflectance of incoming light back in the direction of the light source over a specified range of angles from the reflector's surface. The test emits a light via a projector to the reflector when positioned at multiple angles relative to the projector, and a receiver collocated with the projector, or as close as practicable, measures the magnitude of the reflected light from the reflector as shown below in Figure 37. The light source of the projector must be at least 51 mm (2.0 in) in diameter and 30.5 m (100 ft) away from the reflector sample, and the receiver must have an opening no larger than 0.5 inches vertical by 1 inch horizontal. The observation angle is the angle between the line from the projector to the center of the reflector and the line between the center of the reflector to the receiver. The entrance angle is the angle between the optical axis of the reflector, which is perpendicular to the surface of the reflector, and the line from the center of the reflector to the projector. The test measures the intensity of the reflected light at the position of the receiver. Table 57 and Table 58 below show the minimum reflectance values for clear, colorless reflectors on each bicycle use condition. Amber and red colored reflectors must be at least 62.5 percent and 25 percent the values in the table respectively. The ISO standard specifies acceptance criteria based on two separate groups of reflectors which are designated according to European regulations. Note that the ISO standard specifies only yellow colored reflectance values for pedal reflectors whereas the CPSC specifies minimum reflectance for clear, colorless reflectors. The CPSC standard specifies equivalent reflectance values to the ISA requirements.

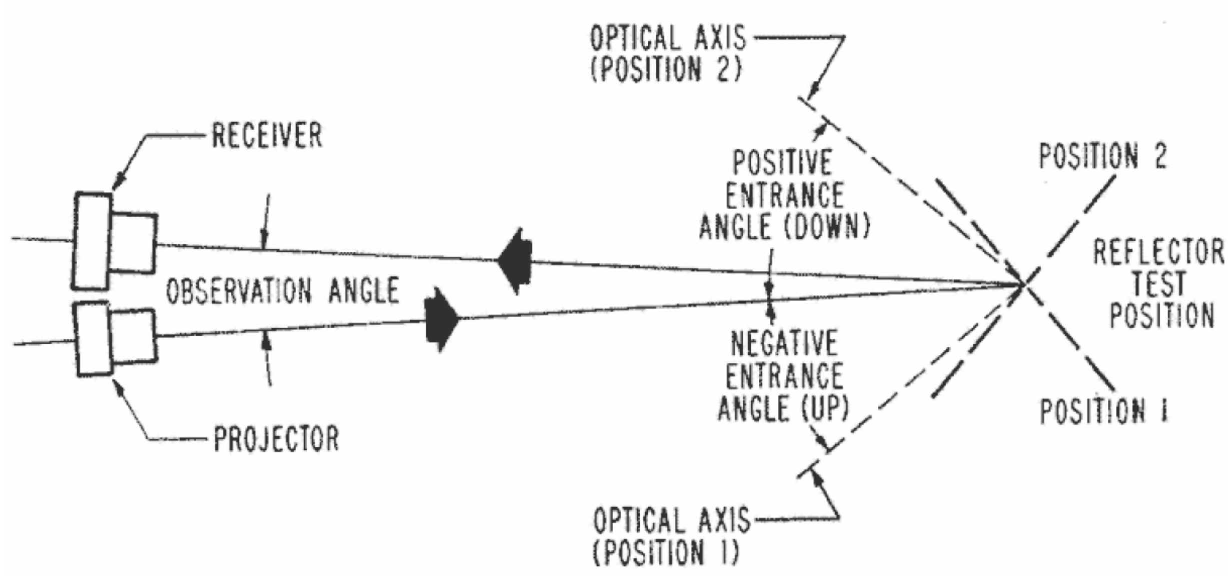

Figure 37. Test Diagram – Reflector Performance Test (side view)

Table 57. Reflector Performance Test – front, rear, and side reflectors (observation angle / entrance angle (v=vertical, h=horizontal) / minimum reflectance value)

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO*</th></tr>
<tr><td>0 – Sidewalk</td><td>-</td><td>-</td><td>-</td><td rowspan="9">Group A Reflectors
0.33˚ / 0˚ / 13.2 cp/fc (1,200 mcd/lx)
0.33˚ / 10˚ v / 8.8 cp/fc (800 mcd/lx)
0.33˚ / 20˚ h / 4.4 cp/fc (400 mcd/lx)
1.5˚ / 0˚ / 0.22 cp/fc (20 mcd/lx)
1.5˚ / 10˚ v / 0.12 cp/fc (11.2 mcd/lx)
1.5˚ / 20˚ h / 0.11 cp/fc (10 mcd/lx)
Group B Reflectors
0.2˚ / 0˚ / 27.4 cp/fc (2,500 mcd/lx)
0.2˚ / 10˚ v / 18.1 cp/fc (1,650 mcd/lx)
0.2˚ / 20˚ h / 9.3 cp/fc (850 mcd/lx)
1.5˚ / 0˚ / 0.29 cp/fc (26 mcd/lx)
1.5˚ / 10˚ v / 0.20 cp/fc (18 mcd/lx)
1.5˚ / 20˚ h / 0.12 cp/fc (11 mcd/lx)</td></tr>
<tr><td>1 – Road</td><td rowspan="8">0.2˚ / 0˚ / 27.0 cp/fc (2,462 mcd/lx)
0.2˚ / 10˚ v / 18.0 cp/fc (1,641 mcd/lx)
0.2˚ / 20˚ h / 9.0 cp/fc (821 mcd/lx)
0.2˚ / 30˚ h / 8.0 cp/fc (729 mcd/lx)
0.2˚ / 40˚ h / 7.0 cp/fc (638 mcd/lx)
0.2˚ / 50˚ h / 6.0 cp/fc (547 mcd/lx)
1.5˚ / 0˚ / 0.28 cp/fc (25.5 mcd/lx)
1.5˚ / 10˚ v / 0.20 cp/fc (18.2 mcd/lx)
1.5˚ / 20˚ h / 0.12 cp/fc (10.9 mcd/lx)
1.5˚ / 30˚ h / 0.12 cp/fc (10.9 mcd/lx)
1.5˚ / 40˚ h / 0.12 cp/fc (10.9 mcd/lx)
1.5˚ / 50˚ h / 0.12 cp/fc (10.9 mcd/lx)</td><td>-</td><td>-</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>-</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>-</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td></tr>
<tr><td>BMX</td><td>-</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>-</td></tr>
</table>

*Only applicable to use conditions 0-3, young adult, and EPAC

Table 58. Reflector Performance Test – pedal reflectors (observation angle / entrance angle (v=vertical, h=horizontal) / minimum reflectance value)

Use	CPSC	ASTM	EN	ISO*
0 – Sidewalk	-	-	-	Group A Reflectors 0.33˚ / 0˚ / 3.3 cp/fc (300 mcd/lx) 0.33˚ / 10˚ v / 2.2 cp/fc (200 mcd/lx) 0.33˚ / 20˚ h / 1.1 cp/fc (100 mcd/lx) 1.5˚ / 0˚ / 0.13 cp/fc (12 mcd/lx) 1.5˚ / 10˚ v / 0.10 cp/fc (9 mcd/lx) 1.5˚ / 20˚ h / 0.07 cp/fc (6 mcd/lx) Group B Reflectors 0.33˚ / 0˚ / 4.9 cp/fc (450 mcd/lx) 0.33˚ / 10˚ v / 3.8 cp/fc (350 mcd/lx) 0.33˚ / 20˚ h / 1.9 cp/fc (175 mcd/lx) 1.5˚ / 0˚ / 0.18 cp/fc (16.5 mcd/lx) 1.5˚ / 10˚ v / 0.13 cp/fc (11.5 mcd/lx) 1.5˚ / 20˚ h / 0.8 cp/fc (7.5 mcd/lx)
1 – Road	0.2˚ / 0˚ / 7.5 cp/fc (864 mcd/lx) 0.2˚ / 10˚ v / 6.0 cp/fc (547 mcd/lx) 0.2˚ / 20˚ h / 3.0 cp/fc (274 mcd/lx) 0.3˚ / 0˚ / 6.0 cp/fc (547 mcd/lx) 0.3˚ / 10˚ v / 4.8 cp/fc (438 mcd/lx) 0.3˚ / 20˚ h / 2.4 cp/fc (219 mcd/lx) 1.5˚ / 0˚ / 0.28 cp/fc (25.5 mcd/lx) 1.5˚ / 10˚ v / 0.20 cp/fc (18.2 mcd/lx) 1.5˚ / 20˚ h / 0.12 cp/fc (10.9 mcd/lx)	-	-	
2 – Trekking		-	-	
3 – Mountain		-	-	
4 – Downhill		-	-	
Young Adult		-	-	
BMX		-	-	
EPAC		-	-	

*Only applicable to use conditions 0-3, young adult, and EPAC, reflectance values for yellow-colored reflectors

Retroreflective Tire Sidewalls

The CPSC standard specifies requirements for when retroreflective tire sidewalls are used in lieu of spoke-mounted reflectors. The retroreflective material must form a continuous circle, withstand 50˚ C (122˚ F) for 30 minutes without detaching, and be resistant to abrasion. This test uses a similar setup as for reflectors as shown above in Figure 37, except the distance between the light source and the retroreflective surface being measured shall be at least 15 m (50 ft) and the diameter of the light source of the projector must be 1/500th of that distance. Also, the receiver must have a sensor area such that the perimeter is no more than 1/100th from its center. The test measures the intensity of the light reflected from the retroreflective surface at intervals no more than 45 degrees around the wheel at multiple entrance and observation angles. The test uses the average of the measurements for each entrance and observation angle. The CPSC standard specifies that the retroreflective surface must meet a minimum ratio A for each combination of entrance and observation angles as shown below in Table 59. The ratio A is a function of the illumination incident upon the receiver, illumination incident upon a plane perpendicular to the incident ray at the specimen position, the distance between the receiver and the center of the wheel, and the minimum radius of the retroreflective circle. The ISO standard specifies the minimum reflectance in terms of the proportion of the distance D between the light source and the retroreflective surface.

Table 59. Retroreflective Tire Sidewall Performance Test (observation angle / entrance angle / minimum acceptable value)

<table>
<tr><th>Use</th><th>CPSC</th><th>ASTM</th><th>EN</th><th>ISO*</th></tr>
<tr><td>0 – Sidewalk</td><td>-</td><td>-</td><td>-</td><td rowspan="8">Group A Retroreflectors
0.33˚ / 5˚ / 1.60D mcd/lx
0.33˚ / 20˚ / 1.40D mcd/lx
0.33˚ / 40˚ / 0.47D mcd/lx
0.33˚ / 50˚ / 0.15D mcd/lx
1.5˚ / 5˚ / 0.11D mcd/lx
1.5˚ / 20˚ / 0.10D mcd/lx
1.5˚ / 40˚ / 0.065D mcd/lx
1.5˚ / 50˚ / 0.020D mcd/lx
Group B Retroreflectors
0.2˚ / -4˚ / 1.21D mcd/lx
0.2˚ / 20˚ / 1.06D mcd/lx
0.2˚ / 40˚ / 0.70D mcd/lx
0.2˚ / 50˚ / 0.21D mcd/lx
1.5˚ / -4˚ / 0.121D mcd/lx
1.5˚ / 20˚ / 0.106D mcd/lx
1.5˚ / 40˚ / 0.070D mcd/lx
1.5˚ / 50˚ / 0.021D mcd/lx</td></tr>
<tr><td>1 – Road</td><td rowspan="7">0.2˚ / -4˚ / 2.2 m (7.25 ft)
0.2˚ / 20˚ / 1.9 m (6.27 ft)
0.2˚ / 40˚ / 1.3 m (4.29 ft)
1.5˚ / -4˚ / 0.22 m (0.73 ft)
1.5˚ / 20˚ / 0.19 m (0.63 ft)
1.5˚ / 40˚ / 0.13 m (0.43 ft)</td><td>-</td><td>-</td></tr>
<tr><td>2 – Trekking</td><td>-</td><td>-</td></tr>
<tr><td>3 – Mountain</td><td>-</td><td>-</td></tr>
<tr><td>4 – Downhill</td><td>-</td><td>-</td></tr>
<tr><td>Young Adult</td><td>-</td><td>-</td></tr>
<tr><td>BMX</td><td>-</td><td>-</td></tr>
<tr><td>EPAC</td><td>-</td><td>-</td></tr>
</table>

*Only applicable to use conditions 0-3, young adult, and EPAC

Front Lamps

The ISO standard contains requirements for bicycles equipped with powered lighting such as lamps or headlights. For front lamps, the standard specifies luminous intensity values for three distinct regions as shown below in Figure 38. The center region spans 20 degrees horizontally and 7 degrees vertically. The horizontal edge region spans 10 degrees to the left and right of the center region on the horizontal, 0-degree axis. The outer periphery spans a total 160 degrees horizontally and 30 degrees vertically from the center axis. Table 60 below shows the required luminous intensity for each of the above regions. The requirement states that the luminous intensity measurements shall be performed with the lamp facing a vertical screen 10 m (32.8 ft) away. The standard allows the front lamp to be either a continuous light or flash at a frequency from 1 Hz to 4 Hz or be able to switch between modes.

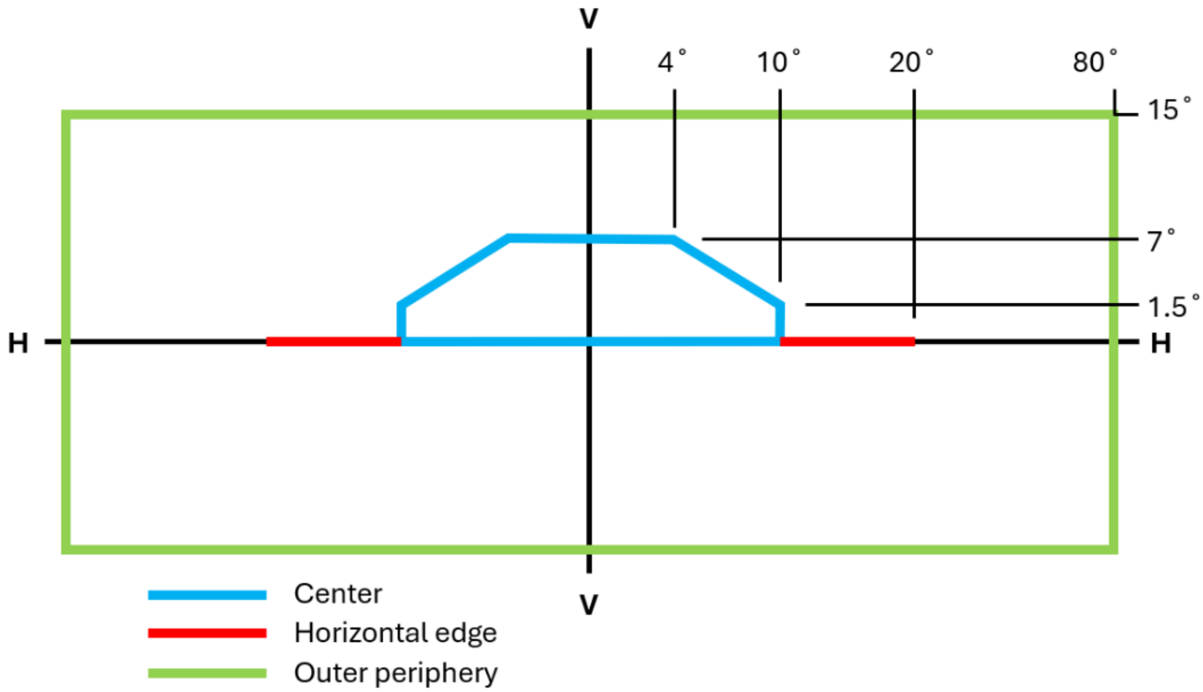

Figure 38. Front Lamp Regions

Table 60. Front Lamp Luminous Intensity (center / horizontal edge / outer periphery / upper limit above horizontal H-H)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd
1 – Road	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd
2 – Trekking	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd
3 – Mountain	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd
4 – Downhill	-	-	-	
Young Adult	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd
BMX	-	-	-	
EPAC	-	-	-	≥ 4 cd / ≥ 2 cd / ≥ 0.05 cd / ≤ 140 cd

Rear Lamps

For rear lamps, the standard specifies luminous intensity values for 6 regions as shown below in Figure 39 and Table 61. The test procedure is the same as detailed above for front lamps. The standard allows the front lamp to be either a continuous light or flash at a frequency from 1 Hz to 4 Hz or be able to switch between modes.

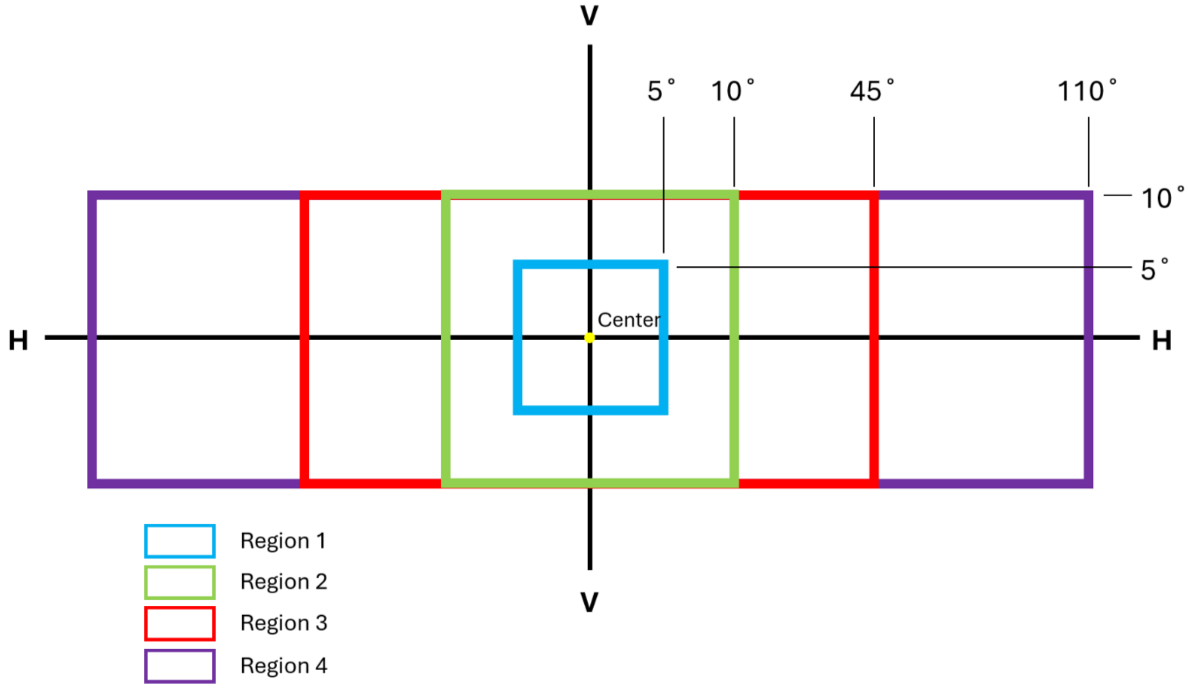

Figure 39. Rear Lamp Regions

Table 61. Rear Lamp Luminous Intensity (center / region 1 / region 2 / region 3 / region 4 / upper limit above horizontal H-H)

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12
1 – Road	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12
2 – Trekking	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12
3 – Mountain	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12
4 – Downhill	-	-	-	
Young Adult	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12
BMX	-	-	-	
EPAC	-	-	-	≥ 2.5 / ≥ 1 / ≥ 0.33 / ≥ 0.1 / ≥ 0.033 / ≤ 12

Stop Lamp

The ISO standard specifies luminous intensity for rear stop lamps or brake lights. The standard requires the luminous intensity at the center point to be at least 40 cd and no more than 185 cd. If the stop lamp function is provided by a rear lamp, the luminous intensity must be at least five times greater than the intensity of the rear lamp. The areas away from the center point shall have a percentage of the luminous intensity of the center point as shown below in Figure 40.

The test procedure is the same as above for the front lamp. The standard requires the stop lamp to have a continuous light.

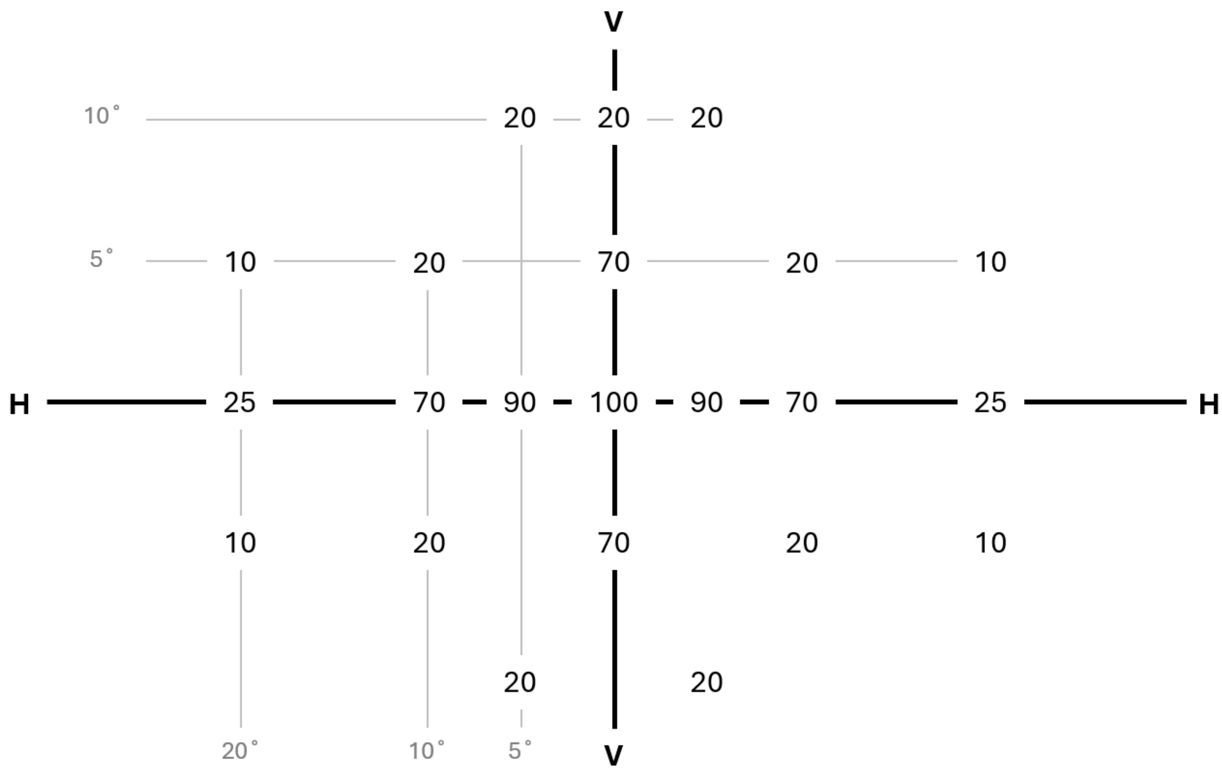

Figure 40. Stop Lamp Luminous Intensity Distribution Percentages

Table 62. Stop Lamp Luminous Intensity

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	40 - 185 cd
1 – Road	-	-	-	40 - 185 cd
2 – Trekking	-	-	-	40 - 185 cd
3 – Mountain	-	-	-	40 - 185 cd
4 – Downhill	-	-	-	
Young Adult	-	-	-	40 - 185 cd
BMX	-	-	-	
EPAC	-	-	-	40 - 185 cd

Daytime Running Lamp

The ISO standard specifies that daytime running lamps shall have a luminous intensity of at least 400 cd and no more than 1,200 cd as shown below in Table 63. The areas away from the center point shall have a percentage of the luminous intensity of the center point as shown below in Figure 41. The test procedure is the same as above for the front lamp. The standard requires the daytime running lamp to have a continuous light and incorporate a device which ensures that the lamp can only be on during daylight with an ambient illumination of at least 1,000 lx.

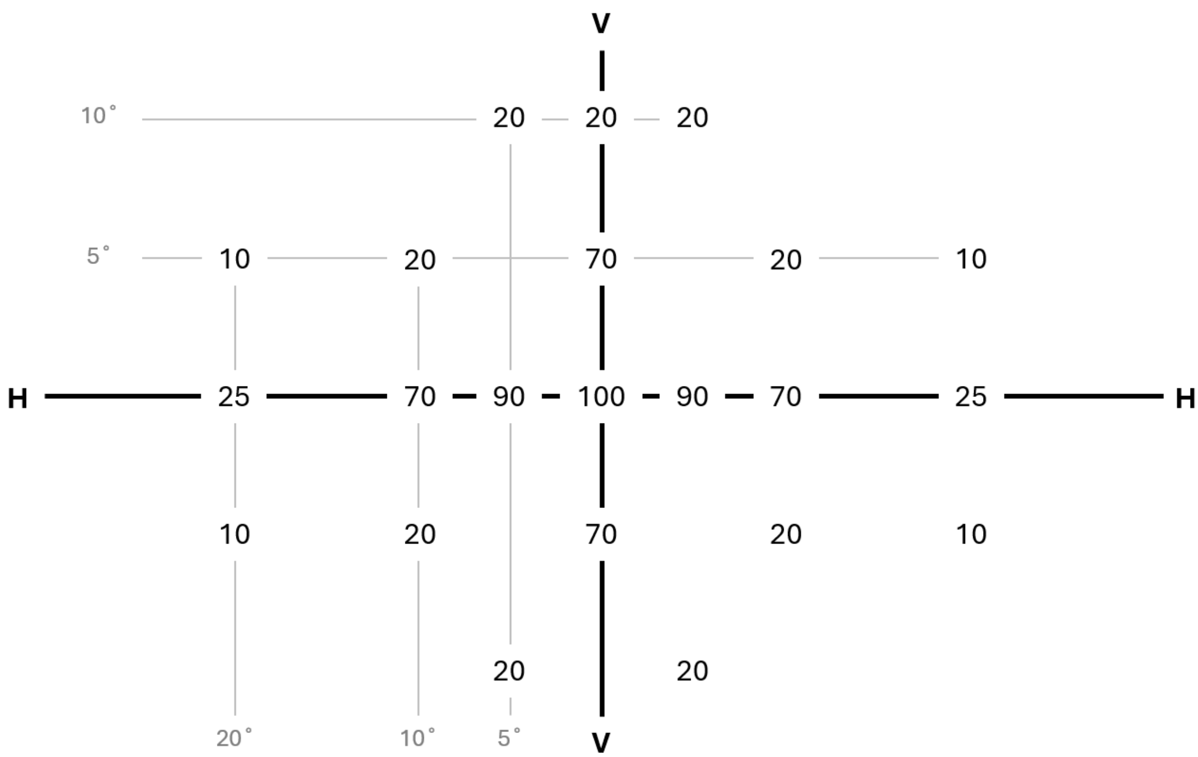

Figure 41. Daytime Running Lamp Luminous Intensity Distribution Percentages

Table 63. Daytime Running Lamp Luminous Intensity

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	400 – 1,200 cd
1 – Road	-	-	-	400 – 1,200 cd
2 – Trekking	-	-	-	400 – 1,200 cd
3 – Mountain	-	-	-	400 – 1,200 cd
4 – Downhill	-	-	-	
Young Adult	-	-	-	400 – 1,200 cd
BMX	-	-	-	
EPAC	-	-	-	400 – 1,200 cd

Road Test

The CPSC, EN, and ISO standards specify a final road test to demonstrate that all systems and components of the bicycle function as intended without failure. This requirement tests a fully assembled bicycle per the manufacturer's instructions and specifications. The road test involves riding the bicycle for at least a specified distance. The CPSC standard specifies that the course shall be ridden with a rider weighing at least 68.1 kg (150 lb). The ISO standards and the EN standard for EPACs specify that the test shall be conducted with added payload up to the bicycle's maximum capacity per the manufacturer's specifications, whereas the EN standards for conditions 1 through 3 only specify that the road test shall be conducted with a rider of appropriate size. The CPSC standard adds that the test course shall include traveling five times over a 30 m (100 ft) cleated course consisting of wooden strips, 51 mm (2.0 in) wide and 25 mm (1.0 in) high, spaced every 1.8 m (6.0 ft), ridden at a speed of 24 kph (15 mph). The EN standard specifies that only use condition 3 bicycles (mountain bikes) are required to complete a similar cleated course five times. After completion of the test, the bicycle shall exhibit stable handling in braking, turning, and steering. The EN and ISO standards also state that the bicycle shall be possible to ride with one hand removed from the handlebar, such as when giving hand signals, without difficulty of operation or hazard to the rider. Table 64 below shows the minimum distance for the road test for each bicycle use condition. The CPSC standard specifies a more stringent distance for the road test compared to the EN and ISO standards and also requires the cleated course for all in-scope bicycles, whereas the EN standard only requires it for mountain bikes.

Table 64. Road Test

Use	CPSC	ASTM	EN	ISO
0 – Sidewalk	-	-	-	-
1 – Road	6.4 km (4.0 mi)**	-	1 km (0.62 mi)	1 km (0.62 mi)*
2 – Trekking		-	1 km (0.62 mi)	1 km (0.62 mi)*
3 – Mountain		-	1 km (0.62 mi)**	1 km (0.62 mi)*
4 – Downhill		-	-	-
Young Adult		-	-	1 km (0.62 mi)*
BMX		-	-	-
EPAC		-	1 km* (0.62 mi)	1 km (0.62 mi)*
EPAC Mtn		-	1 km** (0.62 mi)	1 km (0.62 mi)*

*Ridden with maximum weight capacity per manufacturer's specifications
**Ridden five times at a speed of 24 kph (15 mph) over a 30 m test course consisting of wooden strips, 51 mm (2.0 in) wide and 25 mm (1.0 in) high, spaced every 1.8 m (6.0 ft).

Standards Comparison

The CPSC, ASTM, EN, and ISO standards specify various performance requirements for the many different components of bicycles. Many of the standards specify similar or equivalent requirements, but there are some requirements which vary in terms of procedures, test parameters, or acceptance criteria for the same bicycle components, leading to some divergence in stringency. As shown below in Table 65, the ISO standard contains the most expansive set of performance requirements for electric and non-powered bicycles, containing many requirements with no equivalent specified in the CPSC, ASTM, or EN standards. Of note, the ISO standards specify additional requirements for braking performance such as testing under wet conditions which is intended to minimize the reduction in braking performance, thus ensuring that riders would still be able to stop to avoid hazards even under wet conditions. The ISO standard also specifies more requirements for strength and durability than the mandatory standard for handlebars, pedals, drive systems, wheels, forks, and saddles. The ISO standard contains more recent requirements to address new innovations such as composite wheels to address heat and impact resistance. Lastly, the ISO standard offers expanded visibility requirements compared to the CPSC standard by specifying powered lighting requirements to assist in assuring that others are better able to detect the presence of the bicycle and its rider.

While the voluntary standards have been continuously updated to address changes in bicycle design, use patterns, materials, and safety considerations, the CPSC mandatory standard contains the bare minimum requirements to protect consumers from the risk of many hazards associated with the use of electric and non-powered bicycles, and the combination of the mandatory and voluntary standards has largely led to much safer products.

Table 65. Standards Comparison Table

Requirement	Standard			
	CPSC	ASTM	EN	ISO
Handbrake Lever Strength Test	X		X	X
Handbrake Rocking Test	X		X	X
Hand Lever Operating Force	X			
Footbrake Operating Force Test	X		X	X
Footbrake Strength Test			X	X
Handbrake Stopping Distance Test – Dry	X		X	X
Footbrake Stopping Distance Test – Dry	X		X	X
Handbrake Stopping Distance Test – Wet			X	X
Footbrake Stopping Distance Test – Wet			X	X
Machine-based Braking Performance Test – Dry			X	X
Machine-based Braking Performance Test – Wet			X	X
Brake Heat Resistance Test			X	X
Control Cable End Removal Force Test	X		X	X
Handlebar Stem Forward Bending Strength Test	X		X	X
Handlebar and Stem Assembly Lateral Bending Test			X	X
Handlebar Stem Lateral Bending Strength Test			X	X
Handlebar Stem to Fork Torsional Security Test	X		X	X
Handlebar to Stem Torsional Security Test	X		X	X
Handlebar and Stem Fatigue Test			X	X
Pedal Static Strength Test			X	X
Pedal Impact Test			X	X
Pedal Dynamic Durability Test			X	X

Requirement	Standard			
	CPSC	ASTM	EN	ISO
Drive Chain Tensile Load Test	X		X	X
Drive Chain Pin Push-Out Resistance Test			X	X
Drive System Static Strength Test			X	X
Drive Belt Tensile Strength Test				X
Drive Belt Static Strength Test				X
Wheel Rim Static Strength Test	X		X	X
Wheel/Tire Assembly Impact Test			X	
Wheel Retention Test – Locking device secured	X	X	X	X
Wheel Retention Test – Locking Device Unsecured	X	X	X	X
Threaded Locking Device Minimum Removal Torque Test	X		X	X
Composite Wheels – Greenhouse Effect Test				X
Composite Wheels – Heat Resistance Test				X
Composite Wheels – Impact Test				X
Fork Static Bending Strength Test		X	X	X
Fork Rearward Impact Resistance Test	X	X	X	X
Fork Bending Fatigue and Impact Test		X	X	X
Suspension Fork Compression & Tire Clearance Test		X	X	X
Suspension Fork Tensile Test			X	X
Rigid Non-Welded Fork Tensile Test			X	X
Fork Hub/Disc Brake Static Torque Test			X	X
Fork Hub/Disc Brake Fatigue Torque Test			X	X
Frame and Fork Assembly Horizontal Static Load Test	X			
Frame and Fork Assembly Horizontal Fatigue Test		X	X	X
Frame and Fork Assembly Vertical Fatigue Test		X	X	X
Frame and Fork Assembly Pedaling Forces Fatigue Test			X	X
Frame and Fork Assembly Impact Strength Test – Falling Mass		X	X	X
Frame and Fork Assembly Impact Strength Test – Falling Frame			X	X
Frame Rear Brake Mount Static Torque Test				X
Frame Rear Brake Mount Fatigue Test				X
Saddle Static Strength Test			X	X
Saddle and Post Fatigue Test			X	X
Seat Clamp Static Test	X		X	X
Saddle Post Fatigue Test			X	X
Saddle Post Static Test			X	X
Reflector Performance Test – front, rear, and side reflectors	X			X
Reflector Performance Test – pedal reflectors	X			X
Retroreflective Tire Sidewall Performance Test	X			X

Requirement	Standard			
	CPSC	ASTM	EN	ISO
Front Lamp Luminous Intensity				X
Rear Lamp Luminous Intensity				X
Stop Lamp Luminous Intensity				X
Daytime Running Lamp Luminous Intensity				X
Road Test	X		X	X

Additional Observations

With the continuing evolution of bicycles and the advent of e-bikes, additional hazards may develop with new designs and technologies, and therefore, the standards must continually also evolve over time. Most notably, some e-bikes have entered the market that are significantly larger and heavier than other e-bikes and especially non-power bicycles. Additionally, because e-bikes provide power through an electric motor, this gives more opportunity for longer duration of faster speeds to a greater portion of consumers that may not have otherwise been able to achieve those speeds.

As discussed earlier in this report, many of the fatal incidents with e-bikes involved collisions with vehicles, pedestrians, or fixed objects. One of the contributing factors that may have led to these fatalities is likely inadequate visibility of the e-bikes or riders. 16 CFR part 1512 specifies placement and performance requirements of reflectors for all in-scope bicycles. However, reflectors alone may be limited in effectiveness due to limited visibility distances. Additional conspicuity requirements such as lighting may enhance the detection of e-bikes by automobile drivers. Not only have power requirements decreased and supplies increased, but, because e-bikes already include an electrical power system, the challenges that existed prior to e-bikes for powering such lighting systems no longer apply. Conspicuity lighting may be an inexpensive and effective way to reduce the risk of collision.

Given that e-bikes provide more opportunity for greater sustained speed, this leads to greater potential for more severe injury or death. The EN voluntary standard and many European regulations set the maximum speed of e-bikes at 15 mph, and many state laws regulate e-bike maximum speeds from 20-28 mph. Speed is a critical factor for the rider's ability to avoid a crash and for the severity of a crash due to impact energy. Requirements to limit the maximum speed that the electric motor shall provide assistance for propulsion and/or additional measures to provide rider protection for higher speed and energy crashes, may warrant consideration.

Other considerations to increase stringency of current performance requirements would include the braking performance requirements from part 1512, which involve adding 68.1 kg or 150 lb. to the bicycle to simulate the added momentum from the weight of the rider during the brake tests. Updating the weight parameter to more recent anthropometric data could ensure that a more representative weight is accounted for in the tests. Furthermore, a benefit of e-bikes is that it provides accessibility to many differently-abled riders, particularly heavier riders. Staff may evaluate whether the braking performance requirements are sufficient to reduce the risk of hazards to heavier riders. Another consideration is that the stopping distance requirements from Part 1512 specify that the bicycle must have an initial speed of 24 kph or 15 mph and must stop within a specified distance. Given that e-bikes provide consumers with more opportunity achieve greater speeds over longer periods of time, an increased initial speed parameter for the braking performance requirements could further reduce the risk of hazard. Many of part 1512's strength requirements for bicycle components such as the frame, fork, and wheels apply static, dynamic, and cyclic loads based on typical forces that a bicycle may encounter depending on the use condition of the bicycle. Many of these parameters may be applicable to typical non-powered bicycles. However, given that many e-bikes exist in the market with significantly heavier weight, fatter tires, and able to achieve faster speeds, it may be appropriate to evaluate the stringency of such parameters to account for these emerging products.

Conclusion

The summary provided in this report provides a snapshot of the current versions of the CPSC, ASTM, EN, and ISO standards relevant to electric and non-powered bicycles. The above comparison of standards highlights the similarities and differences between all the standards where many of the standards specify equivalent requirements, but there are also some requirements which differ in terms of procedures, test parameters, or acceptance criteria for the same bicycle components, leading to some divergence in stringency. The international standards, EN and ISO, contain the most expansive sets of performance requirements for electric and non-powered bicycles, containing many requirements with no equivalent specified in the domestic standards. The CPSC mandatory standard specifies the bare minimum requirements for bicycle design, and, in combination with the voluntary standards, it has predominantly led to safer, more robust, and more reliable bicycles while protecting the consumer from many bicycle-related hazards.

If the Commission moves forward with a rulemaking process, staff would propose to continue the analysis of available incident data involving e-bikes and recalls to identify root causes for the hazards that led to the injuries and fatalities. Staff will continue to evaluate the efficacy of the mandatory standard in comparison to other requirements from voluntary standards and determine if changes to requirements may be needed to address these hazards. Based on the comparisons of the standards discussed in this report, staff identified multiple considerations for new or modified requirements which may help further reduce the risk to the consumer such as supplementing visibility requirements with conspicuity lighting, limiting the maximum allowable speed of electric-motor-assistance, or updating braking and/or structural requirements to account for heavier loads and/or faster speeds. Additionally, staff is currently conducting contracted product testing on multiple electric and non-powered bicycles which will provide additional data that will assist in the development of new or updated requirements. This full knowledge base, when completed, could be used to move forward with both mandatory and voluntary standards work.